Warsaw University of Life Sciences – SGGW
Faculty of Applied Informatics and Mathematics
Department of Econometrics and Statistics

QUANTITATIVE METHODS IN ECONOMICS

METODY ILOŚCIOWE W BADANIACH EKONOMICZNYCH

Volume XIX, No. 4

Warsaw 2018

ISSN 2082-792X
e-ISSN 2543-8565

Warsaw 2018, Volume XIX, No.4

The original version is the paper version
Journal homepage: qme.sggw.pl
Published by Warsaw University of Life Sciences Press

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018

CONTENTS

Gian Carlo Blangiardo – Demographic Challenges to Relaunch a Country that Has Lost Vitality 323

Eneida Përmeti Çifligu – How Does Public Debt Affect Economic Growth in Albania? 330

Marcin Dudziński, Konrad Furmańczyk, Arkadiusz Orłowski – Some Proposal of the Test for a Random Walk Detection and its Application in the Stock Market Data Analysis 339

Maria Ferrara, Elisabetta Marzano, Roberta Rubinacci – Credit Rationing and Firms'size:Exploratory Analysis of the Effect of the Great Recession (2010-2016) in Italy 347

Petro Hrytsiuk – The Portfolio of Financial Assets Optimization. Different Approaches to Assess Risk 355

Piotr Jałowiecki, Michał Gostkowski, Krzysztof Zmarzłowski, Tomasz Woźniakowski – Productivity Paradox in Selected Sectors of Agri-Food Production Branch in Poland 366

Sebastian Jarzębowski, Natalia Bezat – Factors Determining Poland – South Korea Trade in Sugar Confectionery 377

Marek Andrzej Kociński – On Stock Trading with Stock Price Drift and Market Impact 388

Monika Krawiec – FX-Linked Structured Time Deposits Versus Barrier and Standard Options: A Comparative Study 398

Blerta Mjeda – Uncertainty Analyses in Albpetrol Company 411

Luiza Ochnio, Grzegorz Koszela, Pornsiri Suebpongsang – Application of Ar_{max} Measure for Analysis of Food Preference Changes in Asian Countries 2001-2013 419

Nicholas Olenev – Identification of an Aggregate Production Function for Polish Economy 430

Gülşah Sedefoğlu, Mehmet Ali Soytaş – Self-Reported Health Status: A Microeconometric Analysis for Turkey 440

Agnieszka Tekień, Krystyna Gutkowska, Sylwia Żakowska-Biemans – Conjoint Analysis as a Statistical Tool for Studying Consumer Behaviour. Characteristics, Types and Examples of Use 452

Speech given during the XIX International Scientific Conference Quantitative Methods in Economic Research by PhD Krystian Szczepański, Director of the Institute of Environmental Protection – National Research Institute 462

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 323 – 329

Received: 17.04.2018
Accepted: 21.12.2018

DEMOGRAPHIC CHALLENGES TO RELAUNCH A COUNTRY THAT HAS LOST VITALITY

Gian Carlo Blangiardo https://orcid.org/0000-0002-6638-2844
Department of Statistics and Quantitative Methods
Università degli Studi di Milano-Bicocca, Italy
e-mail: giancarlo.blangiardo@unimib.it

Abstract: Demographic trends of the Italian population are more and more problematic. The shrink of births, the growing of deaths and the ageing of population will be the main issues to manage in next decades both for economic and socio cultural equilibrium of the Italian society. New policies more family oriented and a best commitment to foster human capital, both immigrants and young Italian people too frequently addressed abroad, are more and more requested to give proper answers to a demographic crisis that could be even more devastating than the economic one.

