Cracow University of Economics

ARGUMENTA OECONOMICA CRACOVIENSIA

No 18

Cracow 2018

Cracow University of Economics

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No 18

Cracow 2018

ISSN 1642-168X

Ministry of Science
and Higher Education
Republic of Poland

The review and language editing of the articles herein was financed from funds designated for the promotion of science under contract No. 845/P-DUN/2018 of the Polish Ministry of Science and Higher Education

ISSN 1642-168X

Original version: printed publication
All the articles published in Argumenta Oeconomica Cracoviensia are available on the journal's website (www.aoc.uek.krakow.pl) and in the CEEOL database (http://www.ceeol.com)

Cracow University of Economics Press
Rakowicka 27, 31-510 Kraków, Poland
www.uek.krakow.pl

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ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 5–9

Dear Readers,

In keeping with its profile, the latest edition of our journal tackles issues in the fields of economy, management science, finance, and other sub--disciplines of economics. While early editions of the journal were primarily focussed on the economics of transformation and systemic changes, over time domestic and foreign authors began to contribute texts on universal themes. The editorial office began to receive an increasing number of high--quality contributions, which prompted us to publish the journal twice a year, starting in 2014. Our ambition is to transform the journal into a quarterly within the next two to three years. Not without significance is the fact that, for several years now, we have published an electronic version of the journal. Texts submitted for publication are assessed in accordance with the standards that apply in prominent periodicals (blind reviews, foreign reviewers).

The journal is a forum for the publication of research results that are theoretical and abstract in nature, not only in the language of economics, but also in the language of mathematics, computer science, and other disciplines. Our intention is to publish texts that refer to the achievements of economic science, to their paradigm, as well as texts that present the findings of empirical research using well-developed methods of analysis. We also publish the results of research in which authors modify the analysis methods as well as works in which new original approaches are proposed.

The present issue of the journal opens with an article on the intensely debated problems of macroeconomic and macrofinancial economic stability. Interest in these issues increased during the financial crisis and in subsequent years, both in relation to individual countries and in relation to groups of countries (economic groupings). For what the financial crisis of 2008 showed was that economic instability in one country quickly spreads abroad. For these reasons it is worth recommending Aleksandra Jurkowska and Michał Boda's article entitled "Macroeconomic Stability in Poland against the Backdrop of Union Tendencies in Light of the Concept of MSP". The authors have applied the Macroeconomic Stability Pentagon

(MSP) method to analyse such macroeconomic variables as the rate of economic growth, the unemployment rate, the rate of inflation, the public finance balance, and the country's current account balance. The results of the analysis using this method have yielded interesting results for European Union Member States, although for reasons of space the article does not contain any in-depth analyses of the reasons for the restoration of macroeconomic equilibrium in particular countries or regions. The issues raised by the authors can and should inspire further research.

After the collapse of the command economy, transformation processes in various countries of the former Eastern bloc proceeded at different rates and on different scales. These changes also brought different results under the new political and systemic conditions from the point of view of the effectiveness of the state's economic, monetary, and fiscal policy. The expectations not only of economists but also of the societies of individual countries in relation to the political transformations were often much greater, as exemplified by Ukraine. For these reasons, it is worth recommending Viktor Shevchuk and Roman Kopych's article, "Fiscal Policy Effects in Ukraine". The authors' analysis of that country's fiscal policy between 2001 and 2016, carried out on a quarterly basis using a vector error correction model (VECM), confirms the assumptions of the Mankiw-Summers model in the case of high demand for money in relation to consumption expenditure combined with significant investment elasticity in relation to the interest rate. Other results obtained on the basis of empirical analysis in the case of the Ukrainian economy differ from the classic relationships between macroeconomic variables. This is why the research results obtained deserve attention.

In recent years, the phenomenon of income inequality in various cross-sections of society has been the subject of intensive research and empirical analysis. It is also of interest to politicians. Income inequalities occur across different sections of society. However, measuring the distribution of income, wealth, and poverty remains an important cognitive and practical challenge. Different methods and models are used in analyses and produce different results. Therefore, each new attempt to verify the distribution of income, in this instance the spatial distribution, is worthy of attention. One such attempt is made by Alina Jędrzejczak and Dorota Pekasiewicz in their article entitled "Properties of Selected Inequality Measures Based on Quantiles and Their Application to the Analysis of Income Distribution in Poland by Macroregion". The authors compare the properties of the classical, Huang-Brill, and Bernstein quantile estimators, taking into

account different sample sizes and different distributions. The results of the simulation experiments obtained by the authors for Polish macroregions will undoubtedly be of interest to researchers of these phenomena as well as to politicians who deal with spatial development disparities.

The methods of studying economic phenomena are a constant challenge from the point of view of expected results and the objectivisation of research findings. In large-scale economic research, the big data method is used in relation to both macroeconomic and microeconomic phenomena, the content of which are phenomena in the real economy or in the financial sector. Without diminishing the significance of this method, one cannot ignore the fact that it is not able to fully describe the phenomena studied. For these reasons, the article by Mirosław Szreder and Jerzy P. Gwizdała, "Possible Future Developments of Sample Surveys in Finance" will undoubtedly be of interest. According to the authors, while so-called sampling methods are usually the main research tool in experimental science, in recent years their importance has been growing in economics and finance too. However, effective use of sampling methods in economics and finance is not easy, among others because they raise the question of the proper sampling frame and the most effective means of communication between interviewer and respondent. Another problem is rapidly growing rates of refusal to participate in this type of research among respondents. Therefore, according to the authors, sampling methods, due to the difficulties in their application, should continue to be supported by the big data method, which may help to improve the quality of results obtained by sampling.

Due to the burden and threat to life and health posed by the external negative effects of economic activity, the methods of measuring these negative phenomena are becoming increasingly important for researchers and practitioners alike. Various methods of measurement are used, hence the results of applying various methods as presented in Adrianna Mastalerz-Kodzis's article, "Application of the Multifractional Brownian Motion Process in Spatial Analyses", are interesting. In the author's opinion, the multifractional Brownian motion process, when applied to conduct an analysis of the degree and variability of environmental pollution, leads to an objective measurement. The method of verifying this hypothesis will likely be of interest to the reader.

The cognitive and practical importance of selecting the right method to analyse economic phenomena and the accuracy of assessments, conclusions, and decisions made, is evidenced by the research results presented in Patrycja Chodnicka-Jaworska's article entitled "Banks' Credit Ratings –

Domestic and Foreign Notes". The research shows that the credit rating of a bank is strongly influenced by the financial indicators the author analyses, if the liabilities of the commercial bank were incurred in the national currency rather than in a foreign currency. The hypothesis was verified using panel ordered probit models for European banks' long-term issuer credit ratings, which were set by S&P, Fitch and Moody's between 2000 and 2015. The verification of this hypothesis should encourage other researchers to analyse this intriguing result using more developed models.

Demographic processes in many (not only) affluent countries related to the ageing of societies, lower fertility, and deteriorating relations between the working age population and retirees give rise to a number of challenges for state policy. One of these is the shape of the pensions system. In recent decades, many countries (Chile, Latin American countries, Poland, and Hungary) have introduced quite radical changes to their pensions systems, which have consisted in a move away from pay-as-you-go (PAYG) systems based on intergenerational solidarity towards a strengthening of private (individual) capital-based systems. After a few decades of experience with capital-based systems, it turns out that the hopes vested in them were overly optimistic. The high cost to the state (public finances) of running a capital--based system has forced many countries (e.g. Chile, Hungary, and Poland) into an equally radical retreat from that system. The process of finding optimal solutions is therefore ongoing, and in the case of Poland, further changes are expected in this area. For these reasons, the article by Anna Ząbkowicz, "Capital-based Pension Funds: The Question of Risk Sharing" will likely be of interest to the reader.

A characteristic feature of the development of modern economic systems is the rapid development of the financial sector and financial innovations in relation to the instruments used. The behaviour of people (households) in the world of money is becoming increasingly difficult. This situation presents a challenge for institutions that provide people not only with economic knowledge, including financial knowledge, but also with methods used in the educational process. This issue is tackled by Beata Świecka and Marta Musiał in their article entitled "Enhancing Financial Literacy – Experiment Results". The authors carried out financial literacy experiments in a Polish university in cooperation with partners from a university in Italy. The article is part of a trend of economics and behavioural finance. The results of these experiments can make a useful contribution to the debate on how to improve economic and financial education in society under the conditions of increasingly complex monetary phenomena.

While commending the present issue to our readers, we would also like to invite contributions in the form of original texts, information about important academic events, and reviews of outstanding books.

Prof. Stanisław Owsiak
Editor-in-chief

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 11–31
https://doi.org/10.15678/AOC.2018.1801

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MACROECONOMIC STABILITY IN POLAND AGAINST THE BACKDROP OF UNION TENDENCIES IN LIGHT OF THE CONCEPT OF MSP

Abstract

This article aims to analyse the trends in the development of factors that determine the level of macroeconomic stability and to assess this level in Poland against the backdrop of different groups of European Union Member States (EU28 countries, Western Europe, Central and Eastern Europe, and Southern Europe) over the period 2006–2015 by using the Macroeconomic Stability Pentagon (MSP) method. The subjects of analysis in the presented method are the rate of economic growth (GDP), the unemployment rate (U), the rate of inflation (CPI), the public finance balance (G), and the country's current account balance (CA). These values form the apexes of a pentagon scaled in such a way that the more desirable the indicator value, the further its corresponding apex is situated from the centre of the system. The article proposes establishing a joint area of the MSP based on a modified classic scale and a scale with regression (these approaches do / do not take into account, respectively, the negative influence of deflation on the general level of macroeconomic stability). The conducted analyses show that in recent years the EU28 countries have returned to the level of macroeconomic equilibrium prior to the crisis of 2008–2009. In Poland the MSP indicator has been growing since 2013 and has significantly exceeded the levels observed in Southern European countries. However, until 2015 its level was still lower than the average for the EU28 and the average set for the Central and East European countries. This was mainly due to the high level of unemployment, which despite a downward trend still remained above the EU average.

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Keywords: economic policy, macroeconomic indicators, macroeconomic stability, Macroeconomic Stability Pentagon (MSP), MSP indicator.
JEL Classification: E52, E62, E63, G01.

1. Introduction

This article aims to analyse the trends in the development of factors that determine the level of macroeconomic stability and to assess this level in Poland against the backdrop of different groups of European Union Member States (EU28 countries, Western Europe, Central and Eastern Europe, and Southern Europe) over the period 2006–2015 by using the Macroeconomic Stability Pentagon (MSP) method. This method facilitates the construction of synthetic stability indicators for specific countries and regions and the comparison of these factors in space and time, which is why it is used to assess the competitiveness of specific economies and to formulate current and long-term economic policy goals. The basis of the concept was developed by A. W. Phillips and R. Mundell. In Poland, the expanded five-indicator model for assessing macroeconomic stability was proposed in 1990 by the Foreign Trade Research Institute (Walawski 2015, p. 69) and was later used by, among others, G. Kołodko (1993), to assess the level of optimisation of the competitive goals of economic policy.

2. Method Presentation

In MSP analysis, macroeconomic stability is identified as a state of general equilibrium in the economy, that is, an internal and external equilibrium, when the functions of production, demand, and supply for all factors of production form an internally dependent system (Walrasian equilibrium or Pareto efficiency). The subjects of the analysis in the method being presented are the rate of economic growth, the unemployment rate, the rate of inflation, the public finance balance, and the current account balance, whose values form the apexes of a pentagon scaled in such a way that the more desirable the indicator value, the further its corresponding apex is situated from the centre of the system. An optimal system is illustrated in Figure 1, while the total area of the pentagon is expressed by the following formula:

$$MSP = [(\Delta GDP \cdot U) + (U \cdot CPI) + (CPI \cdot G) + (G \cdot CA) + (CA \cdot \Delta GDP)] \cdot K,$$

where:

ΔGDP – rate of GDP growth (%),

U – unemployment rate (%),

CPI – consumer price index (%),

G – ratio of budget balance to GDP,

CA – ratio of current account to GDP (%),

K – 1/2 sin 72° (a constant value of 0.4756 equal to half the sinus of the angle found at the central apexes of each of the triangles marked in Figure 1 by the letters a, b, c, d, e; this angle, by assumption, forms a fifth of a full angle thus measuring 72°).

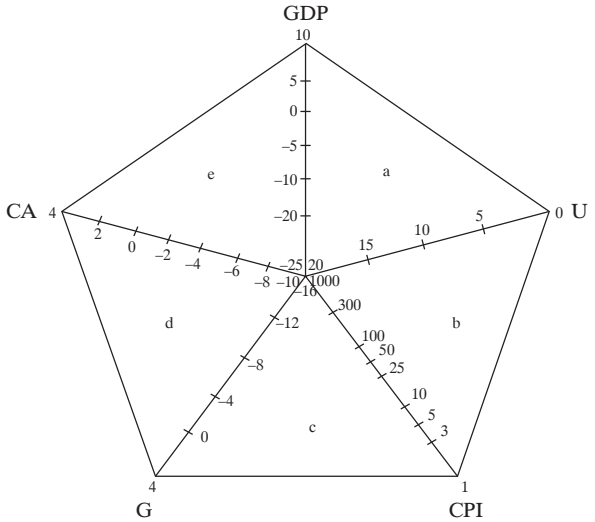

Fig. 1. The Optimal Shape of a Macroeconomic Stability Pentagon

Source: (Siek 2015, p. 3).

The total area of the pentagon is the sum of the areas of the triangles labelled in Figure 1 by the letter a (a real sphere triangle whose area is dependent on the economic growth indicator and the unemployment rate), b (a stagflation triangle whose area depends on the unemployment rate and inflation), c (a budget and inflation triangle), d (a financial equilibrium triangle whose are is determined by the size of the budget balance and the current account balance) and e (an external sector triangle which is a function of the current account balance and GDP growth). The optimal state in an economy is when the area of the pentagon is equal to 1, that is,

every triangle reaches its maximum size equal to 0.2 ($5 \times 0.2 = 1$). This state is impossible to achieve due to many factors. The constituent parts of the MSP are area MSP1, which is dependent on internal factors (the sum of the areas of triangles a, b, and c), and area MSP2, which is dependent on external factors (the sum of the areas of triangles d and e). The values of MSP1 and MSP2 make it possible to identify factors that determine the progress of the stabilisation or destabilisation process. When establishing the area of each triangle it is important to consider that their sides are scaled differently. Most of the scale units on the sides of the pentagon are expressed in percentage points. The exception is the side depicting the level of inflation, where a logarithmic scale is used (because of the large variation in the observed values). Because the classic model does not include the phenomenon of deflation, in this article the CPI axis has been appropriately scaled and the modified scale has been prepared as two variations: a) the outer limit has been set at –2.0% – this method is recommended by K. Raczkowski (2016); the flaw of this approach is that only small scale deflation phenomena (when the rate of inflation drops from +1.0% to –2.0%) are perceived as a desirable situation that positively influences the general level of macroeconomic stability; b) the outer limit, in accordance with the classic scale was set at +1.0%; with this approach every drop in inflation below the outer limit causes an appropriate shortening of the CPI side (scale with regression). Setting new outer limits was also necessary in the case of GDP, G, and CA (the limits were set at 15%, 10%, and 15%, respectively), because many of the indicators characteristic of the countries under review exceeded the classic scale. Despite these corrections, the exceptionally high economic growth rate in Ireland in 2015 (26.3%) still fell outside the scale, which according to many economic event commentators did not fully reflect reality. As a result, in this paper, for the year 2015 Ireland has been assigned the maximum economic growth rate available on the modified classic scale (15%).

3. Macroeconomic Indicators in the European Union and Their Determinants

According to the figures at the end of 2015, the EU economy was the biggest in the world with a GDP equal to 14.7 b EUR (http://ec.europa.eu/eurostat, accessed: 8 March 2017). In the joint GDP of the EU28, the biggest share belonged to Germany, France, the United Kingdom, Italy, and Spain. Despite having by far the greatest economic potential in the

world from a nominal point of view, GDP per capita in EU countries was significantly lower than in the USA, and from 2008 the gap continued to grow. The average macroeconomic indicator values for EU countries in the years 2006–2015 are illustrated in Table 1.

Table 1. Average Macroeconomic Indicators in the EU*, 2006–2015 (%)

Indicator	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
GDP[a] growth rate	5.1	5.0	1.2	–5.6	1.7	1.7	–0.4	0.5	2.3	3.3
Unemployment	4.8	4.2	4.1	5.7	6.5	6.5	7.0	7.2	6.8	6.2
Inflation	3.0	3.3	5.3	1.4	2.0	3.2	2.9	1.3	0.4	–0.1
Public finance balance/GDP	–1.1	–0.3	–2.1	–6.4	–6.3	–4.6	–3.8	–3.5	–2.9	–2.0
Current account balance/GDP	–4.1	–5.0	–4.9	–1.3	–1.1	–0.8	0.1	1.4	1.7	2.2

* average for the EU28, [a] real GDP.

Source: authors' calculations based on: http://ec.europa.eu/eurostat (accessed: 8 March 2017).

From the end of Second World War until the end of the 1970s, Europe underwent a period of dynamic growth. In 2007, the rate of economic growth started to slow down and this trend continued until 2009, when EU countries experienced a recession (average GDP dropped by 5.6%). The biggest drops in GDP were noted in the Baltic States (Lithuania, Latvia, and Estonia, where in 2009 GDP dropped by over 10%), Finland, Slovenia, and Croatia (single-digit decrease). The key factor responsible for the economic slowdown was a gross decline in investments, caused mainly by a reduction in fixed asset expenditure (predominantly in the construction sector). The reduction was a reaction to earlier "overinvestment". The foreign trade balance had a positive influence and total consumption had a neutral influence (the drop in private consumption was offset by an increase in government spending) on the growth of GDP in Member States (Balcerowicz *et al.* 2016, pp. 9, 26–28). Following the introduction of government rescue schemes, in 2010 the average GDP growth of EU countries was 1.7%, and the growth trend was maintained in 2011. In 2012, the average GDP of the EU28 countries in real terms was 0.4% lower than in the previous year. In the years 2013–2015, because of an increase in internal demand (mainly private) and investment stimulus financed by structural funds and company loans (World Bank 2015, p. 27 and 48), the European economies got back on the path of growth, though initially the fiscal changes and foreign trade balance had little effect

on growth (EC 2014, p. 1–3). The pace of growth, however, varied across the EU. Analyses that take into account the cumulative growth of GDP per capita between 2008–2013 show that the countries developing the fastest were Poland, Slovakia, Lithuania, Bulgaria, Sweden, Germany, Malta, Estonia, and Latvia. Countries whose economies developed the slowest, beside the PIIGS countries, were Luxembourg, Slovenia, and Cyprus. In the majority of the second group countries, the economic slowdown was due to a decrease in net export (AMECO 2016, p. 29–31). In Southern Europe, the slump was connected to the drop in the competitiveness of economies, partly caused by the public finance crisis accompanied by a lack of wage discipline (Greece, Portugal) as well as delays in implementing the structural reforms laid out in the Lisbon Strategy and the "Europe 2020" strategy (Italy, Spain) (Albiński 2014, p. 24).

The economic slowdown in EU countries after 2007 was accompanied by an increase in the rate of unemployment between 2009 and 2013. In the first phase of the crisis (2008–2009), average unemployment rose by 1.6%. Between 2009 and 2013, after the stabilisation programmes introduced by the governments of some countries were stopped, unemployment rose by another 1.5%. In 2009, the largest growth in unemployment was recorded in countries that were the worst hit by the economic recession (the Baltic States) as well as Slovakia and Spain. Between 2009 and 2013, the total increase in unemployment was the highest in Greece, Cyprus, Spain, Croatia, Portugal, and Bulgaria. The highest annual rates of unemployment exceeded 20% and were recorded in Greece and Spain (http://ec.europa.eu/eurostat, accessed: 8 March 2017) between 2011 and 2014. In Spain, where the recession was at a moderate level, the labour market situation turned out to be very sensitive to changes in the economy and brought to light the ineffectiveness of the solutions introduced by the Nazara government, which were based on short--term contracts and "junk employment agreements" (Hajder 2013, p. 53). In the years 2014–2015, the clear acceleration in economic growth had a positive effect on the employment figures, and in 2015 the average rate of unemployment in EU countries dropped to 6.2%.

Between 2006 and 2011, the average rate of inflation in EU Member States measured using the HICP indicator fluctuated between 1.4 and 5.3%. A clear downward trend began in 2012; in 2015, average inflation stood at –0.1%, which prompted fears of deflation. Among the reasons for the deflationary pressure were: a drop in energy prices and a drop in internal demand (due to the slowing economy and more restrictive fiscal policy in the aftermath of the public finance crisis in the Eurozone) (Mastromatteo

& Rossi 2015, p. 336–50), and the associated "internal devaluation" in the PIIGS countries (Baldini & Manasse (2016) as well as the raising of interest rates by the EBS in 2001 (Ducrozet, Kukla & Lacan 2011, European Parliament 2015, Bednarczyk 2015), although opinions on this subject are divided. In European Union countries the divergence in inflation rates was far smaller than the divergence in economic growth or unemployment rates. At the end of 2015, the lowest (negative) inflation rates were recorded in 11 EU countries: Bulgaria, Greece, Spain, Croatia, Cyprus, Lithuania, Poland, Romania, Slovenia, and Finland. Only Malta had an inflation rate higher than 1%.

In the years 2006/2007, the average EU budget deficit relative to GDP fell by 0.8 p.p., while in 2007 only two Member States exceeded the allowed 3% limit (one of the convergence conditions) – Greece and Hungary. Over the next two years the average negative balance of the EU government and local government sector grew to –6.4%, and in 2009 budgetary discipline limits were exceeded by 22 Member States (including Germany and Austria, who are seen as the most conservative in fiscal matters). In the period under analysis the highest deficit was recorded in 2010 in Ireland, where it stood at 32.1% of GDP (http://ec.europa.eu/eurostat, accessed: 11 March 2017). The only, or certainly the primary, cause of growing deficits in EU countries was the increase in nominal budget spending, stemming more from current budgetary policy than from economic recession. In the PIIGS countries, the increase in budget spending was stimulated by an increase in pay that exceeded the increase in labour productivity, and by the bank crises (Albiński 2014). The improvement in the balance sheet of the government and local government sector registered from 2010 was primarily caused by an increase in revenue relative to budget spending, brought on by, among others, the effects of actions taken as part of fiscal consolidation (Giżyński 2012, pp. 179–193). In 2015, the average level of deficit in the EU28 settled at 2.0%. Three Member States recorded a budget surplus (Germany, Estonia and Luxembourg). In six countries the deficit exceeded 3% of GDP (http://ec.europa.eu/eurostat, accessed: 11 March 2017) (Greece, Spain, France, Croatia, Portugal, and the United Kingdom), while nine were under the excessive budget deficit procedure (Croatia, Cyprus, France, Greece, Spain, Ireland, Portugal, Slovenia, and the United Kingdom).

During the period under analysis, the highest average current account deficit in the balance of EU payments was recorded in 2007 (–5.0% of GDP). After 2009 this deficit gradually shrank, and in 2012 the average balance of current accounts closed with a surplus (0.1% of GDP).

The surplus persisted until 2015, showing a tendency towards growth. Before the recession, the current account balances of Member States were largely asymmetrical. The imbalance mainly concerned the so-called Eurozone core (Germany and North European countries recorded a high surplus) as well as Central and East European countries (Latvia, Estonia, Lithuania, Romania, Slovakia) and the PIIGS countries (where large deficits were recorded). In the literature on the subject, these imbalances are explained in two ways (Kuziemska 2010, p. 89–105; Belke & Dreger 2011, p. 2). According to convergence theory, the deficits of poorer countries (as well as the surpluses of richer countries) form as a result of the free flow of capital, a reduction in national savings, and an influx of foreign investment. In the light of the theory of competitiveness, a real appreciation in the rate lowers the competitiveness of economies. After 2008, the average current account of the EU28 was a result of two trends (Kuziemska 2010, p. 102). First, countries with a large deficit at the beginning of the crisis experienced a drop in private sector demand (in PIIGS countries it was the result of implementing restrictive economic policy measures) and a slightly less drastic drop in exports. There were also changes to the internal demand structure: in particular, imported products were substituted by local ones. This resulted in a decrease in the deficit of current accounts. Second, in countries characterised by a current account surplus, private demand proved more resilient to perturbations, but a decrease in the current account balance was influenced by a growing public deficit and a drop in world trade (due to greater openness among economies). The result was a decrease (but not the elimination) of the current account surplus.

4. Macroeconomic Indicators in Poland and Their Determinants

Poland is the largest new Member State of the European Union. According to figures published at the end of 2015, it was in sixth place in the enlarged Union (EU-28) in terms of area, population, and GDP (7.1%, 7.5% and 2.9%, respectively) and 24th in terms of GDP per capita (according to PPS)[1]. Poland's share in the economic potential of the EU28 was therefore lower than it would seem from its geographical and demographic attributes (a similar disproportion concerns all the Central and East European countries), although Poland's position has improved significantly since

[1] Eurostat data and authors' own calculations based on Eurostat data (http://ec.europa.eu/eurostat, accessed: 11 March 2017).

entering the European Union. The main macroeconomic indicators for Poland are illustrated in Table 2.

Table 2. Basic Macroeconomic Indicators for Poland, 2006–2015 (%)

Indicator	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
GDP[a] growth rate	6.2	7.0	4.2	2.8	3.6	5.0	1.6	1.4	3.3	3.9
Unemployment	13.9	9.6	7.1	8.1	9.7	9.7	10.1	10.3	9.0	7.5
Inflation	1.3	2.6	4.2	4.0	2.6	3.9	3.7	0.8	0.1	–0.7
Public finance balance/GDP	–3.6	–1.9	–3.6	–7.3	–7.3	–4.8	–3.7	–4.1	–3.4	–2.6
Current account balance/GDP	–4.0	–6.3	–6.7	–4.0	–5.4	–5.2	–3.7	–1.3	–2.1	-0.6

[a] real GDP.

Source: Eurostat data, http://ec.europa.eu/eurostat (accessed: 11 March 2017).

Between 2006 and 2008, the Polish economy was developing relatively fast – GDP growth stood at 4.2–7.0%. As a result of the worldwide economic and financial crisis, the rate of growth dropped to 2.8% in 2009. However, Poland was the only EU country not to experience a recession. According to experts, the Polish development model relied on the private sector and resulted mainly from productivity gains, dynamic export growth, strong internal demand, the influx of EU funding, foreign direct investment, positive demographics, and a stable banking system (Bogdan *et al.* 2015, p. 12). It has also been emphasised that during the economic crisis the main growth stimulator was foreign demand – due to the strong depreciation of the zloty the Polish economy became more competitive on foreign markets, which is why in 2013 the current account balance was close to a state of equilibrium.

Unemployment in Poland until 2015 was regularly at a higher level than the EU-28 average. However, in the last few years of the period under analysis these differences diminished. Polish unemployment is characterised by strong regional variation. Other significant factors are variations due to gender and age. Unemployment is Poland depends not so much on the economic situation as on structure; it results from the level and structure of manpower resources failing to adjust to the real needs of the economy, which condemns some to professional idleness or the need to requalify, while unprofitable branches of production need to be restructured or liquidated (Głąbicka 2001, p. 91). According to research carried out thus far, it appears

that unemployment in Poland is shaped mainly by variations in demand and, to a lesser extent, by factors such as the inflexibility of the labour market and the demotivating role of welfare benefits (Polakowski & Szelewa 2013, p. 7; Bartosik 2012, p. 25–57). Consistently, the greatest challenges in the labour market are the high level of unemployment among young people and the labour participation rate (EC 2015, pp. 3–4).

The Maastricht criterion on price stability was already fulfilled by Poland in 2005–2007. In 2006, Poland (with an inflation rate of 1.3%) found herself in the group of countries with the most stable prices. In 2009, the rate of inflation fell by 0.2 percentage points compared with 2008. In the years 2008–2009 and 2011–2012, the inflation rate in Poland was close to the optimal level, that is, it allowed for sustainable development (as estimated by P. Baranowski (2008, p. 109), the optimal level is 3.5–5% for EU-15). The rapid drop of the HICP indicator between 2013 and 2015 (in 2015, for the first time since 1971, Poland recorded a negative inflation rate of –0.7%) should rather be associated with external factors: a moderate economic situation and a negative demand gap experienced by Poland's main trading partners (a drop in import prices partially limited by the consistently weak zloty) and a decrease in the price of food and fuels (MPC 2015, p. 17).

In the years 2006–2007, because of disciplined budget spending and better than expected economic indicators, it was possible to significantly reduce the budget deficit as a ratio of GDP (Konstanciak 2011, p. 58) – improvements in this area have been recorded since 2003). However, between 2008 and 2010 the deficit grew steadily (reaching a level of –7.3% in 2009–2010), which was the general trend across Europe. In July 2009, the Council of the European Union placed Poland under the excessive deficit procedure, which obliged Poland to reduce the negative balance of public sector finances to 3% of GDP by 2012. In 2010, Poland became one of the European countries with the highest deficit in relative terms (besides the United Kingdom and the PIIGS countries). A major reason for the deterioration of the balance between 2008–2010 was the decline in budget revenue in relation to GDP, which was associated with budgetary policy at the time (the lowering of certain taxes and benefit contributions), the pro-cyclicality of tax revenue in Poland (especially company taxes), and changes in the tax system which allowed companies to reduce their tax base by losses incurred in previous years (Ministry of Finance 2012, pp. 13–15). In 2010, Poland belonged to the group of countries with the highest real and nominal GDP growth in the EU (along with Slovakia, Luxembourg, Germany, Malta, and Sweden), hence the changes in GDP were conducive

to an improvement in the economic performance of the national budget. However, this opportunity could not be capitalised upon, mainly due to the inflexible nature of budget spending (most of which is made up of donations and subsidies) (Lubieniecka 2013, p. 250). According to D. Malinowski (2012, pp. 80–85), the main reason for the increase in the negative balance of public finances in 2010 was the growth in nominal budgetary spending, although what transpires from the Ministry of Finance report (2012, p. 27) is that the growth was mainly due to an increase in spending to finance EU projects. Meanwhile, its impact on the budget deficit was *de facto* neutral, because it was offset by equal amounts of revenue. According to S. Owsiak, the reason for increased spending and therefore the rise in the deficit during the economic crisis, was the need to co-finance EU projects with national public funding[2], which is confirmed in the Ministry of Finance report. The drop in the ratio of the government and local government sector deficit to GDP from 2011 can be attributed to the relative increase in revenue and a drop in budgetary spending. Revenue began to grow as a result of, among others, an increase in the VAT rate (from January 2011), conditions favourable to GDP growth (a big increase in private consumption and public investment, a rise in the proportion of pension contributions to the Social Insurance Fund (FUS) (from May 2011), increases in excise duty, the pro-cyclicality of company income tax, and from 2012 an increase in social security contributions (Ministry of Finance 2012, p. 23 and 29). The drop in spending was mainly the result of fiscal consolidation and the introduction of numerous structural solutions (such as the discipline and stability rule in public finance regulations, salary limits in public entities, a ban on regulations that increased spending, and fiscal rules for local authorities) (Information 2014, p. 9). On 19 June 2015, the ECOFIN Council decided to lift the excessive deficit procedure from Poland, and at the end of 2015 the ratio of public finance to GDP settled at –2.6%.