Keywords: demographic crisis, low fertility, family policies

JEL classification: J10, J11, J68

A PEOPLE WITH LESS FUTURE

In recent years the demographic drift of the Italian population balance show a trend that was once unimaginable. As a consequence of the present dynamics we can observe downward tendency. If we define the demographic asset as "the quantity of future (total life-years) that the residents in Italy have still to spend (globally), according to their number and composition by sex and age, we can realize that it stopped growing. On 1st January 2017 in Italy, at the current conditions of survival, the demographic asset was 2.4 thousand millions life-years (equivalent to 40 years of residual life per capita) of which 1.3 thousand millions to be spent in active age (between 20 and 67 years) and 1 thousand millions to live by retirees, and still during the two previous years (2015-2016) it suffered a loss of 35 million years of life. This occurred in the context of an increase in the share of the future that the Italian population will live in a condition of retirement (from 40.6%

https://doi.org/10.22630/MIBE.2018.19.4.30

of the total expected life-years to 41%) accompanied by the corresponding decrease in the share of expectations potentially to be dedicated to work (from 54.7% to 54.3%). In order to make these calculations, the following thresholds are conventionally adopted:

a) Training: you stay in training until the end of the calendar year during which you have completed 20 years.
b) Work: You enter the labor market from January 1st of the year following the one in which the 20th birthday has been reached, up to the instant in which you reach the 67th birthday.
c) Quiescence: you enter the universe of pensioners starting from the 67th birthday.

What does this imply? First of all, this trend increasingly points out the problem of the sustainability of the welfare system. According to these data, the pension reforms already approved, and the further changes that almost certainly we are awaiting for, must first protect the younger generations, through appropriate corrective mechanisms. The public strategies aimed at revitalizing the national demographic patrimony must be associated with farsighted measures capable of guaranteeing the equilibrium of a social security system, which today is still too complex, unnecessarily rigid and insufficiently reformed.

It must be taken into account how the future demographic accounting in Italy will be inevitably addressed - in the absence of huge contributions on the migratory front - to be characterized by increasingly negative balances between the quantity of future "product", with the entry of new births and of immigrants, and the complex of life-years lost, by death or emigration, or simply consumed by living. The, so much discussed, loss of vitality of Italians, which is due to the strong aging process of the indigenous population, is only partially responsible of this progressive weakening; nowadays, in fact, also the propulsive action deriving from foreign migration flows is being exhausted. The transition from stagnation to demographic regression has not yet shown its worst consequences: it is therefore necessary to move urgently and pragmatically, precisely starting from the great theme of our time: the fall in the birth rate.

THE ABSENCE OF POLICIES TO SUPPORT THE BIRTH RATE

The statistical data that are gradually completing the demographic balance for 2017 convince that a new negative record for the birth rate is going to be achieved (the first eight months of 2017 show a decrease of 2.2%, compared to corresponding time interval in 2016). They make it clear that, in the absence of radical countermeasures, the social and economic effects of the persistent demographic crisis will be increasingly difficult to manage. The problem at stake is "what" to do and "who" must do. There is no doubt that any (desirable) change of direction would require a greater level of attention and resources in favor of practical and incisive actions to support the birth rate, with explicit interventions

aimed, above all, to recover equity in taxation and tariff policies; to favor the reconciliation between maternity and work; to make care services accessible; to develop family-friendly housing policies (see [Piano Nazionale per la Famiglia (2012) Presidenza del Consiglio dei Ministri, Dipartimento per le politiche della famiglia]).

The demographic and family policy should also be of a universal nature, and not limited to the sphere of emergence from poverty and social exclusion. The interventions should then be started in a short time, without the illusion of being able to simply compensate the problem of the fall in the birth rate through the sole contribution of immigration, which is important, however certainly not sufficient.

Which subjects should be called, today, to design and implement these actions? The role of political and institutional actors is obviously decisive; nevertheless, the logic of construction of the dominant political consensus today should be, if not put aside, at least mitigated to face the emergency. Any public initiative, with deals directly or indirectly with the demographic context, requires a far-sighted vision. It has to be coherent in the choices and patient waiting for the fruits: it has to sow today, in order to be able to gather the day after tomorrow. The times of demography involve two generations, about thirty years; those in politics tend to look, in the best case, for a term of five years.

Those who risk consensus in the name of the demographic destinies of the country, for example by promoting a redistribution of the few resources available, would like that immediate confirmation that, on the contrary, the nature of the intervention dilutes over time. The short-circuit decision-making that systematically blocks long-term interventions in Italy also significantly affects the birth rate. On the basis of what has been said, it seems increasingly necessary to encourage a shared culture of demographic change as a phenomenon to be known, in events and consequences, but above all to be governed by mutual agreement, accepting and sharing any costs and sacrifices of choices directed to the common good. The country system, in all its institutional and territorial articulations, should ideally mobilize on the issue of the birth rate fall in a cohesive and harmonious way: it is above all at the local level, in fact, that the demographic problems are felt and must be managed.

MORE CARE OF HUMAN CAPITAL

As we have seen, the Italian demographic asset has stopped growing: the birth rate shows no signs of rising, reducing, as a consequence, the flow of the next generations of young people. Given these premises, it is easy to realize that a top target, which cannot be given up, is making the most of the young demographic resources available in the country, by transforming them into educated human capital. In the context of domestic and European objectives, the issue of early school leaving is certainly a priority in a country, as is Italy, where the number of early drop-outs from the school system, although declining, is still largely greater

than it should, with respect to the desired targets. On the other hand, it is useful to remember how the effects of school drop-outs, should not only considered under the aspects of economic costs for the whole community. Social cohesion and inclusion is involved, together with the risk of poverty and fragility in the population sectors which are more at risk. It is crucial to valorise young people who will soon be called to support the weight of an ever older society. By the skills acquired since childhood and their work, these young generations need to face enormous cultural and identity transformations, especially in metropolitan areas, that aspire to become global cities with a strong orientation to the information and knowledge economy. Among the possible actions intended to contrast school drop-outs are those to make more reliable indicators and detection tools to evaluate the causes of drop-outs and to define more accurate profiles of persons at risk; to adopt an early prevention strategy as early as possible, since the middle school; to intervene on the quality of learning in this school cycle and to take care, thanks to a better orientation, of the critical phase of transition to higher education; to move from a "fight against abandonment" to "fight against school failure", because students having irregular and late study paths are not yet dropped-out, but often they are at the antechamber; to monitor and evaluate the impact of the actions carried out up to now in the various territories; finally, in a medium-long term vision, to overcome the perspective adopted so far, which looks at the drop-outs in terms of the titles obtained (or not), to embrace the skill approach, which at international level now informs the most innovative school policies [see Fondazione Agnelli, VII Commissione della Camera dei Deputati - Cultura e Istruzione 2014].

At the same time, it seems necessary to develop adequate initiatives to counter the other emerging form of dispersion of national human capital, with ad hoc incentives to recall back to Italy the brains who have left the country. The idea of making structural a system of tax advantages for Italian emigrant researchers, if they chose to return to live and work in Italy, even if positive, would probably have a limited impact. The key point would be to recreate favorable conditions for cutting-edge research in terms of funds, structures and scientific culture, also in Italy, and not just limiting to a few excellences. The most advanced countries from this point of view - Europeans (Germany, United Kingdom, France) and not (the United States in the first place) - also tend to guarantee greater consideration to researchers in terms of economic remuneration and career progression, being these aspects strongly encouraging.

A GREATER KNOWLEDGE OF THE PROBLEMS TO HELP THEIR SOLUTION

How can statistical, demographic and other data be illustrated correctly and, at the same time, journalistically captivating? According to the emerging paradigm that pushes towards the data revolution [www.undatarevolution.org], does the proliferation of data of all kinds, big and open, foster the understand of reality? Or, on the contrary, there is a "statistical noise", which is increasing more and more confusing and difficult to manage? How can mass-media filter data publications that should always be accurately verified? How can the organs of Official Statistics support the media and all citizens to facilitate easier access to essential information in such a sensitive period for the country? And finally, how to interface with all the non-official bodies that sometimes tend to express their own interests, positions, hopes, rather than neutral visions of the facts, through the data they try to promote?