Despite the steady real growth of GDP and the significant depreciation of the zloty after 2009, in the period under analysis Poland consistently recorded a current account deficit. This was mainly caused by deficits in trade and in the current account (the result of including people not resident in Poland), partially balanced by fund transfers from the EU (Sawicki 2014, p. 101; Kuziemska 2012, p. 210) (the current account deficit itself was

[2] Statement by S. Owsiak in a recording of a panel discussion entitled "The Desired Directions and Scenarios for Fixing Public Finance in Poland", published in *Ekonomiczne i prawne uwarunkowania i bariery redukcji deficytu i długu publicznego* [Economic and legal conditions and barriers for the reduction of the deficit and public debt] (Szołno-Koguc & Pomorska 2011, p. 27).

financed from the surplus in the capital account). The reduction of the deficit which started in 2013 (in 2015 the current account deficit stood at –0.6% of the GDP) was mainly associated with a positive trade balance caused by the economic recovery in Western Europe. According to the catching-up theory, a negative current account balance is typical for countries that are catching-up.

5. Measures of Macroeconomic Stability – Poland against the Backdrop of EU Countries

Based on the values of macroeconomic indicators (GDP, U, CPI, G, CA), partial measurements PSM1 and PSM2 as well as the synthetic measure PSM were established for the EU28 countries, Western Europe (the 10 "old" and most developed EU Member States), Central and Eastern Europe (countries that joined the EU in 2004, 2007 and 2013, except Cyprus and Malta), Southern Europe (PIIGS countries, Malta, and Cyprus), and Poland between 2006 and 2015. In the case of the aforementioned European regions, these were average values calculated using measurements obtained for individual countries. Figure 2 illustrates the changes to the total area of triangles a, b, c, d, e, which form the pentagon of economic stability for Poland and each region in the period under analysis (the lengths of the sides of the regional pentagons were the average length measured for individual Member States) with a CPI value limit of –2.0%, while Figure 3 illustrates the corresponding changes with a CPI value limit of +1.0% (scale with regression). Comparisons of the values of the averaged indicators with the indicators gathered for Poland are illustrated in Figures 4a–6a and 4b–6b, respectively.

Due to the low intensity of deflationary processes in Europe, the conclusions from an analysis based on the modified classic scale and the scale with regression are similar. Based on an analysis of Figures 4a and 4b, it can be established that in the years 2008–2009 (that is, during the last global financial crisis) the MSP indicator in all the examined EU regions decreased (in Poland and in the countries of Southern Europe the downward trend persisted in 2010), whereas the 2010–2011 period is basically the beginning of a rising trend which lasts until the end of the period under analysis (in Western Europe, this trend began in 2013), as well as an increase in the level of macroeconomic stability. In the 2014–2015 period, in all the regions apart from Western Europe, stability exceeded the levels observed before the crisis. West European countries were, however,

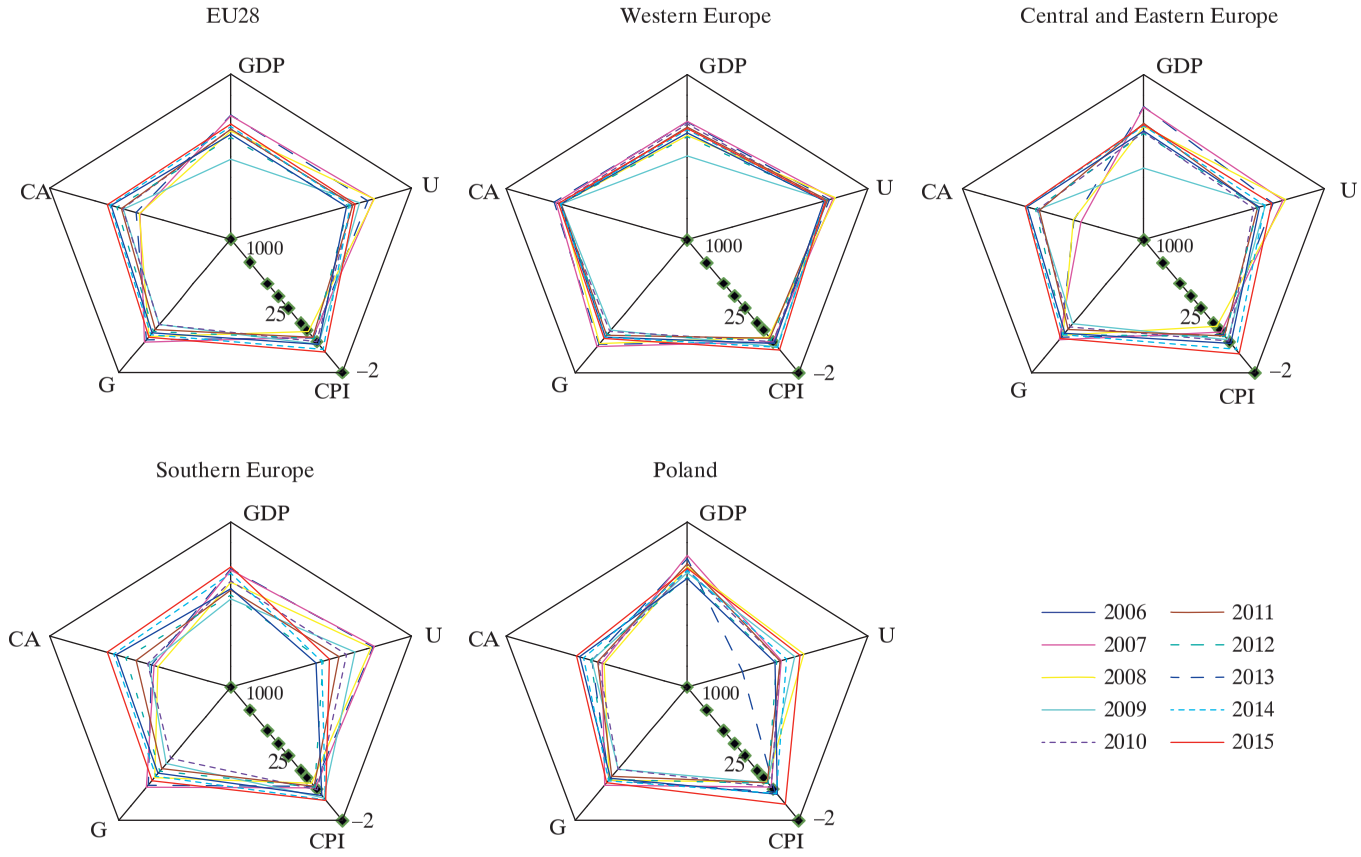

Fig. 2. Macroeconomic Stability Pentagon Divided into European Regions, 2006–2015 – Modified Classic Scale

Source: authors' own calculations based on Eurostat data, http://ec.europa.eu/eurostat (accessed: 11 March 2017).

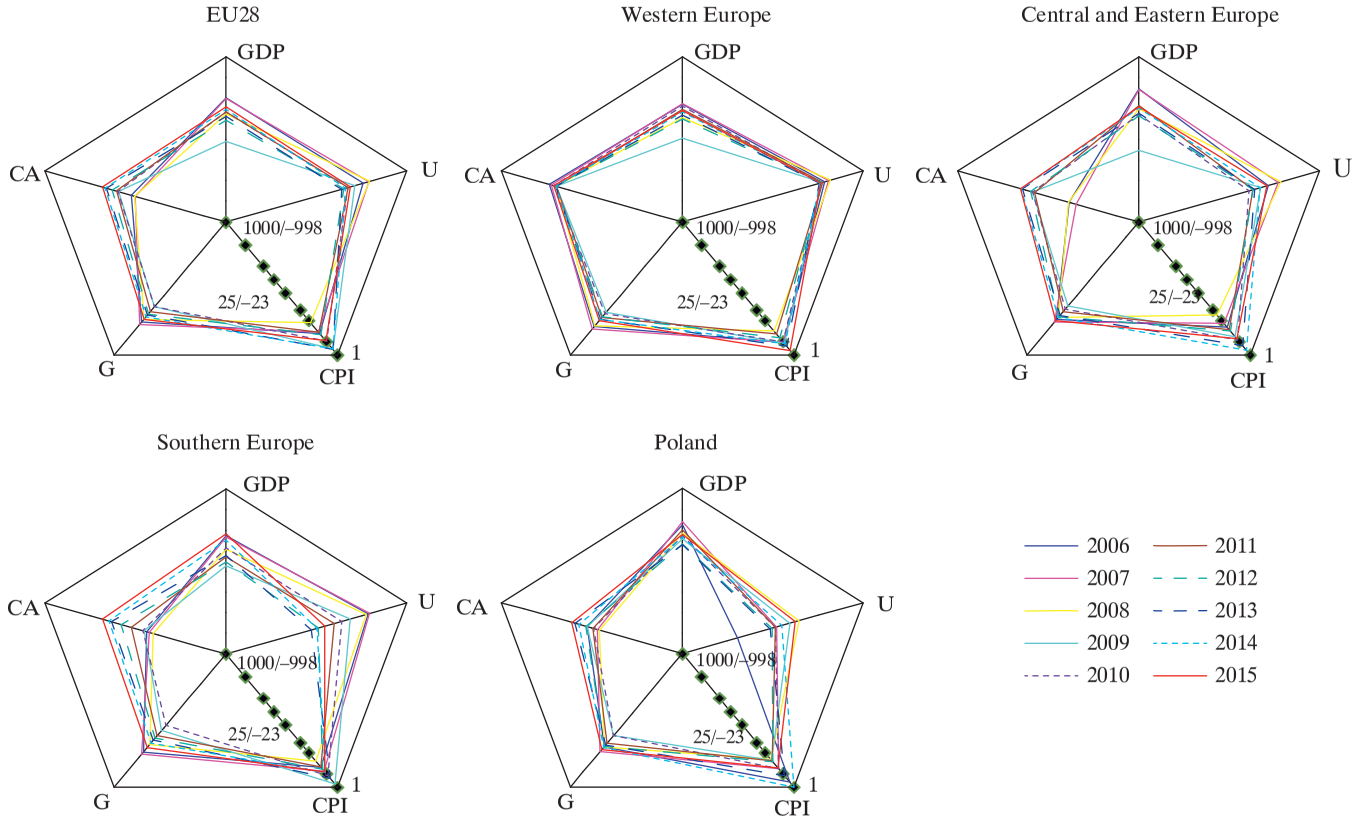

Fig. 3. Macroeconomic Stability Pentagon Divided into European Regions, 2006–2015 – Scale with Regression

Source: authors' own calculations based on Eurostat data, http://ec.europa.eu/eurostat (accessed: 11 March 2017).

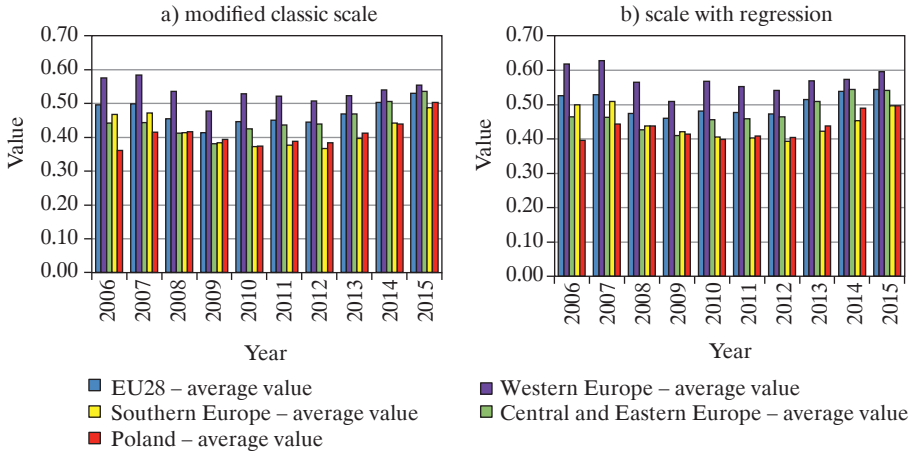

Fig. 4. Synthetic MSP Indicators for Poland and Specified European Regions, 2006–2015

Source: authors' own calculations based on Eurostat data, http://ec.europa.eu/eurostat (accessed: 11 March 2017).

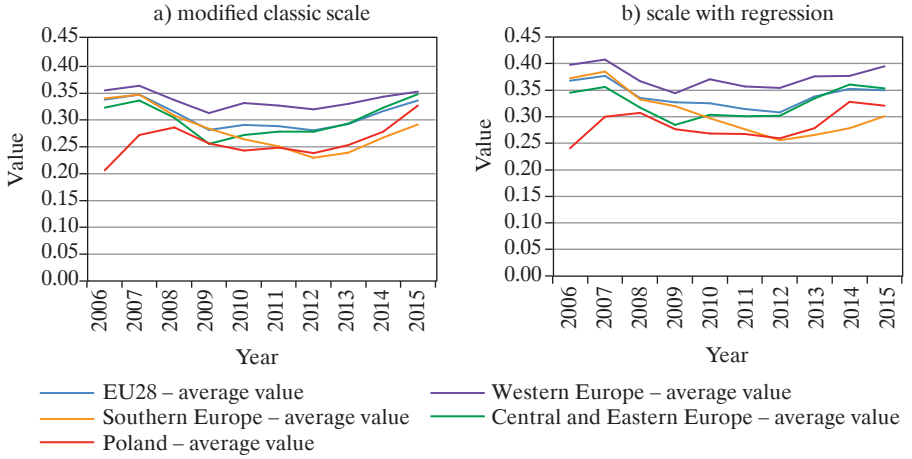

Fig 5. MSP1 Indicator for Poland and Specified European Regions, 2006–2015

Source: authors' own calculations based on Eurostat data, http://ec.europa.eu/eurostat (accessed: 11 March 2017).

the most economically stable over the whole period under analysis (they had the highest values of PSM, PSM1, and PSM2 among all the reviewed groups; cf. Figures 5a and 5b as well as 6a and 6b). After the crisis, Southern

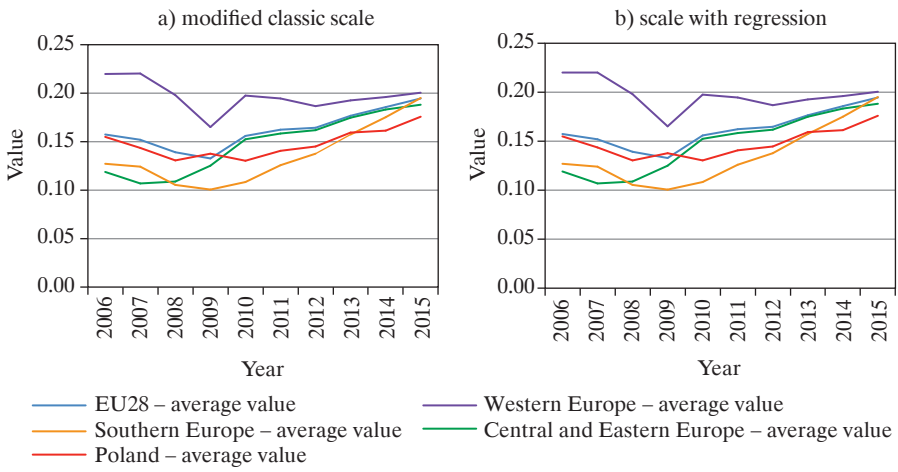

Fig. 6. MSP2 Indicator for Poland and Specified European Regions, 2006–2015

Source: authors' own calculations based on Eurostat data, http://ec.europa.eu/eurostat (accessed: 11 March 2017).

European countries were left with the lowest levels of the MSP indicator. The average level of macroeconomic stability of the Central and East European countries was consistently close to the corresponding average for the EU28, and in the 2014–2015 period it exceeded it slightly. An analysis of Figure 2 and of the length of the sides of the pentagons drawn for the different groups of countries points to the conclusion that the main negative factors influencing the synthetic MSP measurement were:

– for West European countries – the drop in the rate of economic growth during the 2008–2009 period,

– for Central and East European countries – the drop in the rate of economic growth in 2009, the high unemployment rate in the 2010–2013 period, and the deficit in the current account in the 2006–2008 period,

– for Southern European countries – the slow rate of economic growth in the 2008–2012 period, the high unemployment rate in the 2009–2015 period, and the deficit in the current account in the 2006–2011 period.

The shape of the pentagon for the EU28 is a result of the aforementioned trends.

In the case of Poland, despite the clear increase in the MSP indicator during the 2013–2015 period, its value over the whole period was basically below the average values for the EU28, Western Europe, and Central and Eastern Europe (in the case of the latter, the crisis years of 2008–2009

were an exception) and above the average recorded in Southern European countries (with the exception of the 2006–2008 and 2014 periods).

An analysis of the partial indicators MSP1 and MSP2 (Figures 5a and 5b as well as 6a and 6b) allows for more detailed conclusions regarding the potential direction of macroeconomic policy changes in Poland. The MSP1 indicator for Poland over the whole period of analysis was lower than the average calculated for the countries of the EU28, Western Europe, and Central and Eastern Europe, and until and including 2011 – also lower than the average for the countries of Southern Europe. From 2012, the indicator in Poland exceeded the levels observed in Southern Europe. Additionally, using the scale with regression indicates that in the years 2014 and 2015, Poland experienced a noticeable increase and then a drop in the stability of the internal sphere (which is not reflected when using the modified classic scale). Until and including 2009, the MSP2 indicator in Poland was close to the average for the EU28 and higher than the average for Central and East European countries, and until and including 2013 – higher than the average for Southern Europe. In the 2014–2015 period, Poland had the lowest level of the MSP2 indicator among all the country groups under review. Based on the lengths of the sides of the pentagon drawn for Poland, it can be concluded that the factors which positively influenced the state of the internal sphere were the positive rate of economic growth and low inflation. A decidedly negative factor for the value of MSP1 was the high rate of unemployment, which over the entire period under analysis exceeded the EU28 average and partially nullified the positive effects of GDP and CPI. For Poland, the relatively low MSP2 values were due to the strongly negative (until 2012) ratio of the current account balance to GDP, which in the 2009–2011 period coincided with a high ratio of budget deficit to GDP.

6. Conclusions

The analysis presented here allows for the conclusion that in recent years the EU28 countries have returned to the level of macroeconomic equilibrium from before the crisis of 2008–2009. In the majority of the countries, including Poland, this level was even exceeded in the 2014–2015 period. The exception was the West European countries, although this group had the highest MSP values over the whole period under analysis. Although the MSP indicator rose in Poland from 2013 and was higher than the levels observed in Southern European countries, until 2015 it was still lower than the level for the EU28 and also the average levels set for the Central

and East European countries. This state of affairs was mainly caused by the high level of unemployment, which despite a downward trend was consistently above the EU average. Until 2012, the level of macroeconomic stability in Poland was negatively influenced by a relatively high current account deficit, and in the 2009–2011 period – by a high budget deficit (with the consequence that Poland was placed under the excessive deficit procedure). As much as a negative current account balance is characteristic of "catching-up countries" and has recently been significantly reduced, the level of unemployment in Poland is mainly shaped by demand. It is therefore expected that this problem will continue to present a challenge for future economic policy goals.

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Abstract

Stabilność makroekonomiczna w Polsce na tle tendencji unijnych w świetle koncepcji PSM

Celem artykułu jest analiza tendencji w zakresie kształtowania się czynników determinujących poziom stabilizacji makroekonomicznej oraz ocena tego poziomu w Polsce na tle różnych grup krajów Unii Europejskiej (kraje UE28, Europy Zachodniej, Europy Środkowo-Wschodniej oraz Europy Południowej) w latach 2006–2015 z wykorzystaniem metody pięciokąta stabilizacji makroekonomicznej (PSM). Przedmiotem analizy w prezentowanej metodzie są tempo wzrostu gospodarczego (GDP), stopa bezrobocia (U), stopa inflacji (CPI), saldo finansów publicznych (G) oraz saldo bieżących obrotów z zagranicą (CA), których wartości stanowią wierzchołki pięciokąta wyskalowanego w ten sposób, że im bardziej pożądane są wartości wskaźników, tym obrazu-

jące je punkty znajdują się dalej od środka układu. W artykule zaproponowano wyznaczenie łącznego pola PSM na podstawie zmodyfikowanej skali klasycznej oraz skali z regresem (podejścia odpowiednio nieuwzględniające oraz uwzględniające negatywne oddziaływanie zjawisk deflacyjnych na ogólny poziom stabilizacji makroekonomicznej). Przeprowadzone analizy pozwalają sformułować wniosek, że w ostatnich latach kraje EU28 powróciły do poziomu równowagi makroekonomicznej sprzed kryzysu w latach 2008–2009. W Polsce wskaźnik PSM wzrastał od 2013 r. i zasadniczo przekraczał poziomy obserwowane w odniesieniu do krajów Europy Południowej, jednak do 2015 r. jego poziom był wciąż niższy od średniej dla UE28 oraz od średniej wyznaczonej dla krajów Europy Środkowo-Wschodniej. Na taki stan rzeczy wpływała głównie wysoka stopa bezrobocia, która pomimo tendencji spadkowej wciąż utrzymywała się powyżej przeciętnej unijnej.

Słowa kluczowe: polityka gospodarcza, wskaźniki makroekonomiczne, stabilizacja makroekonomiczna, pięciokąt stabilizacji makroekonomicznej (PSM), wskaźnik PSM.

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 33–50
https://doi.org/10.15678/AOC.2018.1802

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FISCAL POLICY EFFECTS IN UKRAINE

Abstract

This paper empirically analyses fiscal policy effects in Ukraine using different identification strategies within the framework of a vector error correction model (VECM). For quarterly data from 2001 to 2016, we find a robust positive impact of both government expenditure and net revenue upon output in Ukraine, which closely corresponds with the predictions of the Mankiw-Summers model in the case of high demand for money in relation to consumption expenditure combined with significant investment elasticity in relation to the interest rate. In other respects, the fiscal policy transmission mechanism exhibits several standard features (such as an increase in government expenditure after a positive shock to revenue or a widening of the budget deficit following an interest rate hike). The results suggest the feasibility of revenue--based fiscal consolidation policies in Ukraine, as better tax collection may contribute to economic growth even in the short run. Since there is a robust conventional inverse relationship between interest rate and output, one of the puzzling results is that government expenditure puts downward pressure on the former, with net revenues being neutral in this respect. Real exchange rate (RER) depreciation is behind the decrease in output in the baseline model, but alternative identification schemes suggest that it is likely to be contractionary in the short run while turning expansionary in the long run.

Keywords: fiscal policy, output, interest rate, real exchange rate, Ukraine.
JEL Classification: C5, E1, E6, H6.

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1. Introduction

Although there is a wide consensus that fiscal consolidation is necessary in order to restore the economic growth in Ukraine, it is not so clear whether expenditure-reducing policies are preferable to revenue-based measures. Both the theoretical arguments and empirical evidence are mixed, with transformation economies not being an exception. In accordance with the policy implications of the standard Keynesian model, expansionary effects of higher government expenditure are found for Croatia (Deskar-Škrbić & Šimović 2015), the Czech Republic (Franta 2012, Klyuev & Snudden 2011), Poland (Haug, Jedrzejowicz & Sznajderska 2013, Laski, Osiatynski & Zieba 2010, Mirdala 2009), Serbia (Hinić & Miletić 2013) and Slovakia (Mirdala 2009, Zeman 2016). Fiscal multipliers of government expenditure in Serbia may reach 0.5–0.6 in times of recession, but they are almost insignificant in periods of expansion (Petrovič & Brĉerevič 2014). The same weak stimulating effect of government expenditure is found for Romania (Boiciuk 2015, Serbanoiu 2012) and Bulgaria (Mirdala 2009, Muir & Weber 2013), providing further support for the general view in the literature that fiscal multipliers are higher during periods of economic recession (Benčik 2014, Karagyozova-Markova, Deyanov & Iliev 2013). No impact of government expenditure on output is found for Slovenia and Serbia (Deskar-Škrbić & Šimović 2015). Using a panel VECM, J. Combes, A. Minea, I. Mustea, and T. Yogo (2016) assert that the expenditure multiplier is positive, but low on average, with its sign, significance and magnitude varying across CEE countries. As obtained for a panel of 10 Central and East European countries by P. Petrović, M. Arsić, and A. Nojković (2014), the government expenditure multiplier is rather high on impact at 0.6 but declines to just 0.2 in the long run (the stimulating effect is much stronger under a fixed exchange rate).

Examples of non-Keynesian effects that imply output growth in the case of government expenditure cuts or higher taxation are not lacking either. For example, G. Tondl (2004) finds negative output effects of government expenditure both in the panel data estimates for 7 CEE countries and in individual country estimates for Hungary, Lithuania, Romania and Poland (to a lesser extent), along with Portugal, Ireland, Greece and Spain (all these euro areas, the so-called PIGS countries, were in the epicentre of future debt problems at the beginning of the 2008–2009 world financial crisis). Only Slovakia demonstrates a positive relationship between government expenditure and growth, with Bulgaria being a neutral case. A. Rzońca and

P. Ciżkowicz (2005) provide evidence that fiscal consolidation in 8 CEE countries contributed substantially to the acceleration of output growth.

The response of output to a government revenue shock is rather negative for the Czech Republic (Franta 2012, Snudden & Klyuev 2011), Slovenia (Jemec, Kastelec & Delakorda 2011) and Slovakia (Zeman 2016). The same outcome is found for Croatia and Slovenia, but the opposite positive effect is observed in Serbia (Deskar-Škrbić & Šimović 2015), Bulgaria, Hungary, and Romania (Mirdala 2009). However, another study for Croatia demonstrates that revenue shock permanently increases industrial production, while in Chile expenditure shock is restrictionary (Ravnik & Žilić 2011). The tax multiplier is close to zero for Poland (Haug, Jedrzejowicz & Sznajderska 2013, Mirdala 2009). In the aforementioned study by G. Tondl (2004), taxation in a broader sense as measured by government revenue is found to be pro-growth for the CEE countries, while the opposite negative effect is obtained for the PIGS countries. However, P. Petrovič, M. Arsić, and A. Nojković (2014) found no effect of net revenues on output for the former, regardless of the exchange rate regime.

R. Mirdala (2009) finds that for the Czech Republic both government expenditure and revenue are expansionary. The same result is obtained for Bulgaria by K. Karagyozova-Markova, G. Deyanov, and V. Iliev (2013), although it is not robust with respect to the choice of estimation method. Calibration of a DSGE for Slovakia demonstrates that a combination of increases in government transfers as well as taxes can stabilise the economy in the short run and improve longer-term growth prospects following a shock with adverse fiscal implications (Múčka & Horváth 2015). Such findings could be interpreted in favour of the Mankiw-Summers model (Mankiw & Summers 1986), which explains a possible symmetry of expenditure and tax effects by modelling the demand for money function in a disaggregated manner, with such components of income as consumption, investments, and government expenditure being included separately. Regardless of a particular modelling setting, the interest rate and income elasticities of money demand are considered to be important factors behind fiscal policy effects, besides such structural features as the existence of nominal rigidities in the economy, the elasticity of labour supply, the interest rate elasticity of investment, the degree of openness of the economy, the exchange-rate regime or the magnitude of wealth effects (De Castro & de Cos 2008). The Mankiw--Summers model provides a middle ground in the discussion on the architecture of fiscal consolidation programmes. While standard Keynesian models imply contractionary effects of higher taxes and government

expenditure cuts, the models of so-called non-Keynesian effects provide positive output responses to both types of fiscal consolidation measures.

Although it is common in empirical studies to prefer government expenditure cuts over revenue-based consolidations (Alesina & Ardagna 2010, Alesina, Favero & Giavazzi 2015), including the experience of fiscal consolidations in the CEE countries for the 1991–2003 period (Afonso, Nickel & Rother 2006), there is evidence is that higher taxes could stimulate private consumption (Giavazzi *et al.* 2005). Even though it is customary to consider tax multipliers for the CEE countries to be small and short--lived, as implied by contradictory results from VAR models with different identification techniques (Karagyozova-Markova, Deyanov & Iliev 2013), it is not confirmed that a positive revenue shock could be expansionary.

This paper analyses fiscal policy effects in Ukraine using a range of VECMs. More specifically, the aim of this paper is to test the predictions of the Mankiw-Summers model of symmetrical government expenditure and net revenue effects on output.

Similar to other studies, for example Karagyozova-Markova, Deyanov & Iliev (2013) or Franta (2012), the results of a standard VECM with a recursive identification scheme are used as a benchmark for alternative modelling specifications. Section 2 reviews an open economy extension of the Mankiw-Summers model. Data and statistical methodology are presented in Section 3. Estimates of the baseline VECM and its extensions are interpreted in Sections 4 and 5. The paper concludes by offering policy recommendations.

2. Theoretical Framework

Conventional econometric models relate the demand for money to the level of GDP, serving as the scale variable determining the transactions demand for money balances. Referring to portfolio and transaction models of money demand as justification for a disaggregated money equation within the familiar IS-LM framework, G. Mankiw and L. H. Summers (1986) demonstrate that tax cuts can constrain aggregate demand, holding that money supply is constant. In the open economy version, the model is presented as follows[1]:

[1] A. Rzońca (2007) uses a similar open economy extension of the Mankiw-Summers to interpret restrictive fiscal policies.

$$Y = C(Y - T, r) + I(Y, r) + G + CA(E, Y, Y^*), \tag{1}$$

$$C_Y,\ I_Y > 0,\ C_Y,\ I_Y > 0,\ CA_E, CA_{Y^*} > 0,\ CA_Y < 0,$$

$$M/P = L(C, I, G, r),\quad L_C > L_I > L_G > 0,\ L_r < 0, \tag{2}$$

$$CA(E, Y, Y^*) + k(r - r^*) = 0, \tag{3}$$

where Y and Y^* are domestic and foreign output, C is consumption, I is investment, r and $r^*$are the domestic and foreign interest rate, G and T are government expenditure and government lump-sum taxes, respectively, CA is the current account, M is the money supply, P is the price level, E is a nominal exchange rate.

Equation (1) relates aggregate demand to private consumption, investments, government expenditure, and price and income effects in foreign trade. Both consumption and investments are proportional to income and inversely related to the interest rate. A similar contractionary channel is provided by the relationship between income and imports. Aggregate demand is stimulated by lower taxes, exchange rate depreciation and higher income abroad. In Equation (2), the money supply in real terms is equilibrated with the demand for money, which is an increasing function of disaggregated income and a lower interest rate. For simplicity, there is no difference between nominal and real interest rates in specifications for the goods and money markets. Equation (3) defines the balance-of--payments (BOP) equilibrium. The current account balance is equilibrated with the net capital inflows. It is assumed that capital flows are dependent on the interest rate differential. For the case of capital immobility ($k = 0$), the BOP equilibrium is achieved solely through relative price adjustment. Under inefficiency of the relative price mechanism, a decline in income is necessary to decrease demand for imports.

A comparative static analysis yields fiscal policy multipliers as follows:

a) floating exchange rate regime:

$$\frac{dY}{dG} = \frac{CA_q\left[(L_G - L_I)I_r + (L_G - L_C)C_r - L_r + kL_G\right]}{\Omega}, \tag{4}$$

$$\frac{dY}{dT} = -\frac{CA_q C_Y\left[(L_C - L_I)I_r - L_r + kL_C\right]}{\Omega}; \tag{5}$$

b) fixed exchange rate regime:

$$\frac{dY}{dG} = \frac{k}{k(1 - C_Y - I_Y) + CA_Y(C_r + I_r)}, \tag{6}$$

$$\frac{dY}{dT} = -\frac{kC_Y}{k(1-C_Y-I_Y)+CA_Y(C_r+I_r)}, \tag{7}$$

where:

$$\Omega = -CA_q\left[(1-C_Y-I_Y)(L_r+L_C C_r+L_I I_r)+(C_r+I_r)(L_C C_Y+L_I I_Y)\right]- \\ -CA_q\left[k(L_C C_Y+L_I I_Y)-CA_Y(L_I I_r+L_C C_r+L_r)\right].$$

Regardless of capital mobility, the determinant Ω is unambiguously negative under standard assumptions that $C_Y, I_Y > 0, C_r, I_r < 0, L_r < 0$, and $C_Y + I_Y < 1$.

For a closed economy ($k = 0$), the multipliers reduce to those obtained by Mankiw and Summers (1986). A fiscal multiplier for government expenditure is positive if $L_G < (I_r L_I + C_r L_C + I_r)/(I_r + C_r + k)$, as long as government spending generates less money demand than a weighted average of consumption and investments and capital mobility is rather low. As for the tax multiplier, higher taxes positively contribute to income only on condition that the consumption-based demand for money is stronger compared to the investment-based demand for money, i.e. $L_C > L_I$, and if the money demand is interest-inelastic relative to the high interest rate sensitivity of investments. However, a stimulating effect becomes not sensitive to structural features in the case of perfect capital mobility ($k = \infty$), as the tax multiplier becomes unambiguously positive: $dY/dT = L_C C_Y/(L_C C_Y + L_I I_Y)$.

A graphical interpretation of government expenditure and revenue effects is presented in Figures 1 and 2, respectively. For a floating exchange rate regime, an increase in government expenditure is followed by higher demand for both goods and services ($IS_0 \rightarrow IS_1$) and money ($LM_0 \rightarrow LM_1$). As there is a BOP deficit at the new internal equilibrium (p. B), the nominal exchange rate depreciates. In turn, it brings about a further expansion of aggregate demand ($IS_0 \rightarrow IS_1$) and an improvement in the external position ($BP_0 \rightarrow BP_1$). The expansionary effect on output is combined with an increase in the interest rate. Under a fixed exchange rate system, the BOP adjustment requires a decrease in the money supply ($LM_1 \rightarrow LM_2$), which reinforces the initial money demand shock ($LM_0 \rightarrow LM_1$). In the new equilibrium (p. C), there is still an increase in income, but it is smaller in comparison to a floating exchange rate case.

As is apparent from Figure 2a, an increase in taxes is followed by a decrease in demand on the goods and services market ($IS_0 \rightarrow IS_1$) and a lower demand for money ($LM_0 \rightarrow LM_1$). If condition $L_G < (I_r L_I + C_r L_C + I_r)/(I_r + C_r + k)$ holds, there is a BOP deficit (p. B)

and an exchange rate is set to depreciate in order to restore the external equilibrium. Consequently, a weaker currency brings about a recovery in demand for goods and services ($IS_1 \rightarrow IS_2$) and an improvement in the BOP ($BP_0 \rightarrow BP_1$).

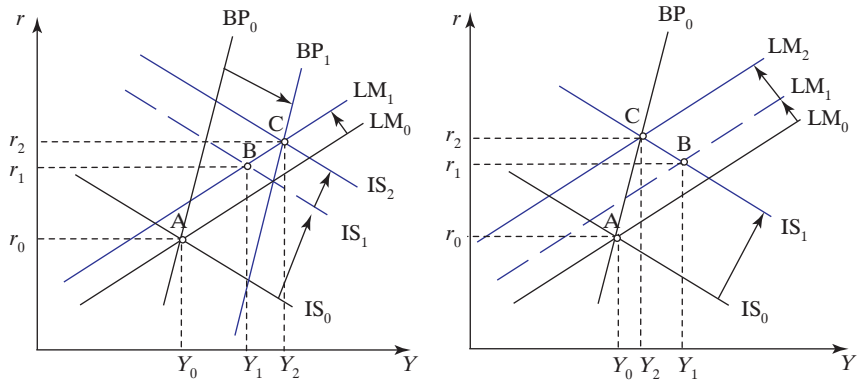

Fig. 1. Effects of Higher Government Expenditure under Low Capital Mobility

Source: authors' own elaboration.

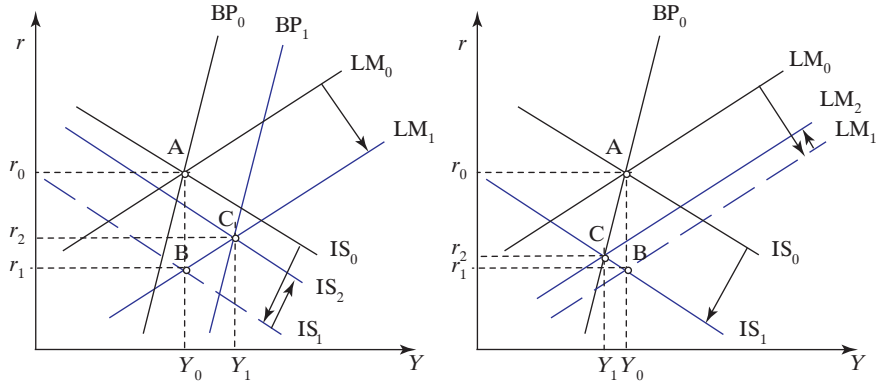

Fig. 2. Effects of Higher Taxes (Low Capital Mobility)

Source: authors' own elaboration.

Assuming exchange rate stability (Figure 2b), a stronger decrease in the demand for money ($LM_0 \rightarrow LM_1$) combined with a somewhat weaker fall in demand for goods and services ($IS_0 \rightarrow IS_1$), implies a worsening of the BOP

position (p. B). Similar to the case of government expenditure (Figure 1b), there is a loss of international reserves leading to a decrease in the money supply ($LM_1 \rightarrow LM_2$) and necessary macroeconomic adjustment (p. C), but this time the macroeconomic equilibrium is achieved both at a lower income and interest rate.

As for the stability of money demand as an important assumption behind the viability of the Mankiw-Summers model, evidence for the stability of long-run demand functions for the M1 money aggregate is obtained for the US, Japan, Canada, UK and West Germany (Hoffman, Rasche & Tieslau 1995), as well as for seven East European countries (Bahmani & Kutan 2010) and four South Asian countries (Narayan, Narayan & Mishra 2009).

3. Data and Statistical Methodology

The data are quarterly observations from 2001Q1 to 2016Q2 taken from Ukraine's Ministry of Finance, which has published quarterly cash figures since 2000, and the IMF *International Financial Statistics* online database. Seasonally adjusted cash figures (in per cent of GDP) for current government expenditure on goods and services and net revenue, G_t and REV_t respectively, are plotted in Figure 1. Government expenditure has increased unevenly over the sample period, with local peaks in 2006, 2009, 2010, and 2013. Net revenue exceeded expenditure over the 2001–2007 period, but the budget balance later deteriorated significantly in the wake of the world financial crisis of 2008–2009. Fiscal consolidation efforts took place in 2011, but the budget deficit widened in the aftermath. Another financial crisis in 2014 brought about a steep decline in the level of both government expenditure and revenue, but the former recovered by the end of 2015 while the latter declined. GDP (Y_t) steadily increased between 2001 and 2008, but the financial crises of 2008–2009 and 2014–2015 brought it down to the 2004 level, despite a steep depreciation of the real effective exchange rate (RER_t).

Table 1. Johansen Co-integration Test

Data Trend	None (I)	None (II)	Linear (III)	Linear (IV)	Quadratic (V)
Trace	57.87 (0)	93.1** (1)	85.6** (1)	99.7** (1)	89.6* (1)
Max-Eng	27.89 (0)	48.1** (1)	47.58** (1)	49.0** (1)	44.79** (1)

Note: we use test types I (no intercept, no trend), II (intercept, no trend), III (intercept, no trend), IV (intercept, trend), V (intercept, trend); *, ** denote rejection of the null hypothesis at the 10% and 5% level, respectively; the number of co-integration vectors is in brackets.

Source: authors' own calculations.

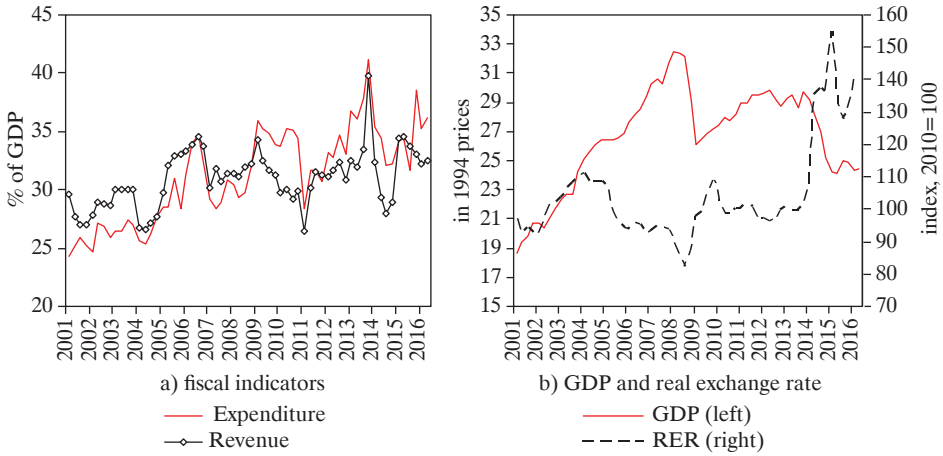

Fig. 3. Ukraine: Selected Macroeconomic Indicators, 2001–2016

Source: Ukraine's Ministry of Finance, IMF *International Financial Statistics*.

As revealed by the augmented Dickey-Fuller (ADF) test (results are available on request), for all the series, the null of unit root cannot be rejected at 1% and 5% statistical significance for their levels, while this is the case for the first differences. As endogenous variables are found to be integrated of order 1, i.e. $I(1)$, it is necessary to investigate the cointegration relationship between them. The results of the Johansen cointegration test are summarised in Table 1. Both the trace test and the maximum eigenvalue test suggest the cointegration rank $r = 1$ with a 5% confidence level.

Since there is a cointegration of endogenous variables, a VAR system with error correction (VECM) should be used. If endogenous variables are $I(1)$ and they are cointegrated with rank r $(0 < r < n)$, then the VECM representation is as follows:

$$A(L)\Delta z_t = -\alpha\beta z_{t-1} + \delta D_t + u_t, \tag{8}$$

where $z_t = (REV_t, G_t, R_t, RER_t, Y_t)$ is the vector of endogenous variables, with R_t standing for the lending rate, $A(L)$ is a matrix polynomial in the lag operator L, D_t is the vector of deterministic variables, u_t is a $k \times 1$ vector of reduced-form disturbances which are assumed to be normally distributed white noise $E[u_t] = 0$ with a constant covariance matrix $E[u_t u_t'] = \Sigma_u$ and $E[u_t u_s'] = 0$ for $s \neq t$, Δ is the operator of the first differences.

The ordering of the variables in the Cholesky decomposition implies that: (a) net revenue does not react contemporaneously (in the same quarter) to exogenous shocks in the other variables, (b) government expenditure reacts contemporaneously only to shocks in net revenues, (c) shocks to fiscal variables determine the level of the interest rate, (d) fiscal variables and the interest rate are behind the changes in the RER, (e) output is affected in the current period by shocks in all other endogenous variables. Contrasted with a standard identification scheme suggesting causality running from output to revenues, our ordering implies that net revenue is influenced in the contemporaneous period by administrative actions and is thus independent of real sector activities, which seems to be an adequate approximation of the Ukrainian reality. In addition to the lagged values of the endogenous variables, the VECM includes the level of external public debt (bn USD), world metal and crude oil prices (index, 2010 = 100), and the crisis dummy (1 for 2008Q3–2009Q4, 2013Q4–2016Q2 and 0 otherwise).

The number of lags is set to two according to LR, FPE, AIC and HD tests. We use a constant and a linear trend in the VECM model, as it brings about better statistical properties of the residuals according to the normality, serial correlation and homoskedasticity tests.

4. Estimation Results

Estimates of the long-run cointegration relationships are as follows (the absolute values of standard deviations of parameter estimates are given in the brackets):

$$\underset{}{REV_t} = \underset{(0.69)}{-4.188G_t} \; \underset{(0.53)}{+2.299R_t} \; \underset{(0.92)}{+0.183RER_t} \; \underset{(0.17)}{+7.732Y_t}. \tag{9}$$

The cointegration relationship (9) implies that net revenue decreases in line with higher government expenditures. A direct relationship between the interest rate and REV_t could reflect stronger tax-collection efforts in the high interest rate environment as it is likely that when facing difficulties in financing debt liabilities government authorities reinforce their tax activities. Depreciation of the RER is not a strong factor behind higher net revenue, as the statistical significance of the coefficient on RER is rather low. The long--run estimates are in favour of a strong link between GDP and net revenue.

Figure 4 presents the impulse-response functions for endogenous shocks. The horizontal axis indicates quarters after a shock. Table 2 reports the portion of the forecast error variance decomposition (FEVD) for endogenous variables.

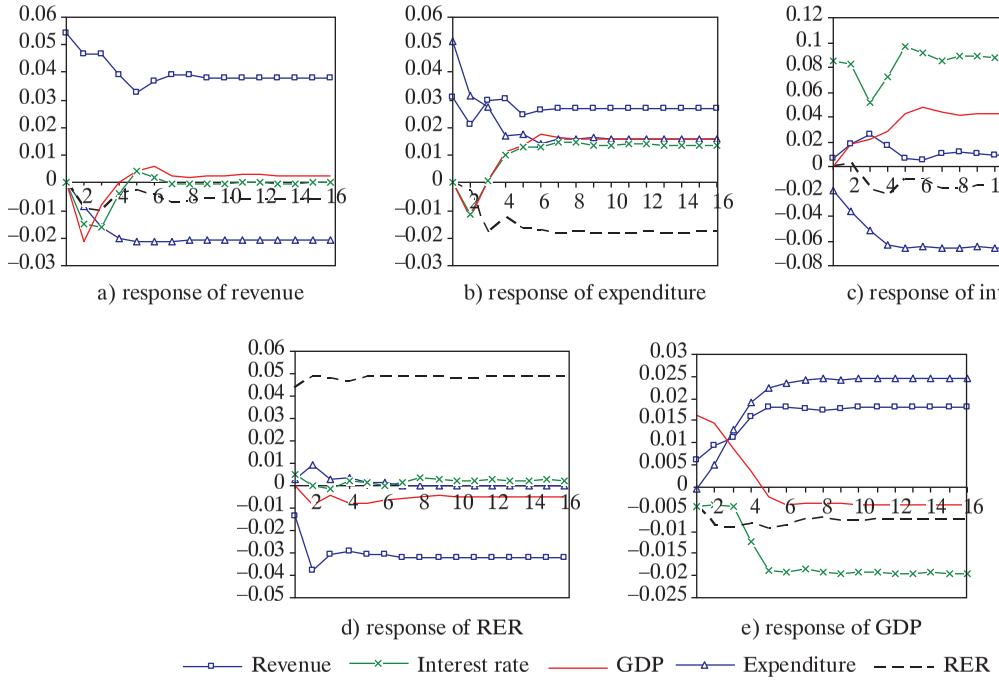

Fig. 4. Impulse Response Functions of Endogenous Variables

Source: authors' own calculations.

Table 2. Forecast Error Variance Decomposition

Responses of	Innovations in	Forecast horizons			
		4	8	12	16
REV	*REV*	82	78	77	77
	G	7	14	16	18
	R	4	3	2	2
	RER	2	2	2	2
	Y	5	3	2	2
G	*REV*	35	37	39	39
	G	53	35	30	26
	R	3	6	8	8
	RER	6	11	13	17
	Y	3	8	10	11
R	*REV*	4	2	1	1
	G	25	28	28	29
	R	64	59	57	56
	RER	3	2	2	2
	Y	5	10	11	12
RER	*REV*	27	28	29	29
	G	1	0	0	0
	R	0	0	0	0
	RER	70	70	69	69
	Y	1	1	1	1
Y	*REV*	24	24	24	24
	G	27	38	41	42
	R	10	22	25	26
	RER	12	7	6	5
	Y	27	8	5	4

Source: authors' own calculations.

Our main result is that both government expenditure and revenue shocks have positive symmetrical and fairly persistent effects on output. Impulse responses are consistent with the predictions of the Mankiw-Summers model. Together, fiscal shocks explain more than 50% of the variation in output. Among other fiscal policy effects, an increase in net revenue contributes to higher government expenditure, which is a standard result in fiscal policy empirical studies (Franta 2012). Following an increase in

net revenue, there is RER appreciation, without any significant impact on the interest rate. A positive government expenditure shock brings about a reduction in net revenue and a decrease in the interest rate (a shock to G_t accounts for 25% to 28% of the variation in R_t), both being not conventional outcomes. For example, a positive response of net revenues and (to a lesser extent) the interest rate to government expenditure is found for the Czech Republic (Franta 2012). A puzzling inverse relationship between government expenditure and the interest rate could result from (1) foreign debt financing or (2) domestic monetary policy accommodation. Shocks to REV_t explain up to 40% of the changes in government expenditure, while the reverse causality is half as strong. The fraction of REV_t in the decomposition of RER_t is as high as 29%, while G_t is more influential with respect to changes in the interest rate.

Government expenditure is likely to be pro-cyclical in the long-run as higher output is associated with an increase in government expenditure on goods and services, but the importance of this link should not be overstated as the fraction of Y_t in the variance decomposition of G_t is below 10%. The response of the revenue to output shock is negative but small and short--lived. Following RER depreciation, government expenditure is likely to decrease (the fraction of RER_t in the variance decomposition of G_t gradually increases from 6% to 17% within the sixteen-period horizon analysed), while net revenue seems to be neutral with respect to changes in the RER. Ukraine's pro-cyclical fiscal response to domestic economic activity is similar to that of Macedonia, while it is counter-cyclical in Bulgaria and Croatia (Petrevski, Bogoev & Tevdovski 2016).

An increase in the interest rate has no significant effect on net revenue, while the effects on government expenditure turn positive after three quarters (a shock to R_t explains less than 10% of changes in G_t). As suggested by the impulse response and the variance decomposition, shocks to the interest rate have negligible effects on the RER. However, there is a strong negative impact of interest rate hikes on output. On the other hand, the output shock is a factor behind the increase in the interest rate, with the fraction of Y_t in the variance decomposition of R_t gradually increasing up to 12%. Somewhat surprisingly, the interest rate does not react to the RER shock, as the latter explains a marginal fraction of the changes in the former.

Besides a worsening of fiscal indicators, a depreciation of the RER has contractionary effect on output, which is consistent with a recent study on Ukraine's economy (Shevchuk 2016). In the presence of fiscal shocks, the RER does not react to changes in both output and the interest rate.

5. Robustness Check

In addition to the baseline model (VECM-I), we estimate two modified VECMs with the same identification scheme of government expenditure and revenue ordered before output (GDP). In the first one (VECM-II), the real exchange rate is replaced with the terms-of-trade variable calculated as the ratio of world metal prices to crude oil prices. In the second one (VECM--III), we replace the interest rate with the money aggregate M2. Next, we use a different identification scheme as follows: $G \Rightarrow R \Rightarrow RER \Rightarrow Y \Rightarrow REV$ (VECM-IV). This is the most popular identification approach in empirical studies, implying a contemporaneous period causality running from output to revenues. Finally, two small-scale models are estimated with the ordering $R \Rightarrow G \Rightarrow Y$ (VECM-V) and $G \Rightarrow Y \Rightarrow REV$ (VECM-VI), respectively. Figure 5 presents the impulse responses implied by all six identification schemes, including that of the baseline VECM-I.

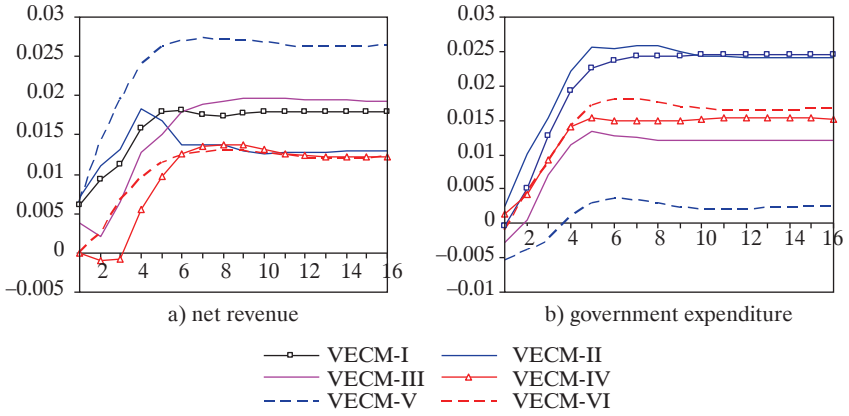

Fig. 5. Alternative Impulse Response Functions of Fiscal Policy Output Effects

Source: authors' own calculations.

Generally, the impulse responses of alternative VECMs are not considerably different from the responses of the baseline VECM-I. The only exception is a three-variable VECM-V, which implies a neutrality of output with respect to government expenditure. On the other hand, this kind of specification seems to overstate the positive impact of government revenues on output. Identification with revenue and expenditure preceding GDP seems to imply stronger fiscal policy effects on output. Using world metal and crude oil prices instead of the RER, or money aggregate M2 instead

of the interest rate, does not substantially change the impulse responses for both fiscal variables.

Alternative identification schemes do not alter (several) other results. First, it is confirmed that there is a negative link between the interest rate and GDP. Second, government expenditure increases after higher revenues, which is quite a standard outcome in empirical studies. Third, revenues decrease in the wake of a positive government expenditure shock but this effect becomes weaker in a three-variable model, regardless of recursive sequencing of fiscal shocks in the contemporaneous period. Fourth, an immediate reaction of net revenues to an output shock is confirmed in VECMs with TOT and money supply variables, but this effect is weaker in an alternative specification with output preceding net revenues (VECM-IV) and a three-variable VECM-V and VECM-VI, with a more articulated positive long-term link between GDP and net revenues as well.

As there is a robust inverse relationship between the interest rate and output, it is confirmed that government expenditure put downward pressure on the former, with net revenue being neutral in this respect. Similar to the baseline model, depreciation of the RER is likely to induce losses in net revenue (to a lesser extent) and cuts in government expenditure, but the latter effect is lost in an identification scheme with output preceding net revenue. However, there are important differences regarding the RER effects on output. Depreciation of the RER becomes a factor behind higher GDP in the specification with money supply (VECM-III) and under an identification scheme with net revenue influenced by output in a contemporaneous period (VECM-IV). The fraction of the RER in the variance decomposition of output increases gradually up to 15% in the long run. There is no change in the pattern of response of the interest rate to an RER shock. Also, it is confirmed that the RER is affected neither by output nor by the interest rate.

6. Conclusion

The main results of the study can be summarised as follows. First, there is a robust positive impact of both government expenditure and revenue on output in Ukraine. The response of GDP to shocks to both fiscal variables is positive and, in most specifications, statistically significant. Such symmetry of fiscal policy effects is in accordance with the prediction of the Mankiw--Summers model for a low capital mobility case under (i) high consumption--based demand for money in comparison with investment-based demand for

money combined with (ii) a significant inverse link between investments and the interest rate. Second, there is an increase in government expenditure after a positive shock to government revenue, with the budget deficit widening after an interest rate hike. Third, RER depreciation brings about a symmetrical decrease in either net revenue or government expenditure, but the latter effect is lost in the identification scheme with output preceding net revenue. Fourth, there is a strong inverse relationship between the interest rate and output across all identification schemes.

Most of our results are robust to various sensitivity checks. Some sort of uncertainty relates to RER effects on output. RER depreciation is behind the decrease in output in the baseline model (VECM-I) but other identification schemes suggest that it is likely to be contractionary in the short run while turning expansionary in the long run.

Contrary to recommendations by Alesina and Ardagna (2010) that spending cuts are more appropriate for stabilising the sovereign debt than tax increases, our results suggest the feasibility of revenue-based fiscal consolidation in Ukraine, as better tax collection as the main source of government revenue may contribute to economic growth even in the short run. At the same time, Ukraine would be better off if the government increased investments in infrastructure, health and education.

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Abstract

Efekty makroekonomiczne polityki fiskalnej na Ukrainie

W opracowaniu przeanalizowano empirycznie efekty polityki fiskalnej w gospodarce Ukrainy z wykorzystaniem modelu autoregresji wektorowej z korektą błędu (VECM). Na podstawie analizy danych kwartalnych z lat 2001–2016 stwierdzono pozytywny wpływ wydatków rządowych i dochodów do budżetu na poziom dochodu na Ukrainie, co odpowiada przewidywaniom modelu Mankiwa-Summersa dla wypadku wysokiego popytu na pieniądz względem wydatków konsumpcyjnych w połączeniu ze znaczącą elastycznością inwestycji względem stopy procentowej. W innych aspektach mechanizm transmisyjny polityki fiskalnej demonstruje pewne typowe cechy, jak zwiększenie wydatków rządowych po wzroście przychodów do budżetu albo zwiększenie deficytu budżetowego wskutek wzrostu stopy procentowej.

Otrzymane rezultaty świadczą o przewadze konsolidacji fiskalnej opartej na zwiększeniu przychodów do budżetu na Ukrainie, gdyż lepsza ściągalność podatków stymuluje wzrost gospodarczy nawet w krótkim okresie. Z uwagi na to, że występuje standardowa odwrotna relacja między stopą procentową a dochodem, większe wydatki rządowe powodują obniżenie stopy procentowej, jak też wskaźnik nie reaguje na przychody do budżetu. Deprecjacja kursu walutowego w ujęciu realnym powoduje zmniejszenie dochodu w modelu podstawowym, ale alternatywne schematy identyfikacji sugerują występowanie efektu restrykcyjnego tylko w krótkim okresie, na dłuższą metę efekt jest ekspansywny.

Słowa kluczowe: polityka fiskalna, dochód, stopa procentowa, realny kurs walutowy, Ukraina.

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 51–67
https://doi.org/10.15678/AOC.2018.1803

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PROPERTIES OF SELECTED INEQUALITY MEASURES BASED ON QUANTILES AND THEIR APPLICATION TO THE ANALYSIS OF INCOME DISTRIBUTION IN POLAND BY MACROREGION

Abstract

Quantiles of income distributions are often applied to the estimation of various inequality, poverty and wealth characteristics. They are traditionally estimated using the classical quantile estimator based on a relevant order statistic. The main objective of the paper is to compare the classical, Huang-Brill and Bernstein estimators for these measures from the point of view of their statistical properties. Several Monte Carlo experiments were conducted to assess biases and mean squared errors of income distribution characteristics for different sample sizes under the lognormal or Dagum type-I models. The results of these experiments are used to estimate inequality, poverty and wealth measures in Poland by macroregion on the basis of micro data originating from the Household Budget Survey 2014.

Keywords: income distribution, inequality, poverty, wealth, quantile estimator.
JEL Classification: C13, C15.

1. Introduction

Statistical measures based on quantiles are frequently applied to the analysis of income distribution as they comprise many popular inequality

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and poverty indices and indicators. Simple dispersion ratios, defined as the ratios of the income of the richest quantile over that of the poorest quantile, usually utilise deciles and quintiles, but in principle, any quantile of income distribution can be used. A version of the decile dispersion ratio using the ratio of the 10th over the 40th percentile which has recently become popular is the so-called Palma ratio. Another popular inequality measure based on deciles is the coefficient of maximum equalisation, also known as the Schutz index or the Pietra ratio. Contrary to the well-known Gini ratio, the quantile-based dispersion ratios are focused on income differences located in the tails of the distribution rather than in the middle groups. They can be used in a supplementary way to overcome the shortcoming of the Gini index, namely, that it is proportionally oversensitive to changes in the middle of the distribution. More sophisticated measures of income inequality have been constructed using differences (or ratios) between population and income quantiles. Probably the first such measure was the Holme's coefficient standardised by Bortkiewicz, which is based on the quantiles of order 0.5. The concentration curve and corresponding synthetic concentration coefficient proposed by Zenga are also defined in terms of quantiles of a size distribution and the corresponding quantiles of the first--moment distribution.

Quantile-based inequality measures are traditionally estimated using the classical quantile estimator based on a relevant order statistic. In many applications these estimates are presented without any information about their precision, which must be a basis for further statistical inference, e.g. statistical hypothesis testing and interval estimation. The problem can be neglected to some extent if we consider the overall population or sample size large enough to apply the asymptotic theory; one should be conscious however, that for heavy-tailed income distributions the sufficient sample size can be very large indeed. For some population divisions (by age, occupation, family type or geographical area) these simple methods have been shown to be seriously biased, and the estimation errors were found to be far beyond the values that can be accepted by social policy-makers for making reliable policy decisions (Jędrzejczak 2015).

This paper addresses the problem of statistical properties of the estimators of popular inequality measures based on quantiles. After a brief description of such measures (section 2), selected quantile estimators are introduced (section 3). Section 4 comprises the results of Monte Carlo experiments conducted to assess biases and mean squared errors of quantile estimators and their functions. In the last part of the paper (section 5)

we present the application of quantile-based inequality, poverty and wealth indices to Polish Household Budget Survey (HBS) data divided by macroregions.

2. Selected Statistical Inequality Measures Based on Quantiles

Distribution quantiles of a random variable X, which is identified with a household or personal income, or the estimators of these quantiles, have been applied in the construction of simple inequality indices such as the quintile dispersion ratio and decile dispersion ratio (for details, see Panek 2011).

The quintile dispersion ratio has the following form:

$$W_{20:20}^{(1)} = \frac{Q_{0.8}}{Q_{0.2}}, \tag{1}$$

where $Q_{0.8}, Q_{0.2}$ are quintiles, respectively, the fourth and the first.