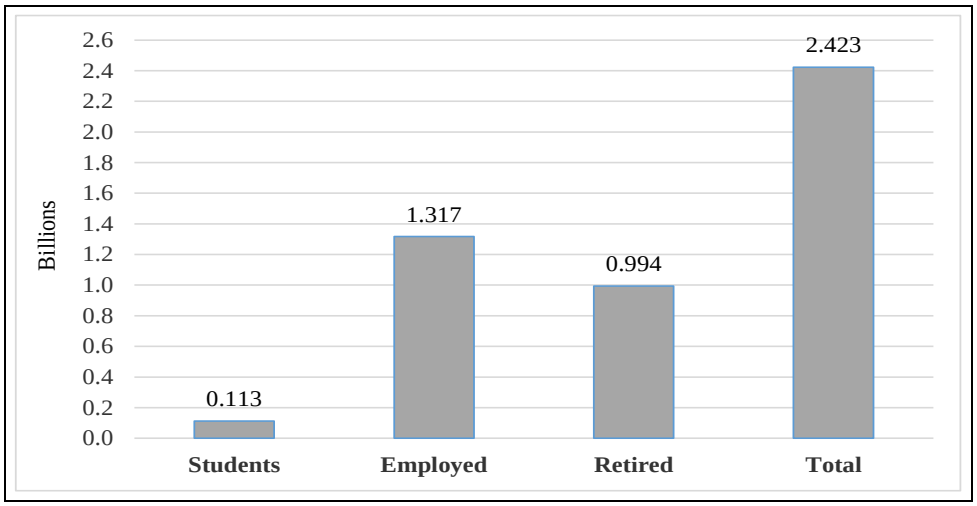
The issue of how statistical data are treated "on" and "by" mass media has a long tradition and has systematically given rise to heated arguments. It is necessary to consider that statistics are one of the possible tools, not only for describing reality, but also for building it, promoting sometimes simplistic, emotional, partial or instrumental views of facts

In some cases there is the evident attempt to publicly accredit particular points of view, through pieces of information to which most citizens are persuaded to recognize as objective and scientific.

The actors, who in various ways have access to the media comment, interpret, discuss the statistics, providing the audience with various frames of interpretation to which they can refer. Communication media show a growing tendency to emphasize demographic data, both official and non-official, not always in an appropriate manner, so that in the public opinion an emotional readings of reality often tend to prevail, supported by data not necessarily certified and documented. On the other hand, due to the uses that can be made of them, demographic statistics are not exempt from the risks typically encountered by economic data, once they have entered the media and political communication circuits. Just think of the present economic crisis and the information that from time to time are used to try to demonstrate, depending on the positions in the field, that: the crisis is finally over; that we are on the right track, but we have not done enough yet; that the situation has remained unchanged for years; that the economic trend has further deteriorated and we are collapsing. Even the demographic data, especially if it were to miss the possibility to interpret them in a simple and linear way, risk becoming fertile ground for similar contests. The organs of Official Statistics have historically a great responsibility in this sense and, today more than ever; they are called to take further steps forward for what concerns the ability to communicate statistics to different users, while respecting their cognitive needs.

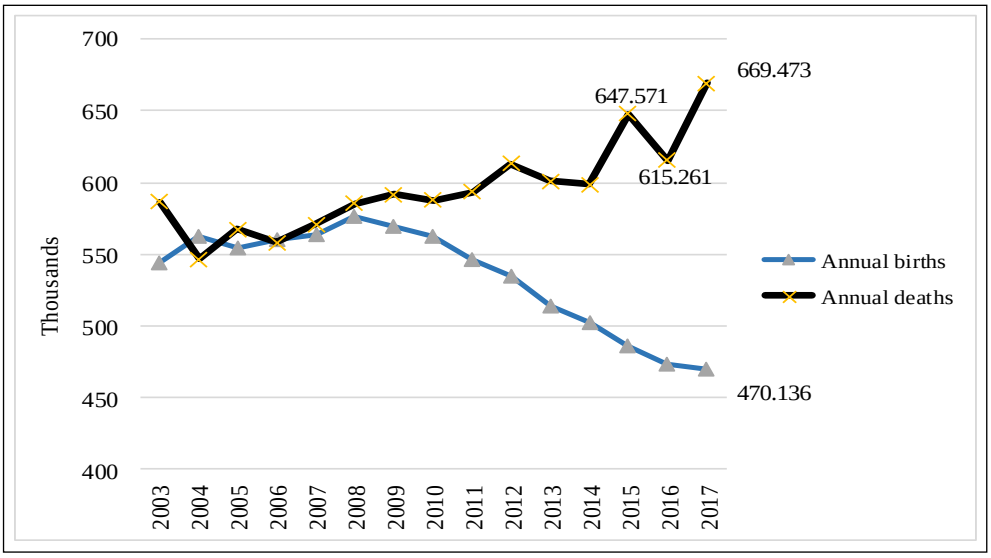
The major national media in turn have a crucial role: to publish verified and verifiable data; this should be done also to encourage greater interaction with the most attentive and eager citizens to deepen public issues, among these demographic. Only in this way, the statistical noise can be reduced in favor of reliable, controllable, significant and really "informative" data.