The quintile dispersion ratio can also be defined as the ratio of the sum of incomes of the richest 20% of the population to the sum of incomes of the poorest 20%:

$$W_{20:20}^{(2)} = \frac{\sum_{i \in GK_5} x_i}{\sum_{i \in GK_1} x_i}, \tag{2}$$

where GK_j is j-th quintile group.

The measure (2) can be interpreted as the ratio of the average income of the richest 20% of the population to the average income of the poorest 20% of the population and is usually calculated on the basis of equivalised income.

Similar ratios can also be calculated for other quantiles, for instance deciles or percentiles (95th and 5th) of income distributions. Using the first and ninth decile we can obtain the following decile dispersion ratio:

$$W_{10:10}^{(1)} = \frac{Q_{0.9}}{Q_{0.1}}, \tag{3}$$

where $Q_{0.9}, Q_{0.1}$ are deciles, respectively, the ninth and the first:
and

$$W_{10:10}^{(2)} = \frac{\sum_{i \in GD_{10}} x_i}{\sum_{i \in GD_{10}} x_i}, \tag{4}$$

where GD_j is j-th decile group.

The reciprocal of the decile dispersion ratio defined by (4) takes values from the interval (0,1) and is called the dispersion index for the end portions of the distribution:

$$K_{1:10} = \frac{\sum_{i \in GD_1} x_i}{\sum_{i \in GD_{10}} x_i} = \frac{1}{W_{10:10}}. \tag{5}$$

If the index $K_{1:10}$ is closer to 1, the inequality is lower (mean incomes in the extremal decile groups are the same).

A popular inequality measure based on income shares received by subsequent decile groups is the coefficient of maximum equalisation, also known as the Schutz index or the Pietra ratio:

$$E = \sum_{j \in I} 100\left(S_j - \frac{1}{10}\right), \tag{6}$$

for $S_j > 0.1$ and $S_j = \frac{\sum_{i \in GD_j} x_i}{\sum_{i=1}^{n} x_i}$, where S_j is income share of the j-th decile group in the total income.

The measure (6) can be interpreted as the portion of the total income that would have to be redistributed (taken from the richer half of the population and given to the poorer half) for there to be income equality.

During a thorough income distribution analysis the problem of inequality measurement is usually interrelated with the estimation of poverty indices. To obtain reliable poverty characteristics it becomes crucial to define and estimate the poverty threshold z_u. There are numerous definitions of this threshold, taking into consideration an absolute or relative approach. The relative poverty line utilised by Eurostat is $z_u = 0.6M_{0.5}$, where $M_{0.5}$ is the median of a random variable X.

On the basis of the poverty line, the popular head-count ratio (at-risk-of--poverty rate) can be determined: $W_{zg.ub.} = F(z_u)$, where F is the distribution function of X.

The poverty threshold and head-count ratio can be estimated using the following estimators:

$$\hat{z}_u = 0.6Me \tag{7}$$

and

$$\hat{W}_{zg.ub.} = \frac{\#\{X_i \le 0.6Me\}}{n}, \tag{8}$$

where $X_1,\ X_2, ..., X_n$ is a random sample and *Me* is the median estimator established on the basis of the random sample.

Wealth indices, concentrated on the upper part of income distribution, are utilised to measure the share of the best-off in a population of households. Among others, a wealth line can be defined as $z_b = 3M_{0.5}$ (Brzeziński 2014, Peichl, Schaefer & Scheicher 2008) and the wealth index based on it is given by: $W_b = 1 - F(z_b)$. These measures can be estimated using the following formulas:

$$\hat{z}_b = 3M_{0.5}, \tag{9}$$

and

$$\hat{W}_b = \frac{\#\{X_i > 3Me\}}{n}, \tag{10}$$

where $X_1,\ X_2, ..., X_n$ is a random sample and *Me* is the median estimator.

Examples of more sophisticated inequality measures, focused on each and every part of an income distribution, are the Gini and Zenga indices. The popular Gini index based on the Lorenz curve is not considered in this paper. The synthetic Zenga index is based on the concentration curve that can be considered a point concentration measure, as it is sensitive to changes at every "point" of the income distribution. The Zenga point measure of inequality is based on the relation between income and population quantiles (Zenga 1990, Jędrzejczak 2012, Greselin, Pasquazzi & Zitikis 2013, Arcagni 2016):

$$Z_p = \frac{x_p^* - x_p}{x_p^*} = 1 - \frac{x_p}{x_p^*}, \tag{11}$$

where $x_p = F^{-1}(p)$ denotes the population p-quantile and $x_p^* = Q^{-1}(p)$ is the corresponding income quantile. Therefore, the Zenga approach consists of comparing the abscissas at which $F(x)$ and $Q(x)$ take the same value p.

The Zenga synthetic inequality index is defined as simple arithmetic mean of point concentration measures $Z_p,\ p \in \langle 0,\ 1 \rangle$.

3. Quantile Estimators and Their Properties

Let X be a continuous random variable with distribution function F and let $Q_p = F^{-1}(p)$ be the p-quantile of the random variable X, where $p \in (0,\ 1)$.

If F is a continuous and strictly increasing distribution function, the pth quantile always exists and is uniquely determined.

The well-known estimator of the quantile Q_p is the statistic:

$$\hat{Q}_p = F_n^{-1}(p) = \inf\{x: F_n(x) \geq p\}, \tag{12}$$

where $F_n(x)$ is the empirical distribution obtaining on the basis of a n-element random sample $X_1,\ X_2, ..., X_n$.

The problem of quantile estimation has a very long history. In the subject literature numerous nonparametric (distribution-free) quantile estimators have been presented. Their particular expressions depend on the underlying empirical distribution function definition.

The classical quantile estimator obtained for the distribution $F_n(x) = \dfrac{card\{1 \leq j \leq n:\ x_i \leq x\}}{n}$ for $x \in R$ is defined by the following formula:

$$\hat{Q}_p = \begin{cases} X^n_{(np)} & \text{for } np \in N, \\ X^{(n)}_{([np]+1)}, & \text{for } np \notin N, \end{cases} \tag{13}$$

where $X^{(n)}_{(k)}$ is an order statistic of rank k.

Among other estimators of quantiles, Q_p we can mention the standard estimator, Huang-Brill estimator, Harrell-Davis estimator and Bernstein estimator, to name just a few (Huang & Brill 1999, Harrell & Davis 1982).

By means of the empirical distribution *level crossing*, which has the following form:

$$F_n(x) = \sum_{i=1}^{n} w_{n,i} I_{(-\infty,\, x\rangle}\left(x^{(n)}_{(i)}\right), \tag{14}$$

where $w_{n,i} = \begin{cases} \dfrac{1}{2}\left[1 - \dfrac{n-2}{\sqrt{n(n-1)}}\right] & \text{for } i = 1,\ n, \\ \dfrac{1}{\sqrt{n(n-1)}} & \text{for } i = 2,\ 3,\ ...,\ n-1, \end{cases}$

we obtain the Huang-Brill estimator of the *pth* quantile Q_p:

$$\hat{Q}^{HB}_p = X^{(n)}_{(q)}, \tag{15}$$

where

$$q = \left[\sqrt{n(n-1)}\left(p - \frac{1}{2}\left[1 - \frac{n-2}{\sqrt{n(n-1)}}\right]\right)\right] + 2. \tag{16}$$

It can easily be noticed that for $p = 0.5$ the estimator of the quantile $Q_{0.5}$ is the order statistic $X^{(n)}_{([\frac{n}{2}]+1)}$.

Another interesting quantile estimator is the Bernstein estimator given by:

$$\hat{Q}_p^{Brs} = \sum_{i=1}^{n} \left[\binom{n-1}{i-1} p^{i-1} (1-p)^{n-i} \right] X^{(n)}_{(i)}. \tag{17}$$

More examples of quantile estimators can be found in the papers of Pekasiewicz (2015) and Zieliński (2006).

4. Analysis of Monte Carlo Experiments

The main objective of the Monto Carlo experiments conducted in the study was to assess the properties of selected estimators of quantiles. We were especially interested in their biases and sampling variances, i.e. the components of their sampling errors. The following estimators have been taken into consideration: the classical quantile estimator (13), Huang-Brill estimator (15) and Bernstein estimator (17). The estimators presenting the best performance were further applied to evaluate the quantile-based inequality measures for income distributions in Poland by macroregion.

In the experiments two different probability distributions were utilised as population models: lognormal distribution, $LG(\mu, \sigma)$, defined by the following density function $f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left(-\frac{(\ln x - \mu)^2}{2\sigma^2} \right)$, $x > 0$ and Dagum distribution $D(\delta, a, b)$, known also as the Burr type-III distribution, with the density function of the form (Kleiber & Kotz 2003) $f(x) = ab^{-a\delta} \delta x^{a\delta - 1} \left(1 + \left(\frac{x}{b} \right)^a \right)^{-\delta - 1}, x > 0$.

The sets of parameters of both theoretical distributions were established on the basis of real income data originating from the Polish HBS and administrative registers, comprising a large variety of subpopulations differing in the level of income inequality, which have been observed over the last two decades. The sample sizes were fixed for each variant as $n = 500$, $n = 1000$, $n = 2000$. The number of repetitions of the Monte Carlo experiment was $N = 20{,}000$. The simulated sample spaces were used to assess, for each estimator, its empirical bias and standard error.

Tables 1 and 2 present the results of the calculations for three quantile estimators: classical, Huang-Brill and Bernstein, for sample sizes 500 and 1000.

Table 1. Properties of Selected Quantile Estimators for Sample Size $n = 500$

Distribution	p	$\hat{Q}_p$		$\hat{Q}_p^{HB}$		$\hat{Q}_p^{Brs}$	
		BIAS	*RMSE*	*BIAS*	*RMSE*	*BIAS*	*RMSE*
LG(8, 0.6)	0.1	–0.215	4.587	–0.489	4.639	0.283	4.419
	0.2	–0.122	3.839	–0.333	3.833	0.194	3.739
	0.3	–0.100	3.535	–0.285	3.550	0.153	3.445
	0.7	0.230	3.574	–0.118	3.548	0.103	3.471
	0.8	–0.161	3.824	–0.158	3.856	0.095	3.728
	0.9	–0.319	4.582	–0.306	4.600	0.077	4.427
LG(8.3, 0.8)	0.1	–0.270	6.095	0.768	6.276	0.448	5.883.
	0.2	–0.150	5.071	0.450	5.140	0.297	4.928
	0.3	–0.089	4.715	0.382	4.756	0.271	4.614
	0.7	0.314	4.754	–0.151	4.703	0.176	4.619
	0.8	–0.158	5.070	–0.195	5.113	0.225	4.955
	0.9	–0.316	6.077	–0.329	6.120	0.259	5.900
D(0.7, 3.6, 3800)	0.1	–0.280	5.558	0.564	5.534	0.279	5.332
	0.2	–0.174	3.957	0.341	3.969	0.105	3.841
	0.3	–0.133	3.298	0.177	3.298	0.073	3.216
	0.7	0.167	2.927	–0.104	2.924	0.065	2.846
	0.8	–0.127	3.247	–0.102	3.234	0.097	3.165
	0.9	–0.203	4.240	–0.212	4.254	0.196	4.128
D(0.7, 2.8, 3800)	0.1	–0.315	7.041	–0.737	7.174	0.433	6.782
	0.2	–0.181	5.065	0.437	5.146	0.213	4.918
	0.3	–0.092	4.228	0.272	4.283	0.184	4.133
	0.7	0.241	3.766	–0.124	3.748	0.118	3.662
	0.8	–0.127	4.159	–0.187	4.138	–0.186	4.061
	0.9	–0.342	5.428	–0.279	5.482	–0.218	5.274

Source: authors' own calculations in Mathematica.

In particular, the tables show the relative biases and relative root mean squared errors of these estimators obtained for predefined population models – lognormal and Dagum – differing across the experiments in the overall inequality level. Similar experiments for the Gini and Zenga ratios were reported in Jędrzejczak (2015).

Analysing the results of the calculations it becomes obvious that the Bernstein estimator performs better than its competitors – its root mean squared errors (*RMSE*) are much smaller than those observed for the other

quantile estimators and its relative biases (*BIAS*) are also smaller, especially when the quantiles of higher orders are taken into account.

Table 2. Properties of Selected Quantile Estimators for Sample Sizes $n = 1000$

Distribution	p	$\hat{Q}_p$		$\hat{Q}_p^{HB}$		$\hat{Q}_p^{Brs}$	
		BIAS	*RMSE*	*BIAS*	*RMSE*	*BIAS*	*RMSE*
LG(8, 0.6)	0.1	–0.087	3.240	0.254	3.248	0.132	3.165
	0.2	–0.079	2.718	0.139	2.726	0.108	2.669
	0.3	–0.039	2.504	0.133	2.511	0.095	2.481
	0.7	0.089	2.528	–0.082	2.521	0.042	2.469
	0.8	–0.077	2.712	–0.077	2.712	0.047	2.680
	0.9	–0.131	3.245	–0.131	3.245	0.041	3.169
LG(8.3, 0.8)	0.1	–0.097	4.350	0.359	4.373	0.302	4.220
	0.2	–0.088	3.581	0.195	3.592	0.177	3.571
	0.3	–0.057	3.336	0.176	3.346	0.134	3.271
	0.7	0.169	3.338	–0.061	3.324	0.108	3.280
	0.8	–0.099	3.620	–0.099	3.620	0.070	3.510
	0.9	–0.116	4.339	–0.116	4.339	0.089	4.208
D(0.7, 3.6, 3800)	0.1	–0.182	3.923	0.313	3.916	0.086	3.803
	0.2	–0.068	2.800	0.141	2.776	0.069	2.741
	0.3	–0.105	2.349	0.114	2.346	0.000	2.303
	0.7	0.010	2.054	–0.080	2.049	0.043	2.013
	0.8	–0.085	2.298	–0.078	2.287	0.032	2.256
	0.9	–0.083	2.984	0.116	2.991	0.121	2.915
D(0.7, 2.8, 3800)	0.1	–0.156	5.073	0.368	5.069	0.221	4.493
	0.2	–0.112	3.580	0.232	3.589	0.082	3.509
	0.3	–0.080	3.015	0.144	2.991	0.062	2.958
	0.7	0.137	2.652	–0.063	2.681	0.073	2.599
	0.8	–0.084	2.956	–0.077	2.935	0.069	2.900
	0.9	–0.133	3.846	–0.112	3.848	0.147	3.774

Source: authors' own calculations in Mathematica.

The bias and *RMSE* of the Huang-Brill estimator are similar to the respective values for the classical quantile estimator. It is worth noting that for all cases biases are rather negligible, so the total errors are dominated by sampling variances. In general, the estimation errors are higher for extremal quantile orders, for the heavy-tailed Dagum model, and they also tend to increase as income inequality increases.

Table 3. Properties of the Quintile Dispersion Ratio Based on Quantile Estimators

Distribution	n	Quintile Dispersion Ratio					
		$\hat{W}^{(1)}_{20:20}$ (stand.)		$\hat{W}^{(1)}_{20:20}$ (Huang-Brill)		$\hat{W}^{(1)}_{20:20}$ (Bernstein)	
		BIAS	*RMSE*	*BIAS*	*RMSE*	*BIAS*	*RMSE*
LG(8.0, 0.6)	500	0.113	4.724	–0.387	4.725	0.054	4.532
	1000	0.070	3.335	–0.194	3.329	0.038	3.239
LG(8.1, 0.7)	500	0.063	5.484	–0.388	5.453	–0.014	5.265
	1000	0.011	3.868	–0.157	3.859	–0.017	3.756
LG(8.3, 0.8)	500	0.134	6.252	–0.549	6.189	0.042	6.004
	1000	0.068	4.444	–0.231	4.473	0.027	4.308
D(0.7, 3.6, 3800)	500	0.156	4.454	–0.262	4.442	0.091	4.275
	1000	0.072	3.154	–0.137	3.120	0.046	3.068
D(0.8, 3.0, 3200)	500	0.174	4.978	–0.323	4.997	0.125	4.794
	1000	0.073	3.521	–0.155	3.492	0.053	3.417
D(0.7, 2.8, 3800)	500	0.235	5.753	–0.287	5.691	0.136	5.505
	1000	0.080	4.044	0.213	4.040	0.046	3.930

Source: authors' own calculations in Mathematica.

Table 4. Properties of the Decile Dispersion Ratio Based on Quantile Estimators

Distribution	n	Decile Dispersion Ratio					
		$\hat{W}^{(1)}_{10:10}$ (stand.)		$\hat{W}^{(1)}_{10:10}$ (Huang-Brill)		$\hat{W}^{(1)}_{10:10}$ (Bernstein)	
		BIAS	*RMSE*	*BIAS*	*RMSE*	*BIAS*	*RMSE*
LG(8.0, 0.6)	500	0.126	6.174	–0.631	6.096	0.021	5.882
	1000	0.065	4.327	–0.324	4.304	0.017	4.191
LG(8.1, 0.7)	500	0.124	7.197	–0.630	7.104	0.013	6.868
	1000	0.084	5.088	–0.273	5.028	0.019	4.926
LG(8.3, 0.8)	500	0.186	8.134	–0.773	8.124	0.029	7.758
	1000	0.124	5.815	–0.352	5.766	0.037	5.615
D(0.7, 3.6, 3800)	500	0.353	6.671	–0.439	6.589	0.181	6.344
	1000	0.162	4.702	–0.211	4.651	0.082	4.543
D(0.8, 3.0, 3200)	500	0.347	7.354	–0.493	7.402	0.234	7.002
	1000	0.097	5.179	–0.266	5.193	0.039	5.009
D(0.7, 2.8, 3800)	500	0.554	8.598	–0.551	8.470	0.283	8.181
	1000	0.181	6.003	–0.298	5.948	0.066	5.800

Source: authors' own calculations in Mathematica.

The next step of the experiment was to study basic statistical properties of the estimators of income inequality measures: $W^{(1)}_{10:10}$ and $W^{(1)}_{20:20}$ given by the formulas (1) and (3). These estimators can be obtained as functions of the subsequent quantile estimators mentioned above. The properties of quintile and decile dispersion ratios are illustrated in Tables 3 and 4. All the values are presented as percentages relative to their corresponding population parameters.

Analysing the results of the calculations presented in Tables 3 and 4 it becomes obvious that the estimators of quintile and decile dispersion ratios based on the Bernstein quantile estimator outperform the estimators based on the classical and Huang-Brill estimators of quantiles. For the Bernstein estimator, the biases and mean squared errors turned out to be substantially smaller for most cases.

5. Application of Inequality Measures to the Analysis of Income Distribution in Poland

The inequality measures based on deciles and quintiles, as well as the Zenga indices, have been applied to income inequality analysis in Poland by macroregion (NUTS1), based on the HBS 2014 sample. They include the decile and quintile dispersion ratios, the reciprocal of the decile dispersion ratio K, the coefficient of maximum equalisation E and the synthetic Zenga index Z. To obtain reliable estimates of these coefficients we used the Bernstein quantile estimator, which turned out to have the highest precision (Tables 1 and 2).

Table 5. Numerical Characteristics of Available Income in Macroregions

Macroregion	Number of households	Minimum	Maximum	Average	Standard deviation
Central	8046	11.00	155017.49	4240.21	3790.53
Southern	7433	12.50	37152.00	3634.03	2179.59
Eastern	6246	10.00	84032.90	3461.45	2876.23
North-Western	5658	3.00	43493.45	3772.15	2611.00
South-Western	3971	1.67	37200.00	3591.07	2337.83
Northern	5575	9.00	126739.54	3646.44	3225.72
Poland	36929	1.67	155017.49	3755.33	2959.95

Source: authors' calculations based on the HBS 2014 sample.

Basic characteristics of the HBS sample, divided by macroregion, are presented in Table 5. Table 6 shows the results of the approximation of the empirical income distributions by means of the Dagum model using the maximum likelihood method. Additionally, in Figure 1 there are histograms and fitted Dagum density curves describing income distributions in Poland by macroregion.

Table 6. Approximation of Income Distributions in NUTS1 by Means of the Dagum Model

Macroregion	Dagum distribution parameters			Overlap measure
	δ	*a*	*b*	
Central	0.790	2.8044	3839.630	0.982
Southern	0.669	3.618	3800.167	0.970
Eastern	0.756	3.051	3286.467	0.971
North-Western	0.743	3.233	3687.076	0.964
South-Western	0.722	3.301	3587.800	0.970
Northern	0.718	3.158	3544.934	0.979
Poland	0.747	3.125	3611.017	0.975

Source: authors' calculations based on the HBS 2014 sample.

Analysing the outcomes of the approximation presented in Figure 1 one can observe very high consistency between the empirical distributions and the theoretical ones. This is also confirmed by the values of a goodness-of-fit measure (the overlap coefficient) calculated for each region and the whole country and presented in the last column of the Table 6.

Table 7. Estimated Inequality Measures for Macroregions

Macroregion	$W^{(1)}_{20:20}$	$W^{(2)}_{20:20}$	$W^{(1)}_{10:10}$	$W^{(2)}_{10:10}$	$K_{1:10}$	E	Zenga
Central	3.049	6.939	5.494	12.085	0.083	26.491	0.386
Southern	2.595	4.962	4.283	7.577	0.132	21.667	0.269
Eastern	2.904	6.147	4.927	9.908	0.101	24.740	0.348
North-Western	2.750	5.577	4.742	8.614	0.116	23.221	0.308
South-Western	2.789	5.375	4.536	8.172	0.122	23.017	0.295
Northern	2.828	6.039	4.814	9.841	0.102	24.412	0.347
Poland	2.819	5.916	4.843	9.526	0.105	22.000	0.338

Source: authors' calculations based on the HBS 2014 sample.

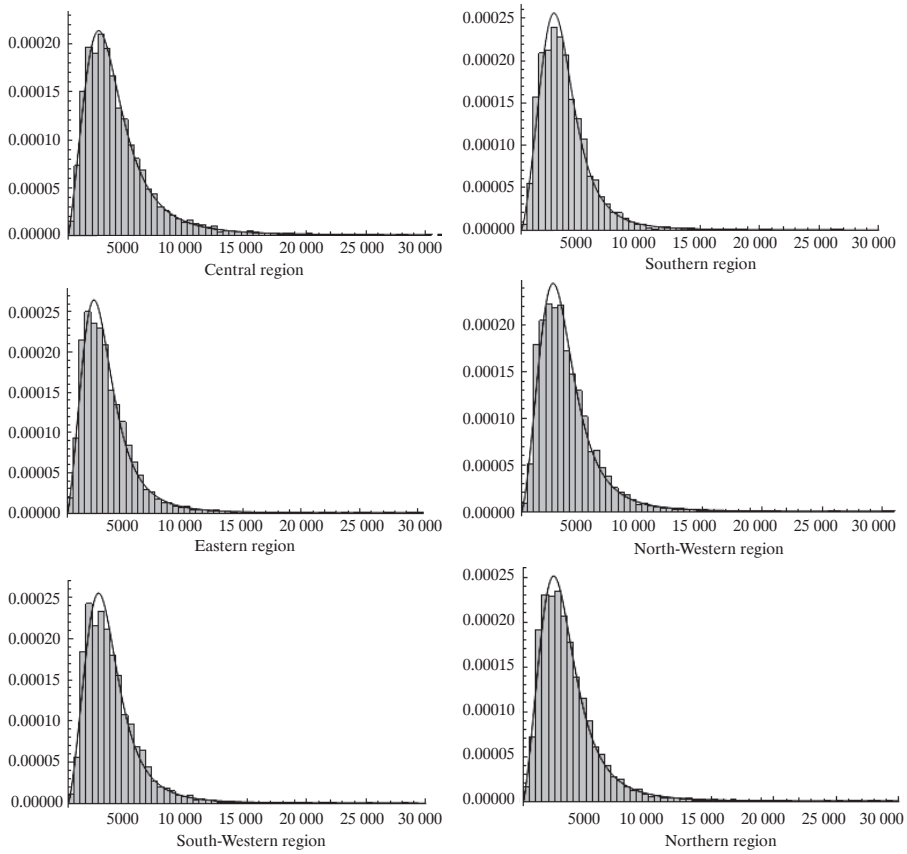

Fig. 1. Income Distributions for NUTS1 and Fitting by Means of the Dagum Model
Source: authors' elaborations in R.

The estimated values of inequality measures such as the decile and quintile dispersion ratios, the reciprocal of the decile dispersion ratio K and the synthetic Zenga index Z, obtained on the basis of implementation of the Bernstein estimator, are given in Table 7. The indexed values of selected inequality measures from Table 7 have been used to order Polish macroregions by inequality level, as is demonstrated in Figure 2. They also show the differentiation of income inequality across regions.

The estimated values of quintile and decile share ratios, as well as the values of synthetic Zenga inequality measures, indicate the Central macroregion as the one with the highest income inequality level. This is

particularly evident for extremal income groups, e.g. the income of the richest 10% of households is 12 times bigger than the income of the poorest 10% ($W^{(2)}_{10:10} = 12.085$). On the other hand, the lowest values of all inequality measures (except for the K index) have been observed for the Southern macroregion. Three macroregions: Central, Eastern and Northern present income inequality above the national level, while in the remaining three: North-Western, South-Western and Southern it was found to be substantially lower than for the whole country (Figure 2). In general, 22% of the total income of Polish households would have to be redistributed from the richer to the poorer groups for there to be income equality ($E = 22\%$).

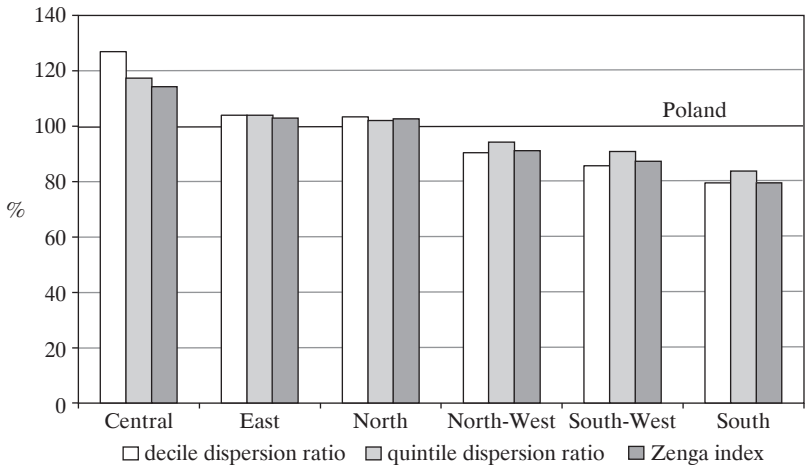

Fig. 2. Selected Inequality Measures for Macroregions (Poland = 100)
Source: authors' elaborations.

The relative poverty threshold established as 60% of equivalent national median income, and the relative wealth line established as the median estimated by means of the Bernstein estimator, are equal to 1181.85 PLN and 5909.23 PLN, respectively. Estimates of the poverty index (head-count ratio (8)) and wealth index (9) for each macroregion based on these thresholds are presented in Table 8. Also contained in the table are the poverty thresholds and wealth lines estimated separately for each macroregion. The indexed values of poverty and wealth ratios (Poland = 100%) are presented in Figure 3.

Table 8. Estimated Poverty and Wealth Measures for Macroregions

Macroregion	Poverty line	Head-count ratio	Wealth line	Wealth index
Central	1394.94	12.73	6974.68	5.42
Southern	1247.39	12.04	6236.93	1.52
Eastern	1085.24	20.12	5426.19	1.68
North-Western	1242.65	12.99	6213.26	1.63
South-Western	1211.82	12.49	6059.09	1.81
Northern	1204.10	16.72	6020.48	2.26
Poland	1181.85	14.46	5909.23	2.56

Source: authors' calculations based on the HBS 2014 sample.

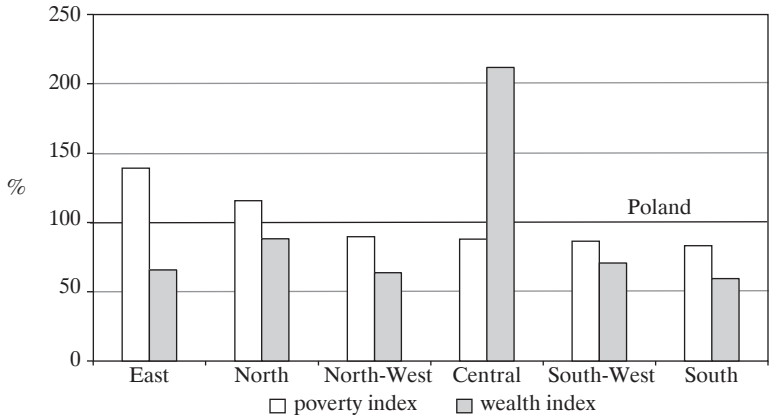

Fig. 3. Poverty and Wealth Measures for Macroregions (Poland = 100)

Source: authors' elaborations.

It is worth noting that the ordering of Polish macroregions by poverty rates is different from the ordering by inequality levels – for some regions (Central) relatively high income inequality does not coincide with high poverty rates, and inversely, relatively low inequality does not always induce low poverty rates (North-Western region). On the other hand, for highly unequal distributions (Central, Eastern), one can observe a large discrepancy between poverty and wealth rates (Figure 3), indicating different within--region inequality patterns – a large amount of inequality due to extremely low income groups (the case of the Eastern region) or extremely high income groups (the Central region).

6. Conclusion

Analysis of income and wage distribution is strictly connected with the estimation of inequality and poverty measures based on quantiles. Therefore, for income data usually originating from sample surveys, it becomes crucial to use the quantile estimators that present satisfying statistical properties. In this paper, the Huang-Brill and Bernstein estimators have been proposed and analysed from the point of view of their sampling errors under several income distribution models. In the simulation studies the properties of these estimators have been compared with the classical one, which is most often applied in practice. The results of the calculations reveal that the Bernstein estimator performs better than its competitors – its root mean squared error (*RMSE*) is much smaller than the one observed for the other quantile estimators and its relative bias (*BIAS*) is also smaller, especially when the quantiles of higher orders are taken into account. Consequently, the Bernstein estimator has been applied to the estimation of various inequality measures for NUTS1 regions in Poland.

The reliable quantile estimators, as well as various inequality, poverty and wealth measures based on them, enabled us to analyse income distributions in Poland by macroregion. The analysis revealed substantial discrepancies between regions in Poland, which can be the basis for further analysis by economists and social-policy makers.

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Abstract

Własności wybranych miar nierównomierności opartych na kwantylach i ich zastosowanie w analizach rozkładów dochodów według makroregionów w Polsce

Kwantyle rozkładu dochodów są wykorzystywane do szacowania różnorodnych miar nierówności, analiz ubóstwa i bogactwa gospodarstw domowych. Najczęściej są one szacowane z użyciem klasycznego estymatora, będącego statystyką pozycyjną odpowiedniej rangi. Głównym celem pracy jest porównanie własności klasycznego estymatora kwantyla z własnościami estymatorów zaproponowanych przez M.L. Huanga i P.H. Brilla oraz Bernsteina. W celu zbadania obciążeń i błędów średniokwadratowych estymatorów kwantyli i miar nierówności opartych na kwantylach przeprowadzono eksperymenty Monte Carlo, rozważając różne liczebności prób i różne rozkłady. W pracy przedstawiono wyniki badań dla populacji o rozkładach lognormalnym i Daguma, które najczęściej charakteryzującą dochody gospodarstw domowych. Wyniki eksperymentów symulacyjnych wskazują, że spośród rozważanych estymatorów najlepsze własności ma estymator Bernsteina, dlatego został on wykorzystany do oszacowania miar nierówności dochodowych, ubóstwa i bogactwa w Polsce w 2014 r. z uwzględnieniem podziału kraju na makroregiony. Analizy przeprowadzono na podstawie danych pochodzących z badania budżetów gospodarstw domowych prowadzonego przez Główny Urząd Statystyczny.

Słowa kluczowe: rozkład dochodu, nierówność, ubóstwo, bogactwo, estymator kwantyla.

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 69–82
https://doi.org/10.15678/AOC.2018.1804

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POSSIBLE FUTURE DEVELOPMENTS OF SAMPLE SURVEYS IN FINANCE

Abstract

Although sample surveys do not play a primary role in research, their impact has increased recently in many areas of finance and economics. At the same time, however, new difficulties have arisen in conducting surveys and making inference on the basis of sample results. These difficulties concern not only up-to-date sampling frames and proper modes of interviewing respondents, but also the rapid increase of non-response rates, which affects the quality of outcomes. In these circumstances it seems reasonable to search for external data in order to reduce the consequences of non-sampling errors. The article presents the authors' view on the possible use of big data as supplementary information. It also discusses some of the main challenges for survey-based research in the near future. The main conclusion is that big data will support rather than overtake surveys in finance in the years ahead.

Keywords: sample survey, statistical inference, survey-based research, big data.
JEL Classification: C10.

1. Introduction

For the last several decades sample surveys have been successfully applied in various research areas, including empirical economics and finance. Their main objective is to describe certain characteristics of the population under study on the basis of a small representative fraction of it – usually a random sample. The increasing impact of survey-based research in modern times is mainly a result of continuous progress in the theory of statistical inference,

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and the rapid development of new technological tools for collecting and processing data.

Statistical inference – estimation and hypothesis testing – is used in finance in a large number of research problems which include inference about unknown parameters that describe various financial phenomena. Together with the theory of probability, inferential statistics constitute a basic set of methods and techniques for analysing stochastic processes and other models popular in financial research and practice. Finance is one of the sciences where a large amount of statistical data is generated every day (or every second, if one looks at it from the global perspective). Therefore, it provides on the one hand good opportunities for testing new inferential approaches and methods, and on the other creates new challenges connected with the increasing complexity of financial problems[1].

Along with research that includes statistical or econometric modelling, other methods are also used in finance where statistical inference plays a vital role, one of these being survey-based research. This kind of research has gained more attention in recent years not only in finance but in empirical economics as a whole. Inference based on incomplete information (sample information) is used in various practical problems, including decision--making in enterprises. Business activity surveys and consumer sentiment surveys are examples of research that tends to be carefully monitored by many players on the market. Survey-based research is the main concept we are focusing on in this paper. The main features of survey-based research are: quantitative characteristics of the variables of interest in the population, sampling techniques which allow the researcher to generalise about the population being investigated, and soliciting information from people using a questionnaire.

The main objective of our paper is to attempt to answer the following two questions:

1) Will the growing popularity of sample surveys in finance, accompanied by time pressure to obtain quick results and the unwillingness of many respondents to cooperate, allow the surveys to remain reliable and accurate sources of information?

2) How likely is it that survey-based research will be overtaken in the near future by investigations based on data-rich information resources, such as metadata, paradata, and big data?

[1] See, for instance, Gwizdała (2013) about the role of reliable information in solving multi-faceted risk problems in banking.

2. The Role of Sample Surveys in Finance

Although survey-based research does not play a primary role in finance, its impact should not be neglected. Moreover, this kind of research has recently become more popular than ever before. In our opinion, there are three main reasons to account for this.

First, quantitative survey research is quite frequently the only way to empirically test theories describing the activities and behaviours of people in financial markets. Additionally, such surveys can be helpful in discovering new phenomena or trends in finance.

Second, the surveys provide data which form the basis for a number of widely recognised indicators, indices, and rankings. All of these are designed to describe certain aspects of financial markets in a condensed, synthetic form. Examples of such measures are: the Global Findex[2], Consumer Confidence Index (CCI)[3], Stock Market Confidence Index[4], PENGAB[5].

Third, the increasing proportion of internet surveys involves lower costs and a shorter period for obtaining information from respondents compared with the pre-internet era. This relates to both nationwide and worldwide surveys, which in the past were particularly difficult to conduct. As a consequence, the whole process of collecting and analysing data is nowadays less costly and less time-consuming than in the past.

The internet and other technological advances have led to growing interest among researchers in sample surveys, not only in finance. Survey--based research tends to drive out other research approaches, including qualitative studies. This tendency may raise some concern, as some researchers seem to ignore the fact that quantitative description essentially simplifies reality. Numbers themselves reflect the real world in a very imperfect manner. Therefore, if a study focuses on the motivations behind the choices of consumers or investors, a quantitative approach may not be appropriate. Moreover, taking into account that in sample surveys respondents' answers are typically confined to a few close-ended statements, and the scales used in particular questions tend to be very simple, it becomes

[2] An index which measures the financial inclusion of people and is based on interviews with about 150,000 adults in over 140 countries.

[3] An indicator, formed from survey results of more than 5,000 US households, gauging financial health, spending power and consumer confidence.

[4] An index based on sample surveys of individual investors and institutions in the United States.

[5] A popular banking sentiment indicator in Poland based on surveys carried out by TNS Polska among bank managers.

clear that the final picture may be far from accurate. There are many examples of such oversimplified surveys in finance[6].

Apart from these constraints, the practical difficulties in performing a survey may also affect the quality of its findings. This includes problems with designing the sampling frame, the refusal of some respondents to cooperate, the misunderstanding of questions (question wording), and in the case of enterprises or institutions – uncertainty about the competence of the respondent representing such an entity. All this creates scepticism among some researchers about the validity and accuracy of scientific findings based on results obtained from sample surveys. H. K. Baker and T. K. Mukherjee (2007) have attempted to answer the question about the current status of survey-based research in finance. They asked editors of 50 "core" and "non--core" financial journals about their views on the role which survey-based research should play in finance literature[7].

Table 1. Role which Survey-based Research Should Play in the Finance Literature

Which of the following statements best describes your view on the role that survey-based research should play in the finance literature?	"Core" journal editors	"Non-core" journal editors	Total (*n*)	Total (%)
A. Survey-based research should be considered equal to other types of original research	-	10	10	43.5
B. Survey-based research should play a complementary role to other types of original research	4	6	10	43.5
C. There is a limited (or no) role for survey-based research relative to other types of original research	2	1	3	13.0
D. The role of survey-based research should be as follows	–	–	–	–

Source: Baker and Mukherjee (2007, p. 21).

The precise questions and answers given by 23 editors who agreed to cooperate are presented in Table 1. Although the majority of editors argue that survey-based research should be considered equal to other types of research or play a complementary role, there are clear differences among

[6] One can be found in Sokołowska (2014, chapter 5).

[7] Classification of journals into "core" and "non-core" was based on perceived quality. The response rate did not exceed 50% in this survey.

them. Those representing "core" journals seem unwilling to consider survey--based research equal to other original forms of research. They indicate that the role of the former should be considered either complementary or limited (or nil). At the same time, "non-core" journal editors view the role of the survey-based research as complementary or equal to other types of original research. None of the editors admitted that survey-based manuscripts are generally discouraged in their journals.

In our opinion, the future status and impact of survey-based research in finance will be equally determined by advances in the theory and practice of sample designs, and by an integrated approach to the combination of sample and non-sample (or external) information. We look at some of the main challenges below. The majority of these are common to all survey-based research and are not limited to applications in finance.

3. Main Challenges for Survey-based Research

The increasing variety and efficiency of ways in which interviewers communicate with respondents seems to be one of the important incentives for using sample surveys in contemporary research. Instead of time--consuming mail surveys which are rarely used these days, telephone surveys and internet (Web-based) surveys have become more popular. It is worth noting, however, that interviewers' relatively easy access to communication channels with respondents does not necessarily imply high sample quality. First, in the era of mobile phones, random digit dialling (RDD), as was applied for years with regard to landline phones, does not unambiguously identify a household or adult. Moreover, population units (respondents) who have more than one mobile phone stand an unequal chance of being selected for the sample. The problem of an appropriate and good quality sampling frame when the survey is based on telephone interviews is still open[8]. In its surveys, the Gallup Organisation uses a 50% listed landline sample and 50% RDD mobile phone sample. This is not, however, a perfect solution, as was proved by the authors of a report aimed at identifying factors responsible for the failure of opinion polls before the US presidential election in 2012 (see Gallup 2013). They argue that there were significant differences, including in the field of demographics, in both these subsamples (selected by mobile and landline phones). The weighting adjustment procedures applied were

[8] In Britain, for instance, different demographic groups have substantially different patterns of mobile/landline use. Most notably, nearly 30% aged between 18 and 34 use a mobile but do not have a landline, while the corresponding rate for those aged 55 and over is just 5%. See Sturgis *at al.* (2016).

able to reduce some differences, although their impact on the final survey results was not without significance.

An alternative could be an internet (online) survey which is as relatively easy for respondents to handle as it is convenient for researchers to process the data recorded. Also, many respondents feel more anonymous and consequently are not tempted to give answers which would be in line with expectations (socially desirable) rather than reflecting their own attitudes or opinions. One of the challenges connected with using internet surveys is the difficulty of constructing sampling frames and designing procedures for recruiting respondents. If these are not properly solved, it is likely that they will generate a so-called coverage error[9]. More challenging, however, is identifying and explaining the differences that tend to crop up between results obtained by telephone and online surveys. Such differences occurred, for instance, in pre-election opinion polls in Britain in 2015, and also in opinion polls before the European Union membership referendum in the UK a year later[10]. There has been little evidence that one of the two ways of surveying respondents is superior to the other. Nor is there any firm knowledge about the circumstances in which one of these modes should be preferred over the other. For this reason, the use of mixed-mode designs or different modes is recommended for different segments of the population.

In finance, where enterprises, households and individual consumers regard a lot of information as confidential, a serious challenge for researchers using surveys is the high rate of non-response. One general reason for people being unwilling to take part in surveys or opinion polls is that many are fed up with them. It is presumably the price we all pay for the increasing number of surveys with which we bother others. Respondents' doubts as to whether the survey is legitimate, declining human interaction in surveys over the decades[11], and concerns about privacy and confidentiality among respondents (disclosure risk) are also responsible for lowering response rates. Nowadays, regardless of the subject of the survey, it is difficult to achieve response rates above 50%[12]. From a statistical perspective, high non-response rates should be considered a serious problem. A high proportion of non-responses can potentially render the whole inference invalid, as

[9] This error arises if not all population units are represented in the sampling frame.

[10] For details, see Sturgis *et al.* (2016).

[11] "The sample survey has been transformed from being a comfortable face-to-face conversation to a highly impersonal experience" (Dillman, Smyth & Christan 2009, p. 1).

[12] Interestingly, or perhaps surprisingly, a mere 50% rate of return was achieved in the previously mentioned survey among editors of financial journals. See Baker and Mukherjee (2007).

estimates are likely to be biased. The consequences of non-response are less harmful only if they can be regarded as missing at random observations. In this particular case, although the estimates suffer from lack of precision, they remain unbiased. However, in practice such fortunate situations are rare. More frequently, non-response is associated or correlated with some other population characteristics. This, in turn, results in underestimating or overestimating the population characteristics of interest. Additionally, in these circumstances the bias does not diminish with an increase in sample size[13]. R. M. Groves and E. Peytcheva (2008) show that at any given level of non-response the actual bias is unknown and may vary considerably. One of the most efficient ways to reduce the non-response error involves enriching sample information with other relevant information that could be used in weighting schemes or calibration procedures. This could be either sample information about other characteristics of the units or non--sample information, including external secondary data, e.g. commercial databases and administrative records. Weights are used in surveys not only for adjusting for non-response, but also for correcting the sample structure in order to improve the precision of inference. The effectiveness of all such measures aimed at substituting non-responses depends on the relevance and quality of the auxiliary data (see Särndal & Lundström 2006).

Apart from these general rules, there exist some practical recommendations for optimising response rates in a particular research area. In our opinion, as regards the field of finance, these recommendations should include generating confidence in respondents as to the anonymity of their answers, assuring them that the survey is valid, and choosing the most appropriate mode for conducting the survey. Because financial issues are commonly regarded as sensitive, it may be useful, for instance, to avoid those interviewing techniques which allow for the presence of other people.

Another challenge worth considering is the problem of sample section. Two questions are particularly important. First, will increasing the volume of information on various populations under investigation be capable of providing sufficient information to reduce the impact of random selection and eventually substitute probability sampling techniques with non--probability equivalents? Second, what is the actual scientific value of increasingly popular opt-in Web surveys?

Let us remember that the classical theory of statistical inference is based on the assumption of having a (simple) random sample. All basic estimation

[13] For details, see Bethlehem (2002) or Szreder (2010, chapter 6.3).

procedures and tests of significance rely on this assumption. However, in practical applications of sample surveys in economics, including finance, or in social science, simple random sampling is used only occasionally[14]. This discrepancy between theory and practice has one main reason. The researcher is not satisfied with using the random selection mechanism, which generates more or less representative samples. He or she seeks a highly representative sample in the particular survey and, as a consequence, is ready to employ other sources of information or knowledge that can improve a purely random selection mechanism. For example, if the population of interest is strongly diversified, stratified sampling which uses prior information about the structure of the population is usually more efficient than simple random sampling. If the amount of external (non-sample) information increases, and ultimately provides substantial knowledge about population units, one can imagine that random sampling can be replaced by non-probability techniques, such as quota sampling. Quota samples are popular in many commercial surveys and opinion polls in Britain[15]. Whether this tendency develops in the near future will depend on new methods and techniques enabling researchers to combine various sources of relevant information, including sample data, for the purpose of inference. The external sources also include administrative records and other official registers which can help verify the reliability of sample data. In Poland, for instance, information given by households and individuals on their incomes requires correction based on other sources of information. It has been shown that the data obtained from representative samples of households in surveys conducted by public statistical bodies are not consistent with the corresponding data records in tax offices[16]. More reliable information, and as a consequence more accurate inference, can be obtained if a combination of both these data sources is employed. It should be noted, however, that the theory of statistical inference does not yet give substantive support for this kind of combined information[17]. Further progress in developing a theoretical

[14] Among his seven original maxims of sampling, C. O'Muircheartaigh (2008, p. 296) includes the following: "Never use simple random sampling!".

[15] MORI-Ipsos claims that "most polls in Britain use quota sampling which pre-determines the demographic make-up of the sample to ensure it matches the profile of the whole adult population" and points out that "historically in Britain, the record of quota samples in predicting elections has been better than that of random samples". For details, see Worcester (1991).

[16] See Kośny and Mazurek (2009), Brzeziński (2015), and Brzeziński and Kostro (2010).

[17] The lack of proper theory also applies to register-based inference. A. Wallgren and B. Wallgren (2007, p. IX) write: "Although register-based statistics are the most common form of statistics, no well-established theory in the field has existed up to now".

framework for estimation and hypothesis testing based on a combination of various information sources seems to be one of the main challenges.

The other problem mentioned above relates to the validity of so-called opt-in (or self-identified) surveys in which respondents are self-selecting. This kind of survey is popular in market research and in some social sciences, mainly because it is inexpensive and convenient, as it attracts people who are really interested in completing the questionnaire. In response to the allegation that the selection bias can seriously affect the representativeness of such samples, proponents argue that it is likely to be compensated for by the large sample size. In fact, it is not. Those who take part in the survey may be systematically different from the remaining units of the population. In practice, people from high-income families refuse to cooperate in all surveys focused on financial issues. Similarly, representatives of large companies tend to be reluctant to complete surveys about their activities, particularly those related to the financial aspects of their activities. The self-selection mechanism and other techniques of convenient sampling will very rarely cover all segments of the population. Ch. Wheelan (2013, p. 118) seems to be correct when he writes: "If you ask 100 people in a public place to complete a short survey, and 60 are willing to answer your questions, those 60 are likely to be different in significant ways from the 40 who walked by without making eye contact". In these circumstances, inference based on such samples can be heavily biased. The amount of bias may be reduced if proper weight-adjustment procedures or other bias-correction techniques are applied. This, however, requires reliable external information about the subject population. Unfortunately, opt-in surveys are frequently used when the researcher has little or no knowledge about the structure of the population in question. Therefore, in research activities, applications of this sample construction technique should be confined to pilot surveys.

4. Big Data – Hopes and Opportunities

In contemporary data analyses a great deal of attention is paid to external sources of data that aim to extend the sample information on which the inference is based. Several categories of external information can be distinguished, depending on the nature and content, including metadata and paradata.

Metadata is commonly understood as "data about the data", i.e. it summarises basic information about the data collected – its structure, content, and context. Examples of metadata are survey instruments,

interviewer instructions, software used for processing data, and documentation of the survey process. This kind of data was probably first recognised and used by official statistics, and then gradually became common in commercial surveys. Collection of various kinds of metadata has been facilitated in recent years thanks to technological progress. Given the problems with declining response rates in sample surveys, the impact of metadata is on the increase. However, this area has witnessed a lack of theoretical background and common standards for using metadata in survey--based research.

Paradata, on the other hand, refers to more detailed information that is more difficult to record. The term "paradata" describes all types of data about the process and context of data collection. According to F. Kreuter (2015), it was first used in the survey research context by M. Couper in 1998 to describe automatically generated process data, such as data from computerised interviewing software. This kind of data includes contact data (day, time, outcome), keystrokes (response times, edits), interviewer personal observations (respondents' interest). Proper use of this sort of data can help reduce the total error in a survey. For example, an analysis of time the respondent took to "click" and answer questions may suggest how interested he or she was in the survey, and consequently what quality of data they provided. Similarly, in telephone or face-to-face interviews, information about the availability of respondents can prove helpful for the researcher[18]. Despite growing opportunities to collect various kinds of paradata in recent years, its future impact will depend on the anticipated progress in working out a systematic approach to handling this kind of data.

Both metadata and paradata constitute elements of a broader concept known as "big data", a term to describe ways of acquiring new knowledge and learning about reality which can be achieved on a large scale by using new opportunities for capturing and processing large-size data files. Some authors who deal with this subject expect revolutionary changes not only in survey-based research but also in our lives. V. Mayer-Schönberger and K. Cukier in their famous book (2013) argue that "the concept of sampling no longer makes as much sense when we can harness large amounts of data" (p. 26), and that "reaching for a random sample in the age of big data is like clutching at a horse whip in the era of the motor car" (page 31). These

[18] For example, in one of the pre-election face-to-face British Social Attitudes surveys in 2015, Labour was six points ahead among respondents who answered the door at the first visit, whereas the Conservatives enjoyed an 11-point advantage among interviewees that required between three and six home visits (see Clark & Parraudin 2016).

statements are, in our opinion, debatable. The authors, who are clearly impressed by the huge amounts of data available, mainly Internet-derived, seem to suggest that quantity can compensate for lack of quality. They are of course aware of the nature of big data, and realise that it may often be unstructured, messy, and possibly of poor quality. Anyone who argues that in such circumstances big data is superior to a well-designed and well conducted sample survey, is paying too much attention to sampling errors and is probably ignoring non-sampling errors. In modern sample surveys the latter are much more difficult to combat than sampling errors. If a survey fails, the principal reasons are likely to be connected with non--sampling errors, which can occur both in sample surveys and in surveys designed to cover the whole population under study. Therefore, one of the main challenges is to seek efficient tools for reducing non-sampling errors. If "sacrificing a little accuracy", to quote (Mayer-Schönberger & Cukier 2013), means ignoring some categories of non-sampling errors prior to analysis, then a well-designed and carefully performed sample survey will presumably provide better quality information about the population of interest.

Substituting a random sample by gathering as much data as possible – "N = all", according to V. Mayer-Schönberger and K. Cukier's concept (2013) – is, in our opinion, also controversial. There are many populations where small fractions may seriously affect the inference if they are not represented in the sample. Even a figure as high as 99% of the population covered in the survey may not be sufficient to make reliable statements about some variables. The slogan "We are the 99%" used by the Occupy Wall Street movement refers to one such variable – global wealth (and the distribution of family wealth in the USA). According to Credit Suisse, the top 1% of adult wealth holders worldwide own more than half of all global wealth. If a researcher fails to cover this one percent of the population, then his or her estimates about the world's wealth will certainly be skewed. Similar examples can be found in Poland, where failure to cover the top 3% of high-income earners in a survey will result in a drop of 25% in the personal income tax they account for (2015).

The use of big data in areas previously occupied by statistical surveys and censuses does not have to be viewed in terms of mutual competition. They are complementary rather than competitive. Big data, and administrative records in particular, may effectively complement sample data. It would be particularly valuable in surveys that are subject to large non-sampling errors, including coverage error, non-response error, and processing error.

In other words, the additional information about the population commonly used in weighting adjustment procedures or calibration techniques may have its origin in big data. We believe that sample surveys supported by big data sources and instruments will play an important role in finance in the near future.

5. Conclusions

Survey-based research has gained acceptance in many sciences, including finance. It is particularly useful if no other possibilities exist for obtaining data that could be employed to generalise findings to a larger (pre-defined) population. However, one can simultaneously observe growing scepticism among some researchers towards the validity and accuracy of surveys which nowadays have to deal with sampling problems and the unwillingness of respondents to cooperate. These and other practical difficulties in conducting surveys mean that auxiliary information has become increasingly desirable. This information can be implemented in weighting schemes and various error correction procedures. Big data is expected to play an important role in handling non-sampling errors. If understood as a broad concept, it involves, among others, metadata and paradata. Both can provide relevant and valuable information about the process and context of data collection. Big data is, in addition, likely to play a supplementary role for sample surveys. Unlike V. Mayer-Schönberger and K. Cukier, we are convinced that big data, despite its huge potential, will not substitute sample surveys in finance and other sciences. Surveys are likely to survive at least into the near future. One of the main challenges in this area, however, is to work out a coherent theoretical framework for applications of combined sources of information in statistical inference.

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Abstract

O możliwym dalszym rozwoju badań próbkowych w finansach

Mimo że badania próbkowe nie stanowią najczęściej podstawowego podejścia w naukach nieeksperymentalnych, to ich znaczenie w ostatnich latach rośnie zarówno w ekonomii, jak i w finansach. Jednocześnie jednak pojawiają się nieznane dotychczas trudności w prowadzeniu badań próbkowych i we wnioskowaniu, którego są podstawą. Są to nie tylko problemy z właściwym operatem losowania i skutecznym sposobem komunikowania się ankietera z respondentem, ale także szybko rosnące wskaźniki odmowy respondentów udziału w tego typu badaniach. W tych warunkach szczególnego znaczenia nabierają informacje spoza próby, mogące poprawić jakość wnioskowania. Artykuł przedstawia punkt widzenia autorów na kwestię wykorzystania możliwości *big data* jako zewnętrznego, wspomagającego próbę źródła informacji. Autorzy prezentują ponadto najważniejsze wyzwania, jakie stawiane są przed badaniami próbkowymi w najbliższej przyszłości. Głównym wnioskiem z rozważań jest przekonanie autorów, że w najbliższej przyszłości *big data* nie zdoła zastąpić badań próbkowych, ale może przyczynić się do poprawy ich jakości.

Słowa kluczowe: badania próbkowe, wnioskowanie statystyczne, badania ankietowe, *big data*.

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 83–97
https://doi.org/10.15678/AOC.2018.1805

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APPLICATION OF THE MULTIFRACTIONAL BROWNIAN MOTION PROCESS IN SPATIAL ANALYSES

Abstract

The article combines methodology applied for time series with elements of spatial econometrics. Its aim is to present a modified method of spatial modelling using selected stochastic processes and the application of that method in economics and other fields of science. The research hypothesis verified in this work can be described as follows: generalised to a multivariate case, Brownian motion processes are a useful tool in econometrics modelling as well as in the analysis of variability and correlation in space. The multifractional Brownian motion process is applied to conduct an analysis of the degree and variability of environmental pollution. The article comprises an introduction, a theoretical part in which concepts connected with the class of stochastic processes in question are clarified, and an empirical part, where selected applications of the aforementioned method are discussed.

Keywords: stochastic process, Hölder function, spatial modelling, variability analysis.
JEL Classification: C15, C32, C33, C51.

1. Introduction

Phenomena and processes that are the subject of studies in economics, environmental science and epidemiology take place in specified spatial--temporal conditions. Analysing these processes, we notice the influence of space and time on their course.

This article describes two types of modelling approach. Both – a methodology of time series including Brownian motion processes, and

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elements of spatial econometrics, in particular methods of new economic geography – are applied. Special attention is paid to processes with a so-called long memory. As early as 1952, T. Hagerstrand pointed to the existence of the memory effect in the spread of economic phenomena, while P. R. Krugman (1991) introduced the development of quantitative methods in spatial analyses. The generalised multifractional Brownian motion process is applied in the present work in the modelling of the variability of spatial data and in the study of spatial correlation. Pointwise Hölder exponents are used in the analysis of variability in space (Ayache & Lévy Véhel 1999, Mastalerz-Kodzis 2003). Selected elements of statistics and spatial econometrics are applied (Paelinck & Klaassen 1983, Suchecki 2010). Methods from time series analysis are implemented in the modelling of data in space and are generalised to a multivariate case (Lévy Véhel & Mendivil 2011, Falconer & Lévy-Véhel 2008, Ayache & Taqqu 2004, Barrière 2007, Echelard, Lévy Véhel and Barrière 2010).

Theoretical considerations connected with the presented topic were focused on, among others, the following works: Mastalerz-Kodzis (2003), Mastalerz-Kodzis (2016b), and Mastalerz-Kodzis and Pośpiech (2017). The aim of the article is to present a modified method of spatial modelling using selected stochastic processes and the application of that method in economics and other fields of science. The research hypothesis verified in this work can be described as follows: generalised to a multivariate case, Brownian motion processes are a useful tool in econometrics modelling as well as in the analysis of variability and correlation in space. The article is composed of two parts: theoretical and empirical.

2. Random Fields

When analysing phenomena and processes that are the subject of studies in economics, environmental science and epidemiology, we notice the influence of space and time on their course and form. Moreover, in almost all cases, the changes taking place are of a random character. Therefore, we must study them in the categories of random fields.

Let $Y_i, i=1,\ldots,k$ be a variable which undergoes random fluctuations in space, then $Y=[Y_1 \ \ldots \ Y_k]^T$ k – a dimensional random field, e.g. a function of the form $Y: D\times\Omega\rightarrow R^k, D\subset R^3$, such that for each $x_0\in D$ the value $Y(x_0,\omega)$ is a k-dimensional random vector determined on a set probabilistic space (Ω, A, P), whereby $R^3=\{(x_1,x_2,t)\}$, while x_1, x_2 stand for longitude and latitude, and t stands for the time variable.

Each of the components of vector Y is a random field, e.g. the function $Y_i: D \times \Omega \to R^1, i = 1, \ldots, k$, such that for each $x_0 \in D$ value $Y_i(x_0, \omega)$ is a random variable. If we determine a third time variable, then the random field $Y(x, \omega)$ is a static field and describes the course of an economic phenomenon in space; if, on the other hand, the variable undergoes fluctuations in time, then the random field also describes the dynamics of the examined phenomenon.

We can distinguish the following classes of random fields:

– homogeneous – invariable in regard to translation in R^3, e.g. $m(x + t_0) = m(x)$ (expected constant value) and $C(x_1 + t_0, x_2 + t_0) = C(x_1, x_2)$ – the covariance function for any $(x_1, x_2, t_0) \in R^3$,

– isotropic, for which the function of medium value and the correlation function are invariable in regard to rotations in R^3 (correlation depends on the distance between points).

We can prove that the multifractional Brownian motion is an isotropic, inhomogeneous random field, and that $E(Y(x, \omega)) = 0$ and $C(x, y) = \frac{1}{2}(|x| + |y| - |x - y|)$.

We agree on the following symbols: $Y(\cdot)$ – the level of the examined spatial-temporal phenomenon, $X(\cdot)$ – factors determining the phenomenon level, $u(\cdot)$ – a random field. Then: $f(Y(\cdot), X(\cdot)u(\cdot)) = 0$. The defined values depend on the spatial argument (of the point in the Euclidean space).

3. Modelling of Time Series with the Use of Stochastic Processes

3.1. General Remarks

The multifractional Brownian motion process (dependent on time) can be used in the modelling of time series. The process with stationary increments, which feature fractional parts of Brownian motion, depends on a constant parameter – the Hurst exponent. This exponent belongs to the range (0, 1) and divides the time series into: persistent – with a positive correlation between the subsequent implementations $(H \in (1/2, 1))$, and anti-persistent, in which the correlation is negative $(H \in (0, 1/2))$. A general case is considered below – processes dependent on the Hölder function. Fractional processes are an exceptional example of multifractional ones, that is, the constant Hölder function is the value of the Hurst exponent.

3.2. Pointwise Hölder Exponent

Let there be a function $f: D \to \Re\,(D \subset \Re)$ and a parameter $\alpha \in (0,1)$. Function f is a Hölder function of class C^{α}, if there are constants $c > 0$ and $h_0 > 0$ such that for each x as well as all of h such that $0 < h \leq h_0$ the following inequality is fulfilled (Daoudi, Lévy Véhe & Meyer 1998, Mastalerz-Kodzis 2003):

$$\left| f(x+h) - f(x) \right| \leq c h^{\alpha}. \tag{1}$$

The Hölder function is of class C^{α} in the surrounding of any point from the domain. As parameter $\alpha \in (0,1)$, we can consider fractional differentiation. The Hölder function is by definition a continuous function in the range. If the function is of class C^{l}, then the fractional value of the function graph equals one. When we only assume that the function is of class C^{0}, then the graph can feature a fractional measure. When we interpret the value of the derivative, then the speed of value variation at the change of the argument is determined. Therefore, when time is the argument (or geographical coordinates of location), then the value of the derivative is the speed of the variation in time (or variation resulting from location on a plane).