Figure 1. Italian demographic patrimony: January, 1st 2017 (living years)



Source: own elaborations based on ISTAT data

Figure 2. Italy: natural movement of the resident population. Years 2003-2017



Source: own elaborations based on ISTAT data

REFERENCES

Fondazione Agnelli (2014) Camera dei Deputati, VII Commissione Cultura, Scienza e Istruzione, 2014.

Piano Nazionale per la Famiglia (2012) Presidenza del Consiglio dei Ministri, Dipartimento per le politiche della famiglia.

www.undatarevolution.org

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 330 – 338

Received: 03.09.2018
Accepted: 21.12.2018

HOW DOES PUBLIC DEBT AFFECT ECONOMIC GROWTH IN ALBANIA?

Eneida Përmeti Çifligu https://orcid.org/0000-0001-7226-2040
Faculty of Economy
University of Tirana, Albania
e-mail: permeti.eneida@yahoo.com

Abstract: The global recession and the sovereign debt of European countries has triggered an intense debate over the effectiveness of fiscal policy and over the consequences of rising public debt. The purpose of this paper is to determine if there exist a correlation between the public debt and the economic growth in Albania, where the economic growth will be considered as the increase of GDP. The results and the methodologies are different in different countries and periods, as represented by various empirical studies. What is the situation in Albania at about the last 25 years? The SVAR methodology is used for analyzing this relationship. The results indicated that an instantaneous increase in real economic growth might increase the public debt and vice versa.

Keywords: economic growth, public debt, SVAR methodology, Albania

JEL classification: H61, H63, O4, F01

INTRODUCTION

The purpose of this study is to analyze the relationship between the public debt and the economic growth in Albania for the last 25 years. Different authors have used different methodologies for the study of the issue and certainly the obtained results have been different. Some have concluded for a positive relationship between the two indicators and others for a negative relationship. Several other studies have come to the conclusion that the public debt has no impact on the economic growth.

The literature identifies some lines: the Classical and the Neoclassical economics and Ricardian view which consider the public debt as detrimental to the economy, the conventional view, according to which the government debt stimulates

https://doi.org/10.22630/MIBE.2018.19.4.31

aggregate demand and growth in the short term and promotes the reduction of capital and national income in the long term and the Modern economics which considers the debt as a driver of economic growth if funds are used for productive purposes.

In this paper, firstly each time series will be analyzed and then the model will be estimated. The data was obtained from the International Monetary Fund for the years 1994-2017. The public debt is taken in real terms as a percentage of GDP and the economic growth in real terms as well. The econometric analysis consists on: the stationary tests (unit roots test), the cointegration test, the regression analysis, the Granger test. If, after the unit roots test, no unit root is found and conclude that the time series is stationary, the model can be estimated using the VAR model. The VAR model is proposed by Sims in 1980 [Sims 1980]. Conversely, if the root of the unit is found, cointegration should be tested. If the variables co-exist, then the VEC model should be used. If the variables are neither stationary nor cointegrated, they should be differentiated. If the first difference is stationary, the VAR model in the differentiated form can be estimated.

REVIEW OF EMPIRICAL LITERATURE

Reinhart and others in the work "Debt Intolerance" took the first steps on the concept of debt intolerance [Reinhart et al. 2003]. The authors have assumed that, besides reputable factors, bankruptcy in the series, may create a vicious cycle, where bankruptcy weakens a country's institutions, making a break-in more likely.

Understanding and measuring debt intolerance is essential to assess the problems of debt sustainability, its restructuring, the capital market integration and the international borrowing space to overcome crises.