Let $x_0 \in D \subset \Re$. Function $f: D \to \Re$ is at point x_0 a Hölder function of class $C^{\alpha}_{x_0}$, if there are constants ε, $c > 0$ such that for each $x \in (x_0 - \varepsilon, x_0 + \varepsilon)$ the following inequality is fulfilled:

$$\left| f(x) - f(x_0) \right| \leq c \left| x - x_0 \right|^{\alpha}. \tag{2}$$

The Hölder point exponent of function f at point x_0 is the number $\alpha_f(x_0)$ expressed by the formula $\alpha_f(x_0) = \sup\{\, \alpha\colon f \in C^{\alpha}_{x_0}\}$. The Hölder function for function f is the function which to each of the points $x \in D$ assigns the number $\alpha_f(x)$.

3.3. Multifractional Brownian Process

Let $H_t\colon [0, \infty) \to (0,1)$ be a Hölder function with an exponent $a > 0$. A multi-fractional Brownian motion process with function parameter H_t is a stochastic process $B_{H_t}(t)$ defined for $t \geq 0$ by the formula (Ayache & Lévy Véhel 1999, Peltier & Lévy Véhel 1995, Mastalerz-Kodzis 2003):

$$B_{Ht}(t) = \frac{1}{\Gamma(H_t + \frac{1}{2})} \left\{ \int_{-\infty}^{0} \left[(t-s)^{H_t - 1/2} - (-s)^{H_t - 1/2} \right] dB(s) + \int_{0}^{t} (t-s)^{H_t - 1/2}\, dB(s) \right\}, \tag{3}$$

where B is the standard Brownian motion process.

The Hölder point exponents inform about the characteristics of the process. Among others, we note that the process does not feature stationary increments when the Hölder function is not constant, and the closer the values of the function are to zero, the bigger the variability of the graph; for function values close to one, the process is smoother. The regularity of the process measured with Hölder point exponents changes in the range (0, 1).

In the multifractional Brownian motion process, the Hölder function is a constant function, which means that the regularity of the process trajectory measured by this function also changes continuously. Further generalisation of the Brownian motion process is based on the replacement of the continuous Hölder function with an discontinuous one (Peltier & Lévy Véhel 1995). A generalised multifractional Brownian motion process, with function parameter $H(t)$ and λ – a real number, is process $\{B_{H,\lambda}(t)\}_{t\in\Re}$ such that for each $t\in\Re$:

$$B_{H,\lambda}(t)=\sum_{n=0}^{\infty}\int_{D_n}\frac{e^{it\xi}-1}{|\xi|^{H_n(t)+0,5}}dB(\xi), \tag{4}$$

where $D_0=\{\xi:\ |\xi|<1\}$ and for all $n\geq 1$ $D_n=\{\xi:\ \lambda^{n-1}\leq|\xi|<\lambda^n\}$.

The multifractional Brownian motion process can be generated with the use of random relocation of the segment midpoint method (Mastalerz-Kodzis 2003, Mastalerz-Kodzis 2016a). Values of the Hölder function close to zero imply a bigger variability of the process; the closer the exponents are to 1, the smaller the variability.

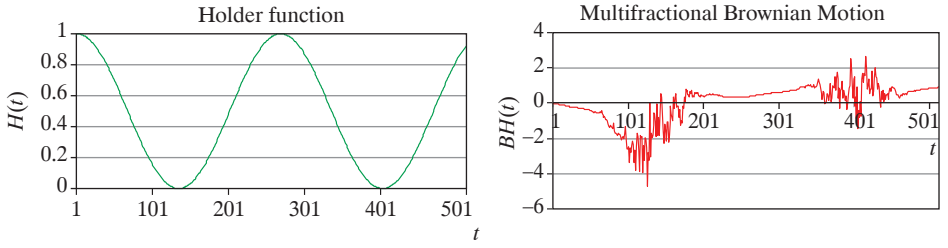

Fig. 1. Multifractional Brownian Motion Process: Hölder Function in the Form $H(t)=\cos^2(6t)$ and Process Simulation for the Set Function $H(t)$

Source: author's own study (formula (5)).

Generally, also in this stage the value of the process is set by the formula:

$$B_{H(t)}(t)=\frac{B(t-d)+B(t+d)}{2}+G\frac{\sqrt{1-2^{2H(t)-2}}}{2^{i*H(t)}}, \tag{5}$$

where $t - d$ and $t + d$ are the former points of time segment interval (0, 1) (see Figure 1).

According to the formula included in Peltier and Levy Vehel (1995) and Mastalerz-Kodzis (2003), we can also estimate pointwise Hölder exponents. Let us use the symbol $\{B_{i,n} = B_H(\frac{i}{n}), 0 \le i \le n\}$ to indicate a Brownian motion process with the Hurst exponent H. Let S_n be given by the formula $S_n = \frac{1}{n-1}\sum_{i=1}^{n-1} |B_{i+1,n} - B_{i,n}|$ and $H_n = -\frac{\log(\sqrt{\pi/2}\, S_n)}{\log(n-1)}$. Then $\lim_{n\to\infty} H_n = H$.

Let $1 < k < n$ be the length of the neighbourhood (range) used to estimate function H. We are going to estimate a function for t from the range $(k / n, 1 - (k / n))$.

Then the estimator $\hat{H}(i/(n-1))$ for $S_{k,n}(i) = \frac{m}{n-1}\sum_{j=i-k/2}^{i+k/2} |B_{j+1,n} - B_{j,n}|$ is as follows:

$$\hat{H}_{i/(n-1)} = -\frac{\log(\sqrt{\pi/2}\, S_{k,n}(i))}{\log(n-1)}. \tag{6}$$

4. Spatial Analyses with the Use of Hölder Function Properties

New Economic Geography (NEG) is a field of science and economics that deals with spatial aspects, among others, with the localisation of economic activity in the world (Suchecki 2010). In the 21st century, consideration of, for instance, the effects of globalisation or environmental pollution is possible, among others, with the use of NEG methods. It is considered that space (geographical location, distance, neighbourhood) has a significant influence on the formation of a given phenomenon or economic process.

In this article, multifractional Brownian motions are, in spatial terms, a tool that enables us to conduct spatial analyses; a study of the variability of the examined phenomenon depending on location and time is conducted. Using the Hölder function we can describe e.g. the differentiation of environmental pollution levels.

The pointwise Hölder exponent is dependent only on parameter t and is responsible for the variability of a process around any point in the range. However, taking into consideration the NEG approach, we can inquire about the application of methodology to spatial economic analyses, conditioning the analyses on specific points in space and taking into consideration the memory effect.

According to the literature (Ayache & Taqqu 2004, Barrière 2007, Echelard, Lévy Véhel and Barrière 2010, Falconer & Lévy-Véhel 2008, Lévy Véhel & Mendivil 2011), the application of methodology in NEG or, more broadly, in spatial econometrics, in analysis of spatial autocorrelation, and in the study of the temporal and spatial memory effect with the Hölder function is justified.

Therefore, generalising to a multivariate case, the Hölder function is dependent on time t and also on a point on a plane (x, y). Therefore, we obtain function $H_t(x, y)$ for $\alpha > 0$ and process $B_{H_t(x,y),\lambda}(x, y, t)$.

Let H be a continuous function. The two-dimensional multifractional Brownian motion process is a process with stationary or non-stationary increments with a covariance function expressed by the formula:

$$E(B_{H(.)}(x), B_{H(.)}(y)) = \| x \|^{H(x)+H(y)} + \| y \|^{H(x)+H(y)} - \| x - y \|^{H(x)+H(y)}. \tag{7}$$

The Hölder exponent measures the regularity of the function graph. If we assume that H is a differentiable function, then, with probability 1 for each (x, y), equality $\alpha_{B_{H(x,y)}}(x, y) = H(x, y)$ takes place. Works by Mastalerz-Kodzis (2016b) and Mastalerz-Kodzis and Pośpiech (2017) describe the way of generating spatial processes dependent on the Hölder function. The first iterative stage of generating the multifractional Brownian motion process in space can be expressed by the following formula:

$$B_{H_t(x,y),\lambda}(x, y, t) = \frac{B_{t-1}(x_1, y_1) + B_{t-1}(x_2, y_2)}{2} + \frac{\sqrt{1 - 2^{2H_t(x,y)-2}}}{2^{i*H_t(x,y)}}, \tag{8}$$

where $(x_1, y_1), (x_2, y_2)$ are the former division points, $H(x, y)$ is the value of the Hölder function for argument (x, y), whereas G in subsequent stages is a series of pseudorandom numbers that constitute the implementation of a variable with a normal distribution $N(0, 1)$.

5. Application of the Pointwise Hölder Exponent in Economic and Epidemiological Spatial Analyses and in Environmental Pollution Tests

Multifractional Brownian motions in spatial terms can be used as a tool that allows multidirectional socio-economic studies to be conducted. Using the value of the Hölder function we can describe e.g. the level of environmental pollution and the effects of an explosion. We can prove that the aforementioned values, as well as other socio-economic characteristics,

are characterised by memory, which means that historical observations (considerably distant or not so distant) influence current values.

We assume that a subset of two-dimensional space $D \in R^2$ and a range of time T is given. We can consider the following cases:

– a fixed moment in time $t_0 \in T$. We can construct a map of the process values in a given moment of time (scan for t_0);

– a fixed point $(x_0, y_0) \in R^2$ (e.g. geographical coordinates). In this case we consider a stochastic process with stationary or non-stationary increments dependent on t. We can use the methods for time series. In a given place $(x_0, y_0) \in R^2$ the process values are the values of any socio-economic characteristic. We analyse the variability of the characteristic in time in a two-dimensional chart and study the memory of the series. For example, in the surrounding area of a given point on a plane we analyse population density, the intensity of occurrence of a certain disease unit, etc. (Mastalerz-Kodzis 2016a, Mastalerz-Kodzis & Pośpiech 2017);

– on a continuous basis in the whole area of the analyses, changes in time and space can be illustrated in a film, where at a steady pace the expansion of a given phenomenon takes place, whereas its intensity is expressed by the point values of Hölder exponents with consideration of the memory effect.

The article by Mastalerz-Kodzis and Pośpiech (2017) describes the application of the aforementioned methods to analyse the spread of environmental pollution resulting from an explosion (in a strictly defined place on a plane with a consideration of time). The article suggests a computer simulation to measure the intensity of the spread of disease. In analyses of an economic nature, the effects of globalisation as well as spatial distribution, correlation, and the variability of characteristics are all described in the following works: Mastalerz-Kodzis (2016b), Mastalerz-Kodzis and Pośpiech (2017).

6. Analysis of the Spatial Variability of Sulphur Dioxide (SO_2) Concentration in the Air in the Silesia Region

Environmental pollution, and especially air pollution, is a serious problem in many cities in Poland as well as around the world. The effects of pollution have an impact on the lives and health of people. Various substances, many of which affect people's health very negatively, are present in the air. One of them is sulphur dioxide.

Sulphur dioxide (SO_2) is a colourless gas with a sharp, pungent and suffocating smell that severely irritates the respiratory tract. It is absorbed into

the human organism by nasal mucosa and the upper part of the respiratory tract. It is poisonous for animals and harmful for plants. Sulphur dioxide is formed as a result fossil fuels that contain sulphur being burned in industrial works, municipal heating plants, and individual boilers. SO_2 is responsible for smog in big urban agglomerations. The acceptable level of hourly sulphur dioxide concentration is 350 $\mu g/m^3$, and it may be exceeded not more than 24 times a year. The acceptable level of average daily concentration is 125 $\mu g/m^3$, and it may be exceeded not more than 3 times a year. An hourly sulphur dioxide concentration of 500 $\mu g/m^3$ is considered alarming.

Empirical analysis was conducted on the basis of data for Poland for the years 2000–2015. The data originates from more than 8,000 measurements per year (24 times per day) carried out by 137 measuring stations in Poland (source: Chief Inspectorate of Environmental Protection (GIOS)). We present the results below, limiting them to one of the most polluted regions in Poland – the region of Silesia. The main results for 17 stations in the province of Silesia and for the station on Babia Góra are included in Table 1. We should note the huge number of measurements (more than 8,300 for each station), which confirms the very high level of completeness of the data (94.8–99.2%). We clearly notice large differences between the minimum and maximum measurements. We can also see that the average concentration in the winter period is considerably higher than in the year as a whole.

Figure 2 presents selected average characteristics of environmental pollution due to SO_2 in years 2000–2015 for a selected station in the province of Silesia, located nearest to the centre of the capital of Silesia – Katowice. The time series indicate the decreasing average values of pollution indicators.

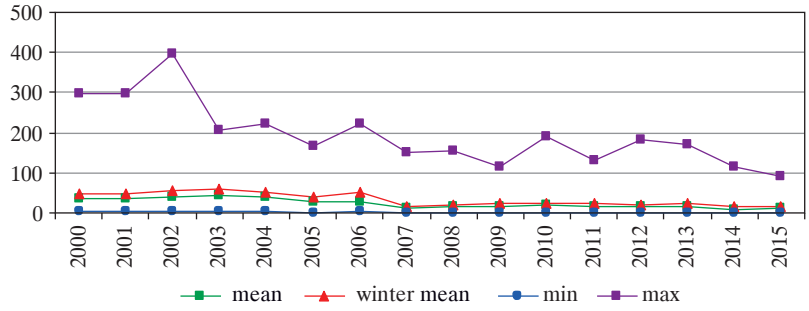

Fig. 2. Data on SO_2 Concentration at the SIKatoKossut Station, 2000–2015

Source: GIOS, www.powietrze.gios.gov.pl (accessed: 20 March 2017), and the author's own study.

Table 1. Measurement Results of SO_2 Concentration in the Air ($\mu g/m^3$) for 17 Stations in the Province of Silesia and on Babia Góra, 2015

No	Station code	Mean	Winter mean	Min	Max	Number of measurements	Completeness of data
1	SlDabro1000L	11.8	16.1	0.8	84.0	8470	96.7
2	SlGliwicMewy	11.3	16.8	0.8	87.1	8654	98.8
3	SlKatoKossut	12.7	16.5	0.8	91.3	8688	99.2
4	SlKatoPlebA4	13.0	16.4	0.1	99.6	8542	97.5
5	SlSosnoLubel	14.3	20.2	0.1	112.8	8559	97.7
6	SlTychyTolst	12.8	19.3	0.7	128.1	8625	98.5
7	SlZabSkloCur	16.0	23.4	0.9	198.8	8630	98.5
8	SlRybniBorki	14.3	20.4	0.1	231.0	8344	95.3
9	SlZorySikors	13.2	19.5	0.9	83.2	8305	94.8
10	SlBielKossak	9.7	14.4	0.6	79.0	8562	97.7
11	SlCzestoArmK	11.6	17.0	0.9	129.5	8502	97.1
12	SlCzestoBacz	9.8	13.7	0.3	107.9	8621	98.4
13	SlCiesMickie	10.2	13.7	0.7	91.0	8393	95.8
14	SlUstronSana	7.1	8.7	0.1	58.5	8688	99.2
15	SlWodzGalczy	14.5	20.9	0.6	131.1	8551	97.6
16	SlZlotPotLes	6.5	9.1	0.3	58.0	8480	96.8
17	SlZywieKoper	17.1	33.2	0.9	125.9	8475	96.7
18	KMŚ Babia Góra	0.6	1.3	0.0	4.2	8356	97.5

Source: GIOS. www.powietrze.gios.gov.pl (accessed: 20 March 2017), and the author's own study.

Figure 3 illustrates the data relating to the SIKatoKossut station. We present the measurements of SO_2 concentration in 2015 and the estimated pointwise Hölder exponents. Using the methodology described in the theoretical part of the article as well as the conducted research, we can draw the following conclusions:

– we observe much bigger values of the exponents for the period from April to October. This means that the 24-hour variability of the SO_2 pollution level is lower;

– lower values were recorded for the period from November to March. This suggests lower variability on the 24-hour pollution map and also positively correlates with a lower concentration of SO_2 pollution (Table 1);

– higher fluctuations were recorded in November and December. We can assume that this is connected with differences in air temperature and the consequent need for heating;

– a high level of pollution was recorded in stations located near to large clusters of houses in the months when the air temperature was low.

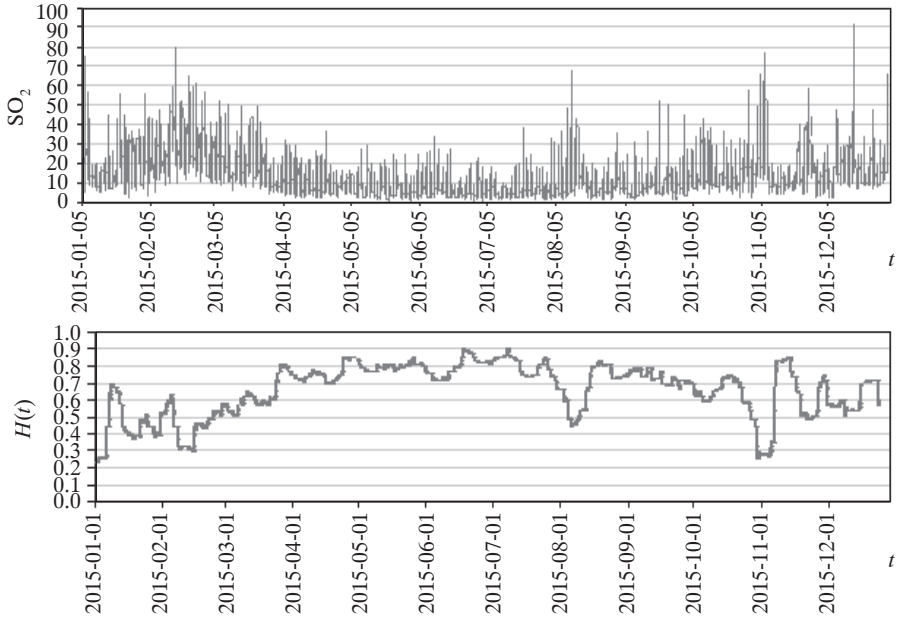

Fig. 3. Data on SO_2 Concentration ($\mu g/m^3$) at the SIKatoKossut Station, 2015. Estimated Pointwise Hölder Exponents

Source: GIOS, www.powietrze.gios.gov.pl (accessed: 20 March 2017), and the author's own calculations – estimation on the basis of formula (6).

Further, using the geographical coordinates of the measuring stations, we defined a matrix of Euclidean distances between the stations. According to its values, we calculated the coefficients of correlation. The results are presented in Table 2.

We can state that:

– the described methodology allows to define coefficients of correlation between selected environmental pollution characteristics for specified points in space at a specified moment in time;

– there exists a strong positive relationship between environmental pollution caused by SO_2 between measuring stations;

– the smaller the distance between stations, the stronger the relationship.

Table 2. Values of Correlation Coefficients with Consideration of the Memory Effect ($0.7 < H(x, y, t) < 0.76$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																		
2	0.96																	
3	0.92	0.89																
4	0.85	0.83	0.81															
5	0.76	0.74	0.73	0.69														
6	0.68	0.66	0.65	0.62	0.58													
7	0.46	0.45	0.44	0.43	0.41	0.39												
8	0.41	0.40	0.39	0.38	0.36	0.35	0.31											
9	0.99	0.95	0.92	0.85	0.76	0.67	0.46	0.41										
10	1.00	0.99	0.95	0.88	0.78	0.69	0.47	0.42	1.00									
11	0.67	0.65	0.64	0.62	0.58	0.54	0.39	0.35	0.67	0.69								
12	0.79	0.77	0.76	0.72	0.66	0.60	0.42	0.37	0.79	0.82	0.59							
13	0.92	0.89	0.86	0.80	0.72	0.64	0.44	0.39	0.91	0.95	0.64	0.75						
14	1.00	1.00	1.00	1.00	0.90	0.79	0.53	0.46	1.00	1.00	0.78	0.94	1.00					
15	0.66	0.64	0.63	0.60	0.57	0.53	0.39	0.34	0.65	0.67	0.53	0.58	0.63	0.77				
16	1.00	1.00	1.00	1.00	0.91	0.80	0.53	0.47	1.00	1.00	0.80	0.96	1.00	1.00	0.78			
17	0.69	0.35	0.24	0.43	0.33	0.25	0.31	0.32	0.21	0.20	0.24	0.15	0.06	0.13	0.06	0.51		
18	0.48	0.74	0.66	0.56	0.70	0.72	0.68	0.73	0.86	0.71	0.61	0.78	0.75	0.55	0.69	1.00	0.62	

Source: author's own calculation.

In the province of Silesia, one of the most polluted regions in Poland, there are 17 measuring stations. In provinces where the level of pollution is low, the number of measuring stations is smaller. In order to identify the geographical location of the main sources of environmental pollution,

the measuring stations should be located closer in those places where the pollution is high.

What is more, the analysed methodology comes from a self-similarity or a spatial statistical self-affinity test. When analysing a region, e.g. Silesia, we can identify large agglomerations with the highest level of pollution. When considering part of a region, a segment on a flat surface, the statistical parameters of the whole region are the same as for the sub-region (statistical self-similarity). In this case, many details become clearly visible and the analysis exposes the sources of SO_2 pollution more precisely.

7. Conclusion

Using methods deriving from the theory of stochastic processes to model the processes that take place in the surrounding world in a spatial perspective is a very useful tool as far as analyses are concerned. Connecting the methods of time series analysis and elements of spatial modelling is useful in view of the possibility to use methodology to model and analyse variability and correlation in space.

Currently, the use of stochastic process methods to model the structure and processes taking place in the surrounding world is a widely applied tool in theoretical and experimental studies, also in economics. Stochastic analysis allows us to determine the level of irregularity of the surface in a quantitative way and enables us to measure the expansion intensity of spatial phenomena. Connecting selected techniques of time series analysis and elements of spatial modelling with geometric methods is useful considering the possibility of using methodology in economic modelling and in analysis of the variability and intensity of spreading in time and space.

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Abstract

Zastosowanie multiułamkowego procesu ruchu Browna w analizach przestrzennych

W artykule połączono metodykę stosowaną dla szeregów czasowych z elementami ekonometrii przestrzennej. Celem było zaprezentowanie zmodyfikowanej metody modelowania przestrzennego za pomocą wybranych procesów stochastycznych, a także aplikacja omawianej metody w naukach ekonomicznych oraz innych dziedzinach nauk. Hipotezę badawczą sformułowano w następujący sposób: uogólnienie na przypadek wielowymiarowy multiułamkowego procesu ruchu Browna jest użytecznym narzędziem w procesie modelowania ekonometrycznego, a także w analizie zmienności i korelacji

w przestrzeni. W artykule zastosowano multiułamkowy proces ruchu Browna do badania stopnia oraz zmienności zanieczyszczenia środowiska. W części teoretycznej przybliżono pojęcia związane z omawianą klasą procesów stochastycznych, natomiast w części empirycznej omówiono wybrane zastosowania omawianych metod.

Słowa kluczowe: proces stochastyczny, funkcja Höldera, modelowanie przestrzenne, analiza zmienności.

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 99–113
https://doi.org/10.15678/AOC.2018.1806

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BANKS' CREDIT RATINGS – DOMESTIC AND FOREIGN NOTES

Abstract

The aim of the paper is to analyse the differences between foreign and domestic notes given to banks by credit rating agencies. Following a literature review, the following hypothesis was proposed: Financial indicators have a stronger impact on the credit ratings of domestic rather than of foreign banks. The hypothesis was verified using panel ordered probit models. The analysis was based on European banks' long-term issuer credit ratings given by S&P, Fitch and Moody between 2000 and 2015.

Keywords: credit rating, default risk, financial indicators, banking sector.
JEL Classification: G21, G24, G32, G33.

1. Introduction

Credit rating agencies play a significant role on the financial market. Their basic goal is to reduce the asymmetry of information between investors and issuers, especially when making investment decisions. Credit rating agencies present issuer-paid and investor-paid notes. In previous research it has been suggested that credit ratings paid by issuers are inflated (Griffin, Nickerson & Tang 2013, Bongaerts 2014, Xia & Strobl 2012, Jiang, Stanford & Xie 2012). Rating inflation can be an effect of the competition between credit rating agencies (CRAs). If issuers pay for notes, CRAs give better notes in order to attract customers (Griffin, Nickerson & Tang 2013). The use of private benefits allows for undesirable opportunistic behaviour in a fully rational model (Opp, Opp & Harris 2013, Winton & Yerramilli 2011). The rating inflation effect is not a result of naïve investors (Bolton, Freixas

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& Shapiro 2012) or unethical CRAs (Mathis, McAndrews & Rochet 2009). Private benefits for investors have similar effects (Bongaerts 2012).

The second type of credit rating is division into domestic and foreign notes. The literature suggests that the impact of financial factors can be differentiated. Foreign currency ratings refer to an entity's ability and willingness to meet its foreign-currency-denominated financial obligations as they become due. They take into account the likelihood of the government imposing restrictions on the conversion of local currency to foreign currency or on the transfer of foreign currency to residents and non-residents. On the other hand, local currency notes are an opinion of an entity's ability and willingness to meet all of its financial obligations on a timely basis, regardless of the currency in which those obligations are denominated, or absent transfer, or convertibility restrictions. Both mentioned types of ratings are internationally comparable assessments.

The described phenomenon suggests that differences may exist between the impact of factors on the domestic and on the foreign credit ratings. In previous studies issuer notes are used in most cases to analyse the impact of credit rating determinants. The aforementioned situation is connected with the fact that credit ratings are in most cases paid by issuers. Consequently, in this paper I focus on long-term issuer credit ratings. Notes proposed for banks by CRAs were used in the analysis. Credit ratings are most popular in banks, because they are notes used for correspondent banking, investment decisions, assessment of credit risk and international banking. As a result, banks are the most important clients of credit rating agencies.

According to the best knowledge of the author, the analysis concerning differences between domestic and foreign factors has not been previously verified. In previous studies we find some research that takes into account banks' credit rating determinants. The assessment of default risk during the estimation of credit ratings consists of three stages. The first is to verify the impact of the country's macroeconomic situation on the financial condition of the assessed entity. Then the impact of the condition of the sector is examined. The final step in the analysis prepared by credit rating agencies is to study the financial condition of the entity.

The aim of this paper is therefore to analyse the differences between foreign and domestic notes given to banks by credit rating agencies. As the factors analysed include the determinants of foreign and domestic credit ratings, only the financial factors of the issuers were taken into account in the analysis. The following hypothesis was proposed: Financial indicators have a stronger impact on the credit ratings of domestic rather than of

foreign banks. To verify the hypothesis, data for European banks between 2000 and 2015 was collected. The analysis was based on European banks' long-term issuer credit ratings given by S&P, Fitch and Moody.

The paper is organised as follows. Section 2 describes previous studies on the factors influencing banks' credit ratings. Section 3 describes the methodology and data. Next (section 4) the differences between the factors of particular credit rating agencies, divided into foreign and domestic credit ratings, are tested. Section 5 offers some conclusions.

2. Literature Review

The first group of research relies on an analysis of the macroeconomic factors in banks' credit ratings. B. Aver (2008) found that the employment or unemployment rate, short- and long-term interest rates and the stock exchange index have a significant impact on the banks' credit risk. The informant factors include the GDP growth (industrial production), exchange rates, and the growth of imports and exports. G. M. Caporale and R. Matousek and C. Stewart (2009) prepared a country index as a measure of macroeconomic risk. In their opinion, a strong relationship exists between the mentioned factor and banks' notes. On the other hand, E. Bissoondoyal--Bheenick and S. Treepongkaruna (2009) found that macroeconomic factors, such as GDP and inflation, have no significant impact on banks' credit ratings. The same results were obtained by W. P. H. Poon, M. Firth and H. Fung (1999) and A. Peresetsky and A. Karminsky (2008).

In the methodology presented by the three largest credit rating agencies, the impact of the sector's financial condition is also taken into consideration. The analysis prepared by F. Pasiouras, C. Gaganis and C. Zopounidis (2006) suggests that banks' notes can have a statistically significant influence on banks' regulations, supervision (measured by capital requirements, restrictions imposed on bank activities, disciplinary power, auditing, entry requirements, economic freedom) and market structure (treated as the share of banks owned by governments or foreign investors), and on bank ratings, apart from traditional bank-specific variables.

The next group of research verifies the impact of the financial indicators' impact on banks' credit ratings. O. A. G. Hassan and R. Barell (2013) prepared an analysis on a sample of US and UK banks based on data from 1994 to 2009 using an ordered probit model. They found out that only a small number of variables had a significant impact on banks' notes. The size, liquidity, efficiency and profitability of banks correctly assign

credit ratings for approximately 74% to 78%. CRAs do not take into consideration leverage asset quality and capital during the estimation of notes. A similar type of research was presented by E. Bissoondoyal-Bheenick and S. Treepongkaruna (2009), who verified factors influencing UK and Australian banks. To prepare the analysis they used short-term and long--term issuer credit ratings proposed by the three largest rating agencies. They found that non-performing loans, total capital ratio, liquid assets to total assets, and return on assets provide relevant information for CRAs to estimate the default risk and banks' notes. W. P. H. Poon, M. Firth and H. Fung (1999) performed an analysis on banks from 50 countries that received notes from Moody. They found out that loan loss provision and profitability ratios are significant for estimation of credit ratings. A. Peresetsky and A. Karminsky (2008) suggested that profitability, liquidity and loan loss provisions were taken into account as major bank characteristics. Credit rating determinants were also studied by G. M. Caporale and R. Matousek and C. Stewart (2009). They used Fitch notes for their analysis. They divided their research into four categories. As variables for banks' financial condition they used total assets, net interest margin, return on equity, liquid to total assets ratio, operating expenses and non-performing loans. F. Pasiouras, C. Gaganis and C. Zopounidis (2006) found that banks with higher profitability, liquidity and efficiency receive higher credit ratings. On the other hand, the negative impact of capital adequacy has been observed. Credit rating agencies suggest that banks' notes largely rely on historical data, which makes them respond sluggishly and after any financial problems are already known to the public (Gogas, Papadimitriou & Agrapetidou 2013).

An analysis of the factors influencing banks' credit ratings has been prepared for subsamples. C. Shen, Y. Huang and I. Hasan (2012) verified the factors influencing banks' credit ratings from 86 countries in the years 2002–2008. They take into consideration: profitability, liquidity, capital, efficiency and quality factors. They divided their sample according to the country's level of development, its geographical location, the quality of the industrial environment (traditions of respect for law and order, the bureaucracy, the level of corruption, and the quality of information), and those with low or high information asymmetry. The effects of financial ratios on ratings are significantly affected by information asymmetries. E. Laere, J. Vantieghem and B. Baesens (2012), by using the classification notes for Moody's and S&P's credit ratings, found that Moody's notes are more sensitive to the condition of the economy. In their opinion, the

level of discretion in the rating process increases with bank opacity and this effect seems higher for Moody's. The analysis of the impact of the size of the assessment of banks was verified by H. Hau, S. Langfield and D. Marques-Ibanez (2012). Rating agencies receive additional earnings from securitisation business provided by larger banks. The analysis of the methodology prepared by a particular credit rating agency was also prepared for a period before and after the crisis (Packer & Tarashev 2011).