Reinhart and others in the "A Decade of Debt" study brought evidence that public debt in developed countries has in recent years reached unrecorded levels since the end of World War I or the Depression big [Reinhart et al. 2011]. Historically, these episodes have been accompanied by a slower economic growth and a restructuring of private and public debt.

The results achieved show that high levels of debt undermine the economic growth, although the US may tolerate higher levels of debt compared to other countries, without soliciting solvency.

The main finding is that in developed countries, the high level of public debt / GDP ratio (over 90%) is associated with a lower increase.

Reinhart and others brought the paper "Debt Overhangs: Past and Present", concluding the existence of a weak link between rising and low debt levels, but when the debt in the report with GDP being over 90%, economic growth rates are on average 1% lower than the forecast [Reinhart et al. 2012].

The level of public debt / GDP ratio in developed countries overall exceeds the critical threshold of 90%. The private debt, which, unlike the public, shows a significant growth trend over the last decades, remains close to the pre-crisis levels.

The problem is exacerbated by the fact that in developed countries, a good part of debt, is owed to foreign creditors, which generally limits the government's means to force creditors to absorb losses.

There are identified 26 episodes where the debt ratio public DEBT/ GDP exceeds 90% since 1800 and economic growth averaged 1.2%. The average duration of debt overrun episodes is 23 years.

Clements and others reported a negative correlation between external debt and growth for a panel of 55 low-income countries for a period that spanned from 1970 to 1999 [Clements et al. 2003].

El-Mahdy and others investigated the debt and growth relationship for Egypt's economy using data spanning 1981–2006 and the study revealed a robust negative relationship between debt and growth [El-Mahdy et al. 2009].

Baum and others investigated the relationship between public debt and economic growth using the dynamic threshold panel methodology for 12 European countries for the period 1990-2012 [Baum et al. 2012]. The study reported a positive and high statistically significant impact of debt on GDP when the debt-to-GDP ratio was less than 67 percent; after which point, there was no relationship between debt and GDP.

Egbetunde examined the impact of public debt on economic growth in Nigeria between 1970 and 2012 using a Vector Autoregressive model [Egbetunde 2012]. The findings revealed a positive relationship between public debt and growth. Also, the study reported a bidirectional link between public debt and economic rowth in Nigeria and this indicates that changes in public debt will cause variation in Nigeria's economic growth and vice versa.

Alfredo Schclarek have taken in consideration for his study 59 developing countries and 24 industrial countries during the years 1970-2002 [Schclarek 2004]. He found a linear negative effect of the external debt on growth. Methodologically, the paper uses the GMM estimator, called dynamic system GMM panel estimator.

Sheikh and others analyzed the impact of domestic debt on economic growth in Pakistan for the years 1972-2009 [Sheikh et al. 2010]. The OLS method is been used for their study. The result showed that the stock of domestic debt affects positively the economic growth in Pakistan.

Uzun and others studied the relationship between debt and economic growth in transition countries for the period 1991-2009, using the autoregressive model with distributed delay (ARDL) [Uzun et al. 2012]. The results showed a positive relationship in long term and these countries were positive in the Laffer curve.

DESCRIPTION OF THE DATA

Initially, it is important to provide a detailed description of the data we will use in the empirical model and, specifically, the univariate uniqueness of two time series: real economic growth and public debt expressed as a percentage of GDP. In

this paper, the real economy is in the center, so both of our series will be in real terms, bearing in mind the role of inflation on public debt and GDP.

These data are annual and include the period 1994-2017, given that public debt / GDP was impossible to find data for 1992 and 1993 or earlier. Data sources, for the foregoing analyzes (as mentioned above in the previous chapter) are the BoA, MoF and IMF. What I have found is a discrepancy in the data in these institutions' reports, for the same indicator or a lack of data for several years. The values are different for the same variable and this is a limitation for the model below. I decided to refer to the values published by the IMF, as they are the most complete.

A summary of the descriptive statistics of the variables is presented below:

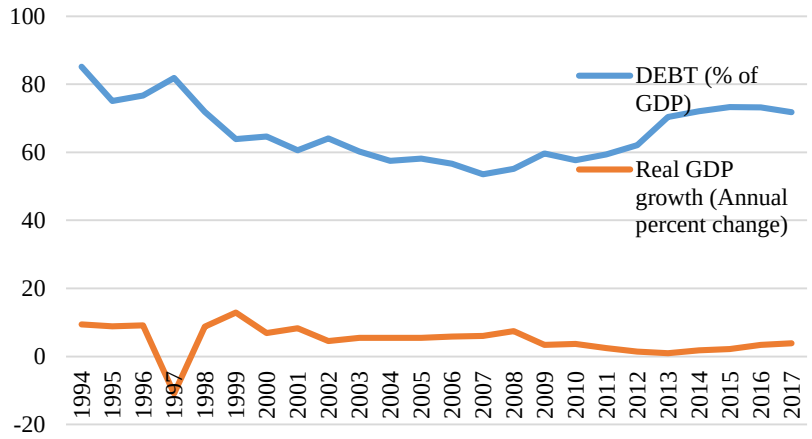
Table 1. Descriptive Data Statistics of the time series

	The mean	The median	The maximum	The minimum	Dev. Standart	Observations number
The real ec.growth (%)	4.88	5.5	12.9	-10.9	4.4	24
The public debt (%GDP)	66.03	63.99	85.17	53.55	8.6	24

Source: own calculations

From the table we see that for each series we have 24 observations. Real economic growth has fluctuated from -10.9% to 12.9%, with an average annual growth of 4.88%, while public debt as a% of GDP fluctuated from 53.55% of GDP to 85.17% of GDP. GDP has been higher than the public debt. The standard deviation of public debt / GDP is almost double the standard deviation of the economic growth. The dynamic behavior of our series is presented in the following chart.

Figure1. Graphic analysis of time series

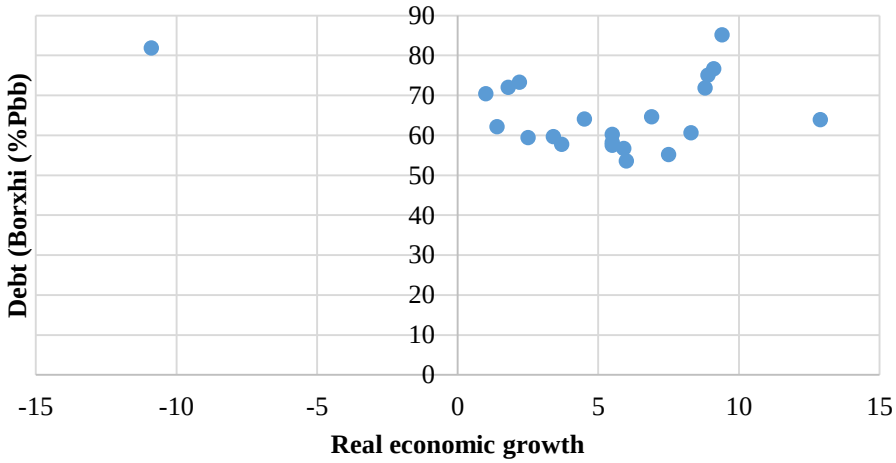


Source: own preparation

The graph shows that there may be a negative relationship between the two indicators and we notice a structural breakdown of both series in 1997 as a result of the economic situation (bankruptcy of pyramid schemes). The highest debt (in relation to GDP) is recorded in 1994 and lower in 2007. The highest economic growth is in 1999 and the lowest in 1997 (for the above mentioned reasons). From the graphs, we expect our series not to be stationary, as we have an upward trend of them all the time, meaning that their average and variance depend on time and are a series of unstable ones. However, complete and accurate conclusions will be drawn after analyzing the model created.

We can also build a graph, placing the two indicators facing each other, to see which value corresponds to the other, for 24 years in a row.

Figure 2. Graphic representation of the relationship between public debt and economic growth



Source: own preparation

From the graph we can see that there is a negative relationship, but it appears at 60% of the debt, since the real economy can't grow fast at the time of debt growth, as debt growth promotes inflation growth instead of the real economy.