This literature review suggests that in previous studies the strength of the impact of financial indicators on the domestic and on the foreign credit ratings was not verified. As a result, the aim of this paper is to analyse the differences between the aforementioned notes given to banks by credit ratings agencies. The following hypothesis has been proposed: Financial indicators have a stronger impact on the credit ratings of domestic rather than of foreign banks.

3. Methodology

The aim of the paper is to analyse the differences between foreign and domestic notes given to banks by credit rating agencies. Quarterly data from 2000 to 2015 was collected for 731 banks from European countries[1] from Thomson Reuters. Credit ratings were decomposed linearly according to the methodology proposed by G. Ferri, L. G. Liu and J. Stiglitz (1999). The results of the decomposition are presented in Table 1.

The dependent variable is the banks' long-term issuer credit ratings published by S&P, Fitch and Moody. As independent variables are treated financial factors belong to: capital adequacy, assets quality, management quality, efficiency and liquidity. To verify the hypothesis, the sample was divided into two groups: foreign long-term issuer credit ratings and domestic long-term issuer credit ratings. The panel ordered probit model was used:

$$y^*_{it} = \beta F'_{it} + \gamma Z_{it} + \delta(F \cdot Z)_{it} + \varepsilon_{it},$$

where:

y_{it} is an unobservable latent variable that measures the credit-worthiness of a bank i in period t (Fitch Long-term Issuer Rating, S&P Long-term Issuer Rating, Moody's Long-term Issuer Rating) for European banks.

[1] Albania, Armenia, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lichtenstein, Lithuania, Luxembourg, Macedonia, Malta, Moldavia, Monaco, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom.

Table 1. Long-term Issuer Credit Ratings Decomposition

Moody's Long-term Issuer Rating		S&P's Long-term Issuer Rating		Fitch's Long-term Issuer Rating	
Rating	Code	Rating	Code	Rating	Code
Aaa	100	AAA	100	AAA	100
Aa1	95.24	AA+	95	AA+	94.74
Aa2	90.48	AA	90	AA	89.47
Aa3	85.71	AA–	85	AA–	84.21
A1	80.95	A+	80	A+	78.95
A2	76.19	A	75	A	73.68
A3	71.43	A–	70	A–	68.42
Baa1	66.67	BBB+	65	BBB+	63.16
Baa2	61.90	BBB	60	BBB	57.89
Baa3	57.14	BBB–	55	BBB–	52.63
Ba1	52.38	BB+	50	BB+	47.37
Ba2	47.62	BB	45	BB	42.11
Ba3	42.86	BB–	40	BB–	36.84
B1	38.10	B+	35	B+	31.58
B2	33.33	B	30	B	26.32
B3	28.57	B–	25	B–	21.05
Caa1	23.81	CCC+	20	CCC	15.79
Caa2	19.05	CCC	15	CC	10.53
Caa3	14.29	CCC–	10	C	5.26
Caa	9.52	CC	5	RD	–5
Ca	4.76	NR	0	D	–5
C	0	SD. D	–5	WD	–5
WR	–5	NULL	0	–	–
NULL	0	–	–	–	–

Source: prepared by the author.

F_{it} is a vector of explanatory variables, i.e.:

$$F_{it} = (tier_{it}, lev_{it}, llp_{it}, npl_{it}, ef_{it}, sec_{it}, nii_{it}, roe_{it}, roa_{it}, opl_{it}, lg_{it}, dg_{it}, dep_{it}, sht_{it}, liq_{it}, dep_{it}),$$

where:

$tier_{it}$ is the Tier 1 ratio, lev_{it} is the leverage ratio, llp_{it} is the loan loss provisions as a percentage of average total loans, npl_{it} is the non-performing loans to total loans, ef_{it} is the efficiency ratio, sec_{it} is the value of securities

as a percentage of earnings assets, nii_{it} is the net interest income ratio, roe_{it} is the return on equity, roa_{it} is the return on assets, opl_{it} is the operating leverage, lg_{it} is the loan growth, dg_{it} is the deposit growth, dep_{it} is the ratio of loans to deposit, sht_{it} is the value of short-term borrowing to total liabilities, liq_{it} is the value of liquid assets to total assets, Z_{it} contains time invariant regressors that are generally dummy variables, ε_{it} is a random disturbance term.

4. Findings

The analysis of the determinants influencing banks' foreign and domestic credit ratings begins with a presentation of the descriptive statistics. The results of the estimation are presented in Table 2. The results obtained suggest that some variables have too few observations to prepare panel ordered probit models. The aforementioned factors include: the efficiency ratio, the return on equity, and non-performing loans to total loans. Because of the small number of observations, separate models have been prepared taking into account the tier 1 ratio and the value of short-term borrowing to total liabilities. The results of the estimation of the impact of financial indicators on credit ratings given by the three biggest CRAs are presented in Tables 3 and 4.

The first group of factors includes those connected with capital adequacy. Tier 1 and leverage ratios are taken into consideration in the group of factors analysed. The Tier 1 ratio has a stronger influence on the foreign notes than on the domestic ones, except for Moody's credit ratings. These differences are quite small. In all cases the increase of Tier 1 causes the downgrade of notes. If the aforementioned variable is too high, it may suggest a higher risk. The impact of the leverage ratio is nearly 0, and in most cases statistically insignificant. No differences between the influence on the domestic and on the foreign credit ratings have been observed either.

The second group of variables verified are those responding to asset quality. One of the measures taken into consideration in the analysis is loan loss provisions as a percentage of average total loans. An increase in the aforementioned variable causes a decrease in credit ratings, except for notes proposed by Moody's. A stronger impact of S&P foreign credit ratings changes than domestic ones was also observed. The negative relationship between the aforementioned variables may be connected with the size of the financial market. On the other hand, if banks make higher-risk loans, they

have to create higher loan loss provisions. As a result, in most cases credit rating agencies treat the higher value of this indicator as a higher credit risk.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
nim	294	3.314888	2.064696	0.496	14.697
ef	546	49.61538	79.48469	–1358.437	327.9935
opl	5241	0.7564703	373.9874	–21059.19	10346.08
llp	4771	1.040742	40.34527	–939.1807	2524.489
tier	2966	12.0013	4.319903	1	52.32019
npl	1258	14.4946	45.35921	0.0000118	475.2475
dep	5170	38.72783	1025.769	–0.0378518	59681.4
sec	5131	20.13894	16.69626	0	129.0259
roa	5592	0.1219394	2.948981	–94.76012	49.42894
roe	378	–1.072151	27.54114	–436.544	57.72256
dg	4678	1.661267	74.27182	–1	4135.54
lg	4720	0.2407734	14.00431	–24.55279	960.9088
lev	5723	16.26293	45.79581	–920.5047	1934.706
nii	5057	0.0676625	0.2712278	–0.010065	18.63425
sht	1806	0.1153017	0.1836614	0	0.9723631
liq	5185	0.0585781	0.061167	6.08e-06	0.4501707
Fitchf	13387	25.14443	37.11777	–5	100
Moodyf	5675	74.32159	18.28831	–5	100
SPf	16199	64.33021	19.96738	–5	100
Fitchd	2169	4.095145	20.10829	–5	78.94736
Moodyd	5662	73.82904	18.64864	–5	100
SPd	17031	61.86542	23.57325	–5	100

Source: prepared by the author.

Credit rating agencies also take management quality factors into consideration. In this analysis, as a measure of the aforementioned group of indicators the value of securities as a percentage of earnings assets was used. In most cases this variable has an insignificant impact on banks' credit ratings, both in the domestic and foreign group of notes.

As a measure of liquidity, the following factors were used: the ratio of loans to deposits, the value of short-term borrowing to total liabilities, and the value of liquid assets to total assets. The impact of the first of

Table 3. Estimation of the Impact of Financial Indicators on the Domestic and Foreign Credit Ratings Given to Banks by S&P

Variable	S&P Foreign						S&P Domestic			
	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$
opl	–0.004	0.001	–0.003	0.000	–0.001	0.204	–0.003	0.000	–0.001	0.021
llp	0.175	0.001	0.109	0.011	–0.004	0.911	0.110	0.010	0.009	0.814
tier	–0.119	0.000	–0.088	0.000	–	–	–0.084	0.000	–	–
dep	1.122	0.005	0.068	0.618	0.473	0.000	0.109	0.422	0.284	0.001
sec	0.009	0.032	0.003	0.385	–0.002	0.567	–0.001	0.815	–0.004	0.208
roa	1.876	0.000	1.099	0.000	0.217	0.001	1.046	0.000	0.392	0.000
dg	2.443	0.002	0.280	0.027	–0.189	0.023	0.279	0.028	–0.210	0.011
lg	–0.908	0.111	–0.008	0.809	0.049	0.082	–0.007	0.839	0.055	0.053
lev	0.048	0.000	0.025	0.000	0.014	0.000	0.025	0.000	0.014	0.000
nii	20.452	0.000	13.195	0.000	7.200	0.000	12.934	0.000	5.577	0.000
sht	12.927	0.000	–	–	–	–	–	–	–	–
liq	4.910	0.097	6.323	0.000	1.078	0.304	6.017	0.000	–0.058	0.953
/cut1	–3.586	0.000	–5.504	0.000	–3.401	0.000	–3.431	0.000	–2.270	0.000
/cut2	–2.251	0.013	–4.319	0.000	–2.906	0.000	–2.810	0.000	–2.253	0.000
/cut3	–1.520	0.089	–3.333	0.000	–2.381	0.000	–2.433	0.000	–2.038	0.000
/cut4	–1.230	0.169	–2.765	0.000	–2.325	0.000	–2.187	0.000	–1.881	0.000
/cut5	–0.540	0.545	–2.503	0.000	–1.944	0.000	–1.952	0.000	–1.854	0.000
/cut6	0.163	0.855	–2.069	0.000	–1.751	0.000	–1.547	0.003	–1.695	0.000
/cut7	1.028	0.251	–1.614	0.000	–1.158	0.005	–1.114	0.030	–1.557	0.001
/cut8	1.236	0.168	–1.150	0.012	–0.566	0.173	–0.669	0.193	–1.072	0.027
/cut9	1.683	0.062	–0.928	0.044	–0.239	0.565	–0.463	0.368	–0.544	0.261
/cut10	3.579	0.000	–0.532	0.247	–0.032	0.939	0.062	0.904	–0.258	0.595
/cut11	4.938	0.000	0.111	0.808	0.406	0.329	0.685	0.184	–0.079	0.871
/cut12	6.440	0.000	0.999	0.030	0.977	0.019	1.558	0.003	0.695	0.153
/cut13	8.333	0.000	2.620	0.000	1.820	0.000	3.204	0.000	1.217	0.012
/cut14	9.663	0.000	3.634	0.000	3.243	0.000	4.211	0.000	2.050	0.000
/cut15	10.720	0.000	5.285	0.000	4.097	0.000	5.868	0.000	3.493	0.000
/cut16	–	–	6.097	0.000	5.537	0.000	6.684	0.000	4.340	0.000
/cut17	–	–	–	–	6.399	0.000	–	–	5.781	0.000
/cut18	–	–	–	–	–	–	–	–	6.649	0.000
obs	459	–	1265	–	1740	–	1310	–	2011	–
group	39	–	61	–	65	–	67	–	72	–
Wald	0.0000	–	0.0000	–	0.0000	–	0.0000	–	0.0000	–

Source: prepared by the author.

these indicators is stronger during the estimation of domestic notes. The small number of observations discouraged the author from comparing the influence of short-term borrowing as a percentage of total liabilities in the domestic and foreign subsamples. The last of these liquidity indicators, the value of liquid assets to total assets, strongly influences the domestic long-term issuer credit ratings presented by Fitch. A weaker reaction in the case of domestic notes was observed in the case of S&P and Moody's.

The last group of factors taken into consideration during the analysis is efficiency indicators. This group of determinants includes: the net interest income ratio, the return on assets, the loan growth and the deposit growth. In the case of Fitch and Moody's long-term issuer credit ratings, a stronger significant reaction to the net interest income ratio is observed in the case of domestic notes. In both cases credit ratings are very sensitive to changes in the aforementioned variable. The return on assets significantly influences each type of credit rating presented by all the credit rating agencies. A stronger reaction to these changes follows for domestic notes than for foreign ones. The last part of the analysis relies on verification of the impact of the growth of deposits and loans. Deposit growth is significant for notes proposed by all credit rating agencies. The domestic notes react strongly to the aforementioned changes, but the direction of the reaction is differentiated. If deposit growth is stronger than loan growth, problems with excess liquidity may occur. On the other hand, the opposite reaction can generate significant problems with liquidity shortage. The described relationship can also generate higher costs connected with bank financing. Deposit acquisition creates interest costs. On the other hand, a high value of deposits can reduce the default risk. Loan growth is more significant for domestic notes proposed by Fitch, Moody's and S&P.

The analysis suggests that financial indicators strongly influence the estimation of the domestic, but not so much the foreign credit ratings proposed by Fitch, S&P and Moody's. This situation could be an effect of using macroeconomic variables during the estimation of the countries' risk and the condition of the banking sector. On the other hand, it could suggest that, when analysing domestic notes, credit rating agencies rely on qualitative variables much more than in the case of foreign credit ratings. The presented findings are also similar for notes generated by Fitch and Moody.

Table 4. Estimation of the Impact of Financial Indicators on the Domestic and Foreign Credit Ratings Given to Banks by Moody and Fitch

Variable	Fitch Foreign						Fitch Domestic		Moody Foreign				Moody Domestic			
	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$
opl	–0.001	0.779	–0.001	0.477	0.000	0.947	0.001	0.870	–0.002	0.071	–0.002	0.116	–0.003	0.018	–0.002	0.168
llp	–4.677	0.020	–3.760	0.000	–0.120	0.173	0.332	0.201	0.133	0.020	0.112	0.038	0.175	0.007	0.111	0.057
tier	–0.169	0.023	–0.236	0.000	–	–	–	–	–0.109	0.000	–	–	–0.121	0.000	–	–
dep	–1.179	0.050	–0.840	0.000	0.000	0.335	–0.001	0.561	–0.002	0.873	–0.004	0.768	–0.002	0.893	–0.007	0.572
sec	0.021	0.087	0.010	0.107	0.006	0.103	0.046	0.104	0.004	0.454	–0.006	0.227	0.001	0.791	–0.007	0.162
roa	1.094	0.365	0.841	0.010	0.129	0.183	–0.023	0.929	1.216	0.001	0.493	0.065	1.629	0.000	0.526	0.071
dg	2.109	0.213	–0.238	0.685	–0.071	0.548	–0.561	0.282	0.318	0.500	–0.389	0.001	0.218	0.646	–0.396	0.001
lg	0.489	0.471	–0.005	0.949	–0.075	0.337	4.171	0.000	0.269	0.722	1.297	0.010	–0.090	0.701	0.230	0.002
lev	–0.022	0.099	0.000	0.972	0.006	0.000	–0.084	0.286	0.021	0.000	0.008	0.000	0.013	0.002	0.006	0.001
nii	–35.270	0.005	–1.559	0.489	2.306	0.001	7.241	0.230	5.175	0.041	0.248	0.876	5.967	0.019	0.517	0.751
sht	12.743	0.000	–	–	–	–	–	–	–	–	–	–	–	–	–	–
liq	–1.303	0.852	–5.402	0.024	–5.748	0.000	–9.191	0.117	–3.118	0.153	–14.192	0.000	–0.002	0.999	–12.551	0.000
/cut1	0.347	0.824	–2.222	0.000	1.213	0.000	2.698	0.095	–4.838	0.000	–4.523	0.000	–4.820	0.000	–4.267	0.000
/cut2	0.656	0.675	–1.810	0.000	1.536	0.000	3.251	0.046	–3.852	0.000	–3.608	0.000	–3.914	0.000	–3.448	0.000
/cut3	0.753	0.631	–1.757	0.000	1.543	0.000	3.509	0.031	–3.770	0.000	–3.540	0.000	–3.835	0.000	–3.385	0.000
/cut4	1.138	0.468	–1.612	0.001	1.547	0.000	4.558	0.006	–3.098	0.000	–2.943	0.000	–3.182	0.000	–2.815	0.000
/cut5	2.114	0.184	–1.520	0.002	1.602	0.000	–	–	–3.061	0.000	–2.884	0.000	–3.145	0.000	–2.758	0.000
/cut6	3.240	0.051	–1.310	0.007	1.626	0.000	–	–	–3.025	0.000	–2.715	0.000	–3.109	0.000	–2.730	0.000
/cut7	–	–	–0.379	0.441	1.634	0.000	–	–	–2.705	0.000	–2.472	0.000	–2.524	0.000	–2.230	0.000
/cut8	–	–	–0.339	0.491	1.641	0.000	–	–	–2.493	0.000	–2.295	0.000	–2.322	0.000	–1.964	0.000
/cut9	–	–	0.340	0.526	1.651	0.000	–	–	–1.798	0.000	–1.641	0.000	–1.804	0.000	–1.476	0.000
/cut10	–	–	–	–	1.696	0.000	–	–	–1.510	0.001	–1.304	0.001	–1.565	0.001	–1.179	0.002

Table 4 cnt'd

Variable	Fitch Foreign						Fitch Domestic		Moody Foreign				Moody Domestic			
	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$
/cut11	–	–	–	–	1.825	0.000	–	–	–0.756	0.098	–0.649	0.095	–0.887	0.054	–0.574	0.139
/cut12	–	–	–	–	1.939	0.000	–	–	–0.013	0.977	–0.021	0.957	–0.122	0.790	0.071	0.855
/cut13	–	–	–	–	2.113	0.000	–	–	0.919	0.046	1.013	0.009	0.815	0.077	1.049	0.007
/cut14	–	–	–	–	2.830	0.000	–	–	1.900	0.000	1.989	0.000	1.742	0.000	1.984	0.000
/cut15	–	–	–	–	3.143	0.000	–	–	3.471	0.000	3.412	0.000	3.937	0.000	3.976	0.000
/cut16	–	–	–		3.444	0.000	–	–	–	–	–	–	–	–	–	–
obs	507		1396		2192		329		529		648		482		583	
group	47		65		73		13		18		18		17		17	
Wald	0.0000		0.0000		0.0000		0.0006		0.0000		0.0000		0.0000		0.0000	

Source: prepared by the author.

5. Conclusions

Credit rating agencies prepare various types of notes. These include domestic and foreign long-term issuer credit ratings. As a result, the aim of the paper has been to analyse the differences between foreign and domestic notes given to banks by credit rating agencies. The hypothesis verified with the use of panel ordered probit models was as follows: Financial indicators have a stronger impact on the credit ratings of domestic rather than of foreign banks. The findings confirm this hypothesis, but the differences between the financial factors and their impact on the credit ratings are small.

In the opinion of practitioners, researchers and the European Commission, credit rating agencies can generate inflated ratings. In the present study, this phenomenon was not observed. To determine the national-scale credit rating, credit rating agencies use criteria that are similar to global-scale criteria. Typically, we first determine our view of creditworthiness on the global scale. Country-specific national-scale criteria provide additional guidance to determine the finer distinctions between credit quality on the national scale. The use of different methodology by credit rating agencies makes domestic issuer credit ratings typically remain within one or two notches of the foreign notes. The analysis suggests that efficiency indicators have the strongest influence on notes.

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Abstract

Credit ratingi banków – noty dotyczące zobowiązań w walucie krajowej i zagranicznej

Celem artykułu jest analiza różnic w notach dotyczących zobowiązań wyrażonych w walucie krajowej i zagranicznej. Przeprowadzono badania literaturowe i postawiono następującą hipotezę badawczą: wskaźniki finansowe silniej wpływają na credit rating banku dotyczący zobowiązań w walucie krajowej niż zagranicznej. Hipoteza została zweryfikowana z użyciem panelowych uproszczonych modeli probitowych. Analiza została przygotowana dla długoterminowych ratingów emitenta europejskich banków, które zostały nadane przez S&P, Fitch i Moody w latach 2000–2015.

Słowa kluczowe: credit rating, ryzyko upadłości, wskaźniki finansowe, sektor bankowy.

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 115–127
https://doi.org/10.15678/AOC.2018.1807

Anna Ząbkowicz

CAPITAL-BASED PENSION FUNDS: THE QUESTION OF RISK SHARING

Abstract

Capital-based pension funds are built from the contributions of their participants and are invested in financial assets. Failed investments cause a fund's capital to shrink, which generates a risk of low pension benefits and/or the insolvency of the fund. The risk can be shared between contributors, pension fund management companies, and the state (under a mandatory pension funds regime). This article attempts to emphasise that, particularly in the case of old-age insurance, the problem of who runs the most risk is pivotal and deserving of greater concern than the issue of whether the rate of return on investment is high enough. The aim is to draw attention to this rather neglected aspect of the recent reforms of the old-age insurance industry.

The method relies on an ordered analysis founded on a review of the relevant subject literature. The point is made that the change from the Defined Benefit (DB) to the Defined Contribution (DC) formula shifts most of the risk onto contributors. On the other hand, this change makes the business relatively safe for private insurers and banks and reduces pressure on the public finance balance sheet. The shift from DB to DC schemes is rather common in Europe, hence the main issues tackled in the article are relevant to a fairly big group of countries (including Poland).

The article discusses the issue of risk-sharing in reference to the modern experience of Chile, a country that pioneered changes with respect to capital-based pensions and DC schemes. It concludes that the element of social solidarity recently introduced into the Chilean system brings some relief to low-income workers and also supports the longevity of the fully-funded Defined Contribution system.

Keywords: pension reforms, funded pensions, Chile, Defined Contribution formula.
JEL Classification: P16, B52.

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1. Introduction

Old-age security is largely placed in the insurance industry, where risk constitutes a crucial value. In Latin American countries as well as in East European countries, the insurance principle can be said to be a consequence of structural pension reforms. The first wave of these reforms originated in Chile, and in the course of the 1980s came to embrace the populations of many other Latin American countries. The second wave, heavily supported by World Bank expertise, reached Poland and numerous countries in Eastern Europe at turn of the 1990s and 2000s. Meanwhile, in the developed countries one could observe a change which, though of a much less radical nature, seemed to be of the same orientation.

The radical standard consisted of twin reforms. The first introduced capital-based pension funds, while the other completely changed the formula for calculating pensions. The idea was to convert pension savings into contributions to privately-managed capital funds. This meant a shift in old--age security systems away from public pension schemes on a pay-as-you-go (PAYG) basis towards individual pension plans on a capital basis. The latter means that funds are used as capital and invested in financial assets, the investment being managed by private companies. In Chile, financing on a PAYG-basis was gradually phased out after 1982, and the country moved towards a fully-funded pension system.

Another fundamental change was the completely different formula for calculating pensions, which determines risk-sharing in the industry. Here, risk is seen as financial responsibility for investment outcomes. Fundamental to risk-sharing in the pension industry is the principle that governs benefits and contributions, suffice it to say that the former principle was replaced with a so-called Defined Contribution (DC) formula. Strikingly, this change, being a common component of reforms aimed at introducing capital-based pension funds, is somewhat absent in public and economic debate or is eclipsed by the issue of whether the rate of return of capital-based pension funds is high enough.

By contrast, this article attempts to demonstrate that the question of who is most exposed to risk seems to be of the utmost importance, particularly in the old-age insurance industry. It discusses the issue of risk-sharing in reference to the modern experience of Chile, a country that pioneered radical changes with respect to both strands of pension reform. Next, it discusses the distributional meaning of the Defined Contribution formula. Then it briefly reviews the most recent reforms in Chile and concludes they

are not going to constitute a counter-revolution as regards the formula for calculating pensions. The Chilean case supports the observation, which may have more general application, that introducing state guarantees into a pension system and thus delivering relief to the lowest social strata may, paradoxically, preserve the system of risk-sharing that makes those strata suffer in the first place.

2. Risk-sharing under a Defined Contribution Formula

As pension funds are built from the contributions of their participants and are used as capital to be invested in financial assets, the risk of failed investments can be shared between contributors, fund management companies, and the state (Barr & Diamond 2009). The point to be made here is that replacing the Defined Benefit formula with a Defined Contribution formula has shifted most of the risk onto contributors.

This risk demonstrates itself in two ways. The outcome of failed investments is that the pension capital shrinks, which generates a risk of low pension benefits and/or the insolvency of the fund. In the event of pension fund insolvency, the question of risk-sharing must discriminate between funds accumulated on a mandatory-insurance basis and those accumulated on a voluntary-insurance basis. Namely, if insolvency affects contributions accumulated as part of mandatory insurance, the implicit responsibility of the state is more obvious. However, let us focus on the more common situation when pension fund operations see shrinking pension capital due to failed investments and when the risk of low pension benefits arises. In such a case, the share of the state depends on an explicit declaration concerning the amount of the minimum pension as acknowledged by the state. Normally, such guarantees apply to pension savings under public management as well as to privately-managed pension funds accumulated on a compulsory basis. The risk to individual contributors or would-be pensioners is even more clear. As far as fund management companies are concerned, they used to be cushioned from this risk with help of certain institutional arrangements, which will be discussed below using the Chilean example.

Let us see which of the parties concerned is most exposed to risk under the new formula for calculating pensions. Under the previous Defined Benefit formula, the value of pension benefit, as calculated in accordance with the rules imposed by the state, was actually guaranteed by the state, which ran the risk that inflows to the system would not balance the outflows due to benefits. Under the new Defined Contribution

formula, the contribution parameters are precise. Contributed savings are transparently registered on individual member accounts and are invested in securities and on the financial markets as well; the value of the pension benefits depends on the return on capital and is therefore uncertain (Bodie, Marcus & Merton 1988). Thus, the shift to the DC formula reduces pressure on the public finance balance sheet (Ostaszewski 2001). Under this rule, the obligations to pensioners match the available funds. In effect, it is the individual contributor who bears the risk of a failed investment (Barr & Diamond 2008). This consequence of introducing the DC formula can be partly mitigated with a solution restricted to mandatory pension savings, namely, an extremely low retirement pension can be topped up to a minimum level by the state.

The DC formula makes activities in the pension industry extremely attractive to management companies. It makes the business safe for private insurers and banks, and it also improves the pension balances for public--fund management agencies. From this micro-perspective one can better comprehend a generalisation made by a certain widely respected institution. According to the International Monetary Fund, "over the last 30 years, the fully funded Defined Contribution formula system has raised national savings, aided the development of capital markets, and reduced fiscal risks" (IMF 2016). Bearing in mind that the first achievement might rather be due to mandatory pension savings, we cannot doubt that the change was in favour of financial firms and the public finances.

Under the DC formula, most of the risk of a failed investment has been shifted to would-be pensioners, and this is another side of the coin. The distributional and political consequences of the change in the formula for calculating pensions have perhaps been easily overlooked in the public debate, and the issue seems to have been marginalised by the reformers.

3. How Individual Risk Exposure Was Limited in Chile

Since the 1981 reform, Chile has remained the country most determined to convert pension savings into privately-managed capital funds. Recently, more than 80% of pension savings in Chile are invested under the rules governing this retirement scheme, basically on a mandatory-insurance basis[1]. In terms of capital, the system allows for concentration of savings

[1] The Chilean retirement system between 1981 and 2008 was composed of two pillars. The first pillar was administered by the state, and the privately-administered second pillar comprised mandatory contributions under AFP management. The former included the PAYG system and

amounting to close to 70% of GDP and for those savings to be managed by new investors. The companies that manage mandatory pension funds, so-called AFPs (*adminstradoras de fondos de pensiones*), invest the pension savings in securities such as shares, sovereign bonds, mortgage bonds, etc., and a substantial portion is invested abroad[2].

The system has worked under the DC formula since 1981. The portfolio risk under such a system was acutely revealed during the recent international financial crisis. Within a very short time, Chilean contributors saw the value of the capital they had accumulated in their individual accounts shrink dramatically. This value, which reached 64.4% of GDP in 2007, plummeted to 52.8% of GDP in 2008.

The year 2008 witnessed a modification of risk-sharing. This was accomplished exclusively due to the re-introduction of systemic guarantees by the state, while the DC formula remained intact. The reforms under the presidency of Michelle Bachelet were undertaken in two steps – in 2008 and 2015. Their core significance can be summarised as rebuilding social security and re-introducing publicly-administered programmes on behalf of retirees. Under the 2008 reform of the Social Security Administration it was officially admitted that mandatory old-age insurance had to be bolstered with pension benefits paid from general taxation. In particular, the poorest 60% of contributors to AFPs were given a supplementary or additional pension benefit known as APS (*aporte provisional solidario*). The modified structure of the pension system is shown in Figure 1.

How dramatic the situation must have been before the crisis struck is indirectly shown by the numbers in the Table 1. These refer to the replacement rate, which is the average pension relative to the average salary during the insured's working life. Despite an improvement after the first wave of reform, total replacement rates in Chile remained close to or below the internationally-acknowledged minimum of 45%, as Table 1 shows. Before this improvement, benefits paid out from the system to the bulk of pensioners were below the national social minimum. The 2007 projections suggested that the monthly income of about one half of pensioners would be little more than half the minimum salary of 390 USD (Mesa-Lago & Bertranou 2016, p. 7). The 2008 reform resulted in a substantial increase in

the heavily-subsidised army and police pension schemes as well as a retirement income safety-net (the guaranteed minimum pension). The contributory pillar lacked voluntary collective savings accounts, and in 2016 these were reported to be still heavily under-developed (Bertranou 2016, p. 16).

[2] Recently, more than 40% of assets under AFP management were invested abroad, and only 11% in local equity (Credit Suisse 2014, p. 3, 5).

average pensions due to tax-financed pension benefits being targeted at the lowest-income beneficiaries. Table 1 presents the extent of this improvement between 2007 and 2014 as well as the relevance of the APS, which is in fact a state subsidy. In 2015, on average, the value of the APS represented nearly 80% of total old-age income. This increase favoured the lowest-income beneficiaries the most and made the real contributory pension increase substantially on average.

Pillar		Non-contributory	Contributory (only fully funded capital accounts)
Administration		Social Security Administration[a]	Pension management companies[b] and insurance companies
Financing		General tax revenues	Workers' contributions according to taxable wage
Benefits	Poorest 60%, no contributions required	Basic pension benefit, PBS[c]	–
	Poorest 60%, some contributions required	Supplementary or additional pension benefit, APS[d]	Self-financed pension benefit, PCI[e]
	Fully contributory	–	Self-financed pension benefit, PCI

[a] Instituto de Prevision Social, [b] AFPs – *adminstradoras de fondos de pensiones*, [c] PBS – *pension basica solidaria*, [d] APS – *aporte provisional solidario*, [e] PCI – *pension autofinanciada*; pension benefit derived from individual pension savings,

Fig. 1. Pension Benefits under the 2008 Reform

Source: based on Bertranou (2016, p. 14, annex 2).

Table 1. Median Replacement Rates, Ten Last Salaries, 2007–2014

Specification	Total	Men	Women
Without APS (self-financed)	34	48	24
With APS (*aporte provisional solidario*)	45	60	31

Source: based on Mesa-Lago and Bertranou (2016, table 2, p. 8).

Although the improvement as a consequence of the 2008 reform seems to be modest by European welfare standards, the new arrangements limited individual risk exposure. Contributors can have their asset losses, like those during the 2008–2009 financial crisis, cushioned by a basic pension or by an additional pension benefit with a social floor (see Figure 1). Extremely low retirement benefits are topped up to minimum level from tax revenues. However, it should be stressed that this social floor covers a fraction of the

system's beneficiaries, namely, the poorest 60% of retirees and would-be pensioners. Those with work income above a certain level contribute to the fully-funded individual saving accounts scheme and bear the full risk (Bertranou 2016, p. 10).

The supporters of fully-funded pensions in Chile maintain that individual risk exposure was already limited thanks to mandatory pensions engineering (Knowledge@Wharton 2009). Since the start of their operations, the AFPs have been obliged to meet a minimum level of return for each of the managed funds. In the event that an AFP fails to meet the guarantee obligation, it must transfer the difference between the actual return and the minimum level from its own reserve fund. This idea of "benchmarking" is familiar to everyone who is acquainted with the Polish counterpart of the Chilean AFPs, namely, the OFEs. However, in spite of the improvements in the Chilean arrangement, it turned out to be quite a soft "stick". The sanction is only triggered if a pension fund's return is below the minimum level for three consecutive years, which makes it easy to manipulate. Moreover, the benchmark for AFPs is the weighted average return of all funds, so it is enough to follow the investment choices of the biggest AFPs, which try to remain close to the average and thus be spared any compensation on behalf of affiliates of the managed fund (Hyde 2014, p. 16–17).

There is, however, a novelty in mandatory pensions engineering that seems to be a direct response to the question of excessive risk exposure of contributors. Fund affiliates can choose from among different income funds, with young people being supposed to invest in variable income funds with a relatively high risk, while older people are supposed to choose funds with lower profitability and thus be less exposed to possible losses. Although this sounds like a good idea when presented by policy-makers and experts, the loopholes are easy to detect in practice. What makes academic commentators sceptical is the asymmetric information where a regular client and a fund-employed advisor are concerned (Garcia-Huitron & van Leuvensteijn 2015). Another barrier to rational choice on the part of clients is the limited understanding of unskilled people.

As far as the management companies engaged in mandatory old-age insurance are concerned, they are largely free of the risk associated with failed investments that could adversely affect their incomes. Since 1981, the AFPs collect fund-affiliates' contributions, credit them to workers' accounts, and invest these monies according to the regulations set by the government. They also contract with insurance companies to provide survivorship and

disability insurance to their fund affiliates. For these services, each AFP charges an administrative commission and a premium on its own behalf and on behalf of the insurance company. The basis of these fees, which is the affiliates' contributions to the funds and fund's assets, is secured by the system. Since affiliation to an AFP fund is mandatory, AFPs do not need to compete for savings with other financial institutions such as banks or stock exchanges; in this sense, they are legally privileged.

Moreover, the concentration of assets in the mandatory old-age insurance industry has progressed. The number of AFPs dropped from 21 to 5 between 1994 and 2008, with the concentration of contributors in the three major AFPs jumping from approximately 67% to more than 86% (Mesa-Lago & Bertranou 2016, p. 9). Inevitably, this makes the Big Three free of anxiety in the face of benchmarking and the possibility of losing monies of their own under this arrangement.

Consequently, instead of desirable market competition and a decrease in administrative costs, average fees increased between 1981 and 2008. High fees, which the AFPs charge to account holders, result in profits that are much larger than in other sectors of Chile's financial services industry. Between 1991 and 2004, AFPs earned an average return of 27% on assets. In 2005, administrative fees represented a record 91% of AFPs' income (Kritzer 2008, p. 77, 79).

What makes the business safe for AFPs aggravates the risk of low benefits to contributors. As the official supervisory institution, the Social Security Administration, stated in 2008: "Account holders have had lower net rates of return (and smaller pensions) in part because AFPs have charged high administrative fees" (Kritzer 2008, p. 77).

The year 2008 witnessed a minor change in the contributory component and a more significant change in the non-contributory pillar. The reform, recommended by presidential advisers (the Marcel Commission) and fully approved by parliament, entailed the funding or co-funding of benefits from tax revenues being extended from a very small fraction of the population to the poorest 60% of the population. Thus, a social protection floor was established, which is regarded as one of the major accomplishments of the reform. According to the reformers, contributions to the system from general tax revenues are to be extended while leaving the AFP component at the core of the system. A new report by experts from the Bravo Commission, presented to President Bachelet in September 2015, proposed to maintain the *status quo* with possible increases in tax-financed benefits. Another option proposed to introduce a social insurance component, thus reducing

the size of the individual savings component along with increased scope for the basic pension benefit (PBS). Such scenarios[3] seem to go along with the view of pension management companies and conservative think tanks, supported by foreign experts and international organisations, which highlight the need to maintain the *status quo* and allow for some change in the volume of financing and parametric changes only[4] (Bertranou 2016, p. 3). Even a new social insurance component would not signal a revolution; it should be considered rather as an attempt to support the longevity of the AFP pillar thanks to state contributions from general taxation. For those who believe the state should be an arbiter between the private sector and the interests of society, this finding may come as a great disappointment.

To summarise: the reform of the Chilean pension system follows the line of extending the safety net with the help of increased tax-financing, leaving the contribution-benefit formula intact. The shift from the DB formula to the DC formula, in addition to the privatisation of pension funds, constituted the basis of the structural reform in Chile in 1981. In 2015, however, the Bravo Commission's assessment of the pension system, though obviously fair in enumerating the problems (Barr & Diamond 2016, p. 6), did not touch the issue at all. While attitudes towards the contributory pillar managed by private AFPs were rather clear-cut, a change in the contribution-benefit relationship remains out of the question. Since no sort of investment is risk--free, "the only thing left (...) is to wait until the recessionary economic cycle is over...". Interestingly enough, this argument was put forward by Professor Fernando Bravo (Knowledge@Wharton 2009, p. 2, 4), who was a member of the Marcel Commission and subsequently head of the Bravo Commission. The shift back from the DC formula to the DB formula did not win the support of the Bravo Commission because it received only one expert's vote (Oręziak 2016)[5].

[3] Most probably, the Chilean government and the congress will attempt to implement some of the specific proposals but may leave decisions about the global proposals (*status quo* or social security) until the end of 2017.

[4] Parametric and institutional changes that would constitute challenges to AFPs are recommended, like setting maximum allowable losses for abnormal investment periods, relating charges and commissions to the real performance of administrators, along with simultaneous and/or shared monitoring of the system's operations by all parties: the AFPs, their contributors, and the government.

[5] Professor Leokadia Oręziak was invited to the Commission by President Bachelet after having published a book entitled *Open Pension Funds. Catastrophic Privatisation of Pensions in Poland* (Oręziak 2014), which may be of interest to Polish readers.

4. Conclusion

The Chilean case shows how easy it is to prevent public debate on the issue of the formula for calculating pensions. At the same time, the Chilean system is one which creates extreme individual risk exposure for those who contribute their savings to it. The radical reform of 1981 abolished the employer's contribution and shifted responsibility onto workers, who saw their taxable income diminish due to mandatory pension savings deposited in order to be capitalised and also due to commissions and premiums paid to management companies and insurance companies. They bear the portfolio risk revealed by fluctuations in the value of capital accumulated in individual accounts. The system gives them no chance to opt out in the face of a steady decline in the annual real rate of return (from 20.6% to 8.8% since the inception of the system[6]). With employers as outsiders and with management companies rewarded without any direct link to the rate of return on investment, those who suffer losses are the contributor-employees[7].

Bringing the state back into the Chilean pension system does not mean any fundamental change in risk-sharing on behalf of contributors. Rebuilding the social security solidarity mechanism, relatively modest in scope as it is, seems to be the most relevant recent change with respect to risk-sharing in the Chilean pension system. It brings some relief to low--income workers who, having a basic pension benefit guaranteed by the Social Security Administration, need not to be exposed to investment risk any more. And it sees the state bringing back general taxation revenues into the pension system.

Regarding the main issue tackled in this paper, the current new reforms are not going to signal a counter-revolution with respect to the formula for calculating pensions[8]. So far, they have left the foundations of the system intact (Barr & Diamond 2016, p. 8). The companies who manage mandatory pension funds under the DC rule remain safe in the light of recent reform projects. Paradoxically, by guaranteeing the lowest pension benefits and thus providing relief to the lowest social strata, the state supports the longevity of the fully-funded Defined Contribution formula system.

[6] This data was retrieved from Mesa-Lago and Bertranou (2016, p. 12).

[7] This grossly unfair position is acutely realised by the Chileans; it prompted nationwide protests to demand new reform of the country's pension system.

[8] Argentina, for instance, implemented a radical return to the previous Defined Benefit formula and public PAYG system in 2008, having eliminated the private component and having transferred private savings to the Social Security Administration.

Apparently, universal old-age insurance is a very special branch of finance due to its original social mission. The traditional core idea of designing old-age insurance has been security, which is provided in the form of an income (pension) paid to a person of retirement age. In other words, an income high enough to protect against poverty has been at the heart of the mission. This is the essence of the Defined Benefit formula. Basically, public insurers could provide benefits consistent with the social minimum, mostly due to financing on a PAYG basis, since this system of financing allowed for income redistribution. According to the DB formula, the benefit may be based on the worker's final wage and length of service. However, it does not depend on the amount of assets accumulated in the person's name, and the risk to pension assets of varying rates of return ultimately falls on the sponsor. In the traditional system the public management agency was backed by the state budget, which was the sponsor. Under the structural pension reforms, the basic relationship between contributions and benefits was changed in the system as a whole. The guaranteed social minimum was withdrawn from part of the pension industry and the risk of old-age poverty was shifted from the managing agent to the contributor, with extremely low retirement benefits being topped up to a minimum level from social aid resources. Under the DC formula, the benefit is determined by the amount of capital paid in towards a person's pension. The consequent change in risk-sharing among the contributors to the funds, the fund management companies, and the state is fundamental to how the reform is evaluated by the parties involved.

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Abstract

Kapitałowe fundusze emerytalne i kwestia rozłożenia ryzyka

Kapitałowe fundusze emerytalne są tworzone ze składek swoich członków celem ich inwestowania na rynkach finansowych. Nietrafione inwestycje powodują zmniejszenie kapitału emerytalnego, co rodzi ryzyko niskich świadczeń emerytalnych lub niewypła-

calności funduszu. Ryzyko może się rozkładać na płacących składki, na firmy zarządzające funduszami i na państwo (kiedy oszczędzanie z kapitałowymi funduszami jest przymusowe). W artykule stwierdzono, że centralny problem – szczególnie w ubezpieczeniach na starość – stanowi to, kto ponosi największy ciężar ryzyka. Kwestia ta zasługuje na większą uwagę niż rentowność systemu. Celem jest zwrócenie uwagi na ten mało zauważany element współczesnych reform systemów ubezpieczeń emerytalnych.

Zastosowana metoda polega na uporządkowanej analizie, opartej na znajomości literatury istotnej dla podjętego tematu. Zamiana formuły liczenia świadczeń emerytalnych, czyli przejście od zdefiniowanego świadczenia do zdefiniowanej składki, oznacza zwiększenie obciążenia ryzykiem dla płacących składki (ubezpieczonych). Z drugiej strony ta zmiana czyni branżę emerytalną relatywnie bezpieczną dla prywatnych firm ubezpieczeniowych i banków, a także zmniejsza napięcie bilansowe w sektorze finansów publicznych. Przechodzenie od zasady zdefiniowanego świadczenia do formuły zdefiniowanej składki jest w Europie raczej powszechne, a zatem postawione kwestie mają znaczenie dla dużej grupy krajów, w tym Polski.

W artykule rozważa się zagadnienie podziału ryzyka, odnosząc się do współczesnego doświadczenia Chile – kraju, który jest pionierem zmian zarówno w sensie kapitałowych funduszy emerytalnych, jak i formuły zdefiniowanej składki. Analiza przypadku prowadzi do wniosku, że komponent solidarności społecznej wprowadzony ostatnio do systemu chilijskiego, ograniczając ryzyko pracowników o najniższych dochodach, zarazem podtrzymuje żywotność systemu opartego na kapitalizacji emerytur i na zasadzie zdefiniowanej składki.

Słowa kluczowe: reformy emerytalne, kapitalizacja emerytur, Chile, formuła zdefiniowanej składki.

ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 18 • 2018
ISSN 1642-168X
AOC, 2018; 18: 129–140
https://doi.org/10.15678/AOC.2018.1808

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ENHANCING FINANCIAL LITERACY – EXPERIMENT RESULTS

Abstract

The goal of the paper is to assess whether a short course in financial education has a positive impact on subjective and objective assessments of financial knowledge. We present the results of a financial literacy experiment conducted at the University of Szczecin in 2016. The experiment was the outcome of international cooperation with Italian researchers, which allowed us to compare results obtained in Italy and in Poland. It was conducted with the methodology proposed by the Italian team. The experiment covered three topics: basic interest compounding, inflation and risk diversification.

Based on a sample of university students, we provide evidence that, in Poland too, a small-scale training intervention has both a statistically and economically significant effect on subjective assessments of financial knowledge and on objective assessments of investment attitudes.

Keywords: financial literacy, financial planning, financial education, investment attitudes.
JEL Classification: D14, G11, I20.

1. Introduction

The low level of household financial literacy raises doubts about the quality and rationality of the process of financial decision-making. Financial education is aimed at improving those decisions by helping consumers to acquire the knowledge and skills needed to understand the choices they face.

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The subject literature points to the importance of financial education in increasing knowledge and financial awareness, which is expected to translate into effectiveness in the field of financial decisions (Lusardi & Mitchell 2014). Many studies of financial capability, financial literacy and financial education show that financial education has a positive impact on consumer behaviour and financial welfare. Lower levels of measured financial literacy are associated with lower rates of planning for retirement, lower rates of asset accumulation, lower participation in the stock market, higher rates of using alternative financial services and higher levels of debt (Ambuehl, Bernheim & Lusardi 2014, Brown *et al.* 2014; Xiao & O'Neill 2016). In order to examine the impact of financial education on financial knowledge, an experiment was carried out. It had previously been performed in Italy, and then was carried out in Poland using the same tools and methods.

The goal of this paper is to assess whether a short course in financial education has a positive impact on subjective and objective assessments of financial knowledge. The purpose of our study is to explore the potential effects of financial education on the financial literacy of young Polish consumers. We test the hypothesis that financial education is positively associated with financial capability. We present the results of a financial literacy experiment conducted in 2016. The experiment was the outcome of international cooperation with Italian researchers, which allowed us to compare results obtained in Italy and in Poland. The experiment covered three topics: basic interest compounding, inflation and risk diversification. Based on a sample of university students, we provide evidence that, in Poland too, a small-scale training intervention has both a statistically and economically significant effect on subjective and objective assessments of financial knowledge. The article describes financial knowledge and financial education, which are significant issues for European Union policy. Moreover, the article contains a international comparison of results.

2. Financial Literacy and Related Terms – Conceptual Framework

In order to achieve adequate transparency in the area of financial awareness it is essential to conceptually operationalise the main concepts and related terms. The broadest concept is financial capability, which is an important factor for the well-being of household members. Financial capability is the ability to apply appropriate financial knowledge and perform desirable financial behaviours to achieve financial goals and enhance financial well-being. Financial capability is a combination of

financial literacy and financial behaviour whose purpose is to achieve financial wellbeing (Xiao 2016). According the National Financial Educators Council, financial literacy means "possessing the skills and knowledge on financial matters to confidently take effective action that best fulfils an individual's personal, family and global community goals" (NFEC 2014). The International Network on Financial Education has defined financial literacy as "a combination of awareness, knowledge, skill, attitude and behaviour necessary to make sound financial decisions and ultimately achieve individual financial wellbeing. OECD INFE members agreed that the various terms used to describe this concept (including in particular financial literacy and financial capability, but also financial culture and financial insight) could be used relatively interchangeably as they reflect similar perceptions of the reality they aim to cover. It was therefore decided to use the most common international term, financial literacy, for the purpose of this measurement survey" (INFE 2011). Financial literacy is knowledge of financial concepts and how the knowledge is used to make financial decisions, taking into account available resources and the unique situation of each individual or family (Delgadillo 2014). According to Xiao (2016), in addition to financial literacy, a second component that creates financial capability is financial behaviour, which should be understood to mean human behaviours relevant to money management. Financial behaviour often includes behaviours related to earning, spending, saving, and protecting (Xiao 2016).

The development of financial awareness is affected by financial education. The definition of financial education developed by the OECD in 2005 already identifies financial well-being as one of the main outcomes of the financial education process: "the process by which financial consumers/ investors improve their understanding of financial products, concepts and risks and, through information, instruction and/or objective advice, develop the skills and confidence to become more aware of financial risks and opportunities, to make informed choices, to know where to go for help, and to take other effective actions to improve their financial well-being" (OECD 2015). Financial education is believed to improve financial literacy, motivate desirable financial behaviours, and enhance financial well-being among consumers (Lusardi & Mitchell 2014).

No single definition of financial literacy exists in the literature. It means different things for different people and organisations. Below we present some sample definitions.

Table 1. Definition of Financial Literacy

Organisation	Definition
Organisation for Economic Cooperation and Development	A combination of awareness, knowledge, skill, attitude and behaviour necessary to make sound financial decisions and ultimately achieve individual financial well-being
Advisory Council on Financial Literacy	Personal financial literacy is the ability to use knowledge and skills to manage financial resources effectively for a lifetime of financial well-being. Personal financial literacy is more than just being able to balance a checkbook, compare prices or get a job. It also includes skills like long-term vision and planning for the future, and the discipline to use those skills every day
United States Government Accountability Office	Financial literacy, sometimes referred to as financial capability, has been defined as the ability to use knowledge and skills to manage financial resources effectively for a lifetime of financial well-being. Financial literacy encompasses financial education – the process by which individuals improve their knowledge and understanding of financial products, services, and concepts. However, to make sound financial decisions, individuals need to be equipped not only with a basic level of financial knowledge, but also with the skills to apply that knowledge to financial decision making and behaviours. Efforts to improve financial literacy can take many forms. These can include one-on-one counselling; curricula taught in a classroom setting; workshops or information sessions; print materials, such as brochures and pamphlets; and mass media campaigns that can include advertisements in magazines and newspapers or on television, radio, or billboards. Many entities use the Internet to provide financial education, which can include information and training materials, practical tools such as budget worksheets and loan and retirement calculators, and interactive financial games
Authors	**Definition**
A. Lusardi and O. S. Mitchell	Financial literacy is peoples' ability to process economic information and make informed decisions about financial planning, wealth accumulation, debt, and pensions. Financial literacy has been defined as the level of financial knowledge and the ability to apply the knowledge to improve financial status (2014). Financial literacy is the ability and tools needed to plan and carry out retirement saving plans. Those who display higher financial literacy are more likely to save and invest in complex assets, such as stocks (2006)

Table 1 cnt'd

Authors	Definition
W. G. Gale and R. Levine	Financial literacy is the ability to make informed judgments and effective decisions regarding the use and management of money and wealth. Financially illiterate households make poor choices that affect not only the decision-makers themselves, but also their families and the public at large, making the improvement of financial literacy a first-order concern for public policy
Z. Kovalčíková, L. Smoroň and R. Strenk	Financial literacy is the indication of a state of constant development that allows to each person to respond effectively to new personal facts and a constantly changing economic environment
B. D. Bernheim and D. M. Garrett	Financial literacy is an not isolated category but a specialised part of economic literacy that is related to the ability to ensure income, to move on the labour market, to make decisions about one's payments, and the ability to realise the possible consequences of the one's decisions on current and future income
J. Xiao	Financial literacy has not yet been directly linked to how households choose among different kinds of assets

Sources: Xiao (2016), OECD/INPE (2015), Gale and Levine (2010), GAO (2014), Lusardi and Mitchell (2006, 2014), Kovalčíková, Smoroň, and Strenk (2011), ACFL (2008), Bernheim and Garrett (2003).

3. Measuring Financial Literacy

The experiment consisted in investigating financial knowledge and awareness. Participants of the study were be divided into two groups. One of the groups was be trained in basic economic concepts, while the other one was the reference group. The training course lasted approximately 30 minutes and was conducted by a university lecturer. Two survey questionnaires were used for data collection: *ex post* and *ex ante*. The first study was conducted a week before the course. The second study was conducted a month after the course was complete. The questions were not exactly the same as in the first study, but the answers to those questions were fully comparable.

To measure financial literacy and investment attitudes we used a questionnaire developed by the Italian team (Brugiavini *et al.* 2015). The questionnaire included three questions to measure financial literacy: "Inflation", "Interest compounding" and "Diversification", and three

questions to measure investment attitudes: "Real vs Nominal", "Investment plan", "Rule of 72". We asked one more question to assess how the participants rated their financial literacy. This additional question focused on measuring the respondents' self-assessed financial literacy according to a numerical scale from 1 to 7, with 1 being the lowest and 7 the highest.

The experiment was carried out in Italy and in Poland (pilot version). In Italy it was conducted at a university in the north-east of the country. The experiment was conducted via the internet (among 579 persons) and in a laboratory (100 persons) in the 2013/2014 academic year. In Poland the pilot version of the experiment was conducted at the University of Szczecin in the north-east of the country. It was conducted using a paper questionnaire (among 185 persons) in the 2015/2016 academic year. The participants were students studying for Bachelor's degrees in management, logistics, law and administration.

4. Evidence from the Experiment in Poland

Table 2 presents the sample averages for all the outcomes of interest collected both before and after the intervention took place for the treated and control groups. Among the sample of participants who completed the experiment, 79 were assigned to the treated group and 89 to the control group. Unfortunately, the outcomes after intervention relate to a smaller sample (61 – treated group, and 74 – control group).

The probability of answering the two questions in the objective financial literacy domains ("Interest compounding" and "Diversification") correctly increases for students in the treated group but decreases for those in the control group. Unfortunately, the probability of answering the "inflation" question correctly decreases for students in the treated group and for those in the control group. The probability of answering the questions in the investment attitude domains correctly increases for students in the treated group and for those in the control group.

The greatest variation is in the "Real vs nominal" question. For this question the probability of choosing the correct answer increases by 48% for the treated group and by 24% for the control group. For the "Investment plan" question this probability increases by 24% for the treated group and decreases by 3% for the control group. For the "Rule of 72" question this probability increases by 37% for the control group and decreases by 18% for the treated group. If we look at the variation in the overall number of correct answers in the investment attitudes domains, we find that it increased by

about 16% for participants of the short financial course and by 24% for the control group.

Finally, it is worth noting that self-assessed financial literacy, which measures respondents' confidence in their financial education, increased by 10% for the treated group and by 11% for the control group.

Table 2. Financial Literacy, Investment Attitudes, and Self-assessed Financial Literacy before and after the Intervention for the Control and the Treated Group

Specification	Before intervention		After intervention	
	treated	control	treated	control
Financial literacy (% of correct answers)				
Inflation	62%	67%	49%	47%
Interest compounding	42%	49%	43%	35%
Diversification	63%	74%	66%	43%
Number of correct answers	1.7	1.9	1.57	1.26
Investment attitudes (% of correct answers)				
Real vs nominal	45%	50%	67%	64%
Investment plan	33%	44%	41%	43%
Rule of 72	52%	40%	43%	55%
Number of correct answers	1.3	1.3	1.51	1.62
Self-assessed financial literacy				
Mean score	3.19	3.59	3.53	4.0
Observations	79	89	61	74

Source: based on the primary research.

Table 3. Correlation between Financial Literacy, Investment Attitudes, and Self-assessed Financial Literacy

Specification	Self-assessed financial literacy	
	before intervention	after intervention
Financial literacy	0.1127 ($p = 0.156$)	–0.012 ($p = 0.893$)
Investment attitudes	0.1127 ($p = 0.100$)	0.0981 ($p = 0.271$)

Source: based on the primary research.

Table 3 shows the correlation between self-assessed literacy and financial literacy and investment attitudes. Unfortunately, all correlations are statistically insignificant ($p > 0.050$). The experiment in Poland was conducted on a pilot group, but reveals the restrictions that can prevent such an experiment from being conducted.

5. Financial Literacy in Poland and Italy

For several years now, the world has been conducting research on financial literacy. Professor Elaine Kempson from the Personal Finance Research Centre in Bristol published a report (Kempson 2009) devoted to the methodology of financial literacy research, in which she draws attention to the problem of the worldwide variety of research in terms of research assumptions, construction of questionnaires, determination of the research sample, etc. The comparative analysis of the different financial literacy studies carried out in Poland and Italy is incorrect from a methodological point of view, hence the results and conclusions of international studies conducted both in Poland and Italy will be presented below.

In 2012, ING Group examined financial literacy in 11 European countries: Spain, France, Italy, Turkey, Austria, Germany, Netherlands, Belgium, Luxembourg, Poland and the UK. Poland took 7th place in the financial knowledge test with a score below the average for all countries (2.74 correct answers), while Italy took 2nd place (about 2.8 correct answers). The questions in the test were related to issues such as interest rates, inflation, bonds, mortgages, profit, and return.

For the first time in 2012, the OECD Programme for International Student Assessment (PISA) measured the financial literacy of 15-year-old students. The questions respondents were asked were aimed at identifying the level of financial knowledge and assessing the behaviours and attitudes of many aspects of financial awareness, such as managing household budgets, short- and long-term financial planning, and the determinants of the choice of financial products. Out of the 18 participating countries, 12 are in Europe, including Poland and Italy. The research was repeated in 2015. The second assessment covered 15 countries and economies, including Poland and Italy. The financial literacy assessment methodology is presented in the PISA 2015 Assessment and Analytical Framework (OECD 2016b). Poland's mean score in financial literacy performance was 510 in 2012 and decreased by 25 points to 485 in 2015, while Italy's mean score increased from 466 in 2012 to 483 in 2015 (OECD 2017, p. 179). The single continuous scale of financial literacy constructed for the PISA 2015 assessment was divided into five levels according to robust statistical principles. The descriptions of the proficiency levels were generated on the basis of the tasks assigned within each level in order to encapsulate the kinds of knowledge and skills needed to successfully complete those tasks. The set of descriptions is presented as a proficiency scale (OECD 2017, p. 75). Level 5 is the highest described

level, and Level 1 is the lowest. The distribution of Polish and Italian student performance across the proficiency levels is shown in Table 4. More Polish than Italian students scored 624.63 points or above (Level 5). In 2015, the financial literacy assessment was also conducted among adults (OECD 2016a, p. 17). However, Italy did not participate in the research.

Table 4. Percentage of Polish and Italian Students at Each Proficiency Level in Financial Literacy

Country	Percentage of students at each proficiency level in PISA 2015				
	Level 1 or below (below 400.33 points)	Level 2 (from 400.33 to less than 475.10 points)	Level 3 (from 475.10 to less than 549.86 points)	Level 4 (from 549.86 to less than 624.63 points)	Level 5 (at or above 624.63 points)
Italy	19.8	25.2	29.3	19.2	6.5
Poland	20.1	24.5	28.4	19.0	8.0

Source: OECD (2017, p. 179).

Standard & Poor's Ratings Services, in collaboration with renowned research institutions including Gallup, the World Bank Development Research Group and the Global Financial Literacy Excellence Center, conducted a survey whose aim was to determine the level of global financial knowledge[1]. In the S&P Global FinLit Survey, financial literacy was measured by four questions concerning basic numeracy, interest compounding, inflation, and risk diversification[2]. In the research, a person is defined as financially literate when he or she correctly answers at least three out of the four financial concepts described above. Based on this definition, 33% of adults worldwide are financially literate. Poland in the general assessment of Standard & Poor's, which includes 148 countries, took 40th position with a score of 42%. This is a result similar to the average for the so-called new European Union (41%) – the group of countries which joined the Community in 2004 or later – but is significantly lower than the average for the European Union as a whole, which is 52%. To compare: Italy has some of the lowest financial literacy rates in the south of Europe. There are 37% of adults who are financially literate (Klapper, Lusardi & Oudheusden 2015, pp. 6–8, 23–25).

[1] The survey was based on interviews with more than 150,000 adults across 148 countries. Of the 148 countries targeted for data collection in 2014, 144 countries successfully collected data and met Gallup quality standards.

[2] The questions are available in Klapper, Lusardi, and van Oudheusden (2015).

To compare the results of our experiment with the Italian one, the subjects in Italy were students at a medium-sized university in the north-east of the country. The research sample consisted of 579 students in the field experiment and 100 students in the laboratory experiment. Based on the sample, the Italian team provided field and laboratory evidence that a small--scale training intervention has both a statistically and economically significant effect on subjective and objective assessments of financial knowledge. Their research also shows that the intervention increases self-assessed knowledge more than actual financial knowledge (Brugiavini *et al.* 2015).

To conclude: both Poland and Italy have low levels of financial literacy, which is a good reason to seek effective ways of improving it. Unfortunately, the financial education experiment was exposed to a number of external factors that are difficult to measure and adversely affected the results of the study.

6. Conclusions

In summarising of the presented theoretical and empirical deliberations, one should point to the methodological limitations of the experiment, which significantly affected its results. These include:

– the respondents' lack of anonymity, which in many cases resulted in consent not being given to participate in the study,

– the respondents' lack of motivation to complete the questionnaires – questions left unanswered or marked randomly,

– the control group was susceptible to the influence of other factors that also could lead to changes in behaviour and increase financial knowledge,

– the returns of end surveys were unfortunately at a lower level than those conducted before the experiment.

Statistical analysis of the obtained results allowed us to demonstrate that undergoing a course in finance raises subjective assessment of the level of financial literacy and objective assessment of investment attitudes. Unfortunately, it failed to demonstrate that undergoing a course in finance raises objective assessment of financial literacy, which is probably due to the methodological limitations of conducted pilot study.

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Abstract

Poprawa wiedzy i umiejętności finansowych – wyniki eksperymentu

Celem artykułu jest wykazanie, że krótki kurs z zakresu finansów pozytywnie wpływa na subiektywną i obiektywną ocenę poziomu wiedzy i umiejętności finansowych. Artykuł prezentuje wyniki pilotażowego eksperymentu dotyczącego wiedzy i umiejętności finansowych, który został przeprowadzony na Uniwersytecie Szczecińskim w 2016 r. Eksperyment jest efektem współpracy międzynarodowej, na podstawie metodyki badań zaproponowanej przez Włochów i dotyczy trzech zagadnień: obliczania odsetek, inflacji i dywersyfikacji ryzyka.

Na podstawie przeprowadzego eksperymentu można wnioskować, że kurs z zakresu finansów ma pozytywny wpływ na subiektywną ocenę poziomu wiedzy i umiejętności finansowych oraz obiektywną ocenę postaw inwestycyjnych.

Słowa kluczowe: wiedza finansowa, planowanie finansowe, edukacja finansowa, postawy inwestycyjne.

ISSN 1642-168X