HYPOTHESIS OF THE STUDY

There are some important questions: Does public debt affect economic growth?

Does it have a negative or positive effect on economic growth?

The hypothesis to be study is: Public debt has a negative effect on the economic growth. Theoretical frameworks and relevant studies can give some answers, but it is important that the hypothesis be empirically tested.

ECONOMETRIC ANALYSIS

Time series represent a structural breakdown in 1997. In this year, bankruptcy of pyramid schemes occurred. To analyze if the series have unit root I have generated on R software, the Zivot and Andrews test. According to the results in the table, the public debt results I (1) non-stationary and should be differentiated before the regression model is created, while the economic growth is I (0), stationary.

Table 2. Zivot and Andrews test for the model A, B and C

The model	Real economic growth	Public debt	1%	5%	10%
A	-5.5901	-3.021	-5.34	-4.8	-4.58
B	-4.8519	-3.9884	-4.93	-4.42	-4.11
C	-9.6232	-3.817	-5.57	-5.08	-4.82

Source: own calculations

Table 3. Zivot and Andrews test after the first differentiation for the model A, B and C

The model	Public debt first differenced	1%	5%	10%
A	-5.8513	-5.34	-4.8	-4.58
B	-5.8889	-4.93	-4.42	-4.11
C	-6.461	-5.57	-5.08	-4.82

Source: own calculations

The VAR model: $Y_t = A_1Y_{t-1} + A_2Y_{t-2} + ... + A_pY_{t-p} + \varepsilon_t$
Or the matrix form: $Y_t = A(L)\, Y_{t-i} + \varepsilon_t$

Before estimating a VAR model three conditions will be tested:

- the stationarity of the time series;
- the appriopriate lag length;
- the model should be stable.

The first condition is linked with the calculations of Table 2 and Table 3. The model is stable because all the roots of the polynom A(L) are less than 1. For chosen the appropriate lag length the results of Table 4 will be analyzed:

Table 4. The lag length criteria

Lag length	FPE	AIC	SC	HQ
1	17.616241	2.851891	3.112637	2.798296
2	29.401301	3.297640	3.732216	3.208315
3	44.227400	3.535245	4.143652	3.410190
4	37.496628	2.983986	3.766223	2.823201
5	35.866272	1.994599	2.950668	1.798084

Lag length	FPE	AIC	SC	HQ
6	NaN	-Inf	-Inf	-Inf
7	0	-Inf	-Inf	-Inf
8	0	-Inf	-Inf	-Inf
9	0	-Inf	-Inf	-Inf
10	0	-Inf	-Inf	-Inf

Source: own calculations

The appropriate order of our model is 6. So the equations for our two time series are:

$$\mathbf{Y_{1t}} = \alpha_{10} + \beta_{11}Y_{1t-1} + \beta_{12}Y_{2t-1} + \gamma_{11}Y_{1t-2} + \gamma_{12}Y_{2t-2} + \delta_{11}Y_{1t-3} + \delta_{12}Y_{2t-3} + \phi_{11}Y_{1t-4} + \phi_{12}Y_{2t-4} + \lambda_{11}Y_{1t-5} + \lambda_{12}Y_{2t-5} + \mu_{11}Y_{1t-6} + \mu_{12}Y_{2t-6} + u_{1t} \quad (1)$$

$$\mathbf{Y_{2t}} = \alpha_{20} + \beta_{21}Y_{1t-1} + \beta_{22}Y_{2t-1} + \gamma_{21}Y_{1t-2} + \gamma_{22}Y_{2t-2} + \delta_{21}Y_{1t-3} + \delta_{22}Y_{2t-3} + \phi_{21}Y_{1t-4} + \phi_{22}Y_{2t-4} + \lambda_{21}Y_{1t-5} + \lambda_{22}Y_{2t-5} + \mu_{21}Y_{1t-6} + \mu_{22}Y_{2t-6} + u_{2t}$$

Matrix form:

$$\begin{pmatrix} Y1t \\ Y2t \end{pmatrix} = \begin{pmatrix} \alpha 10 \\ \alpha 20 \end{pmatrix} + \begin{pmatrix} \beta 11 & \beta 12 \\ \beta 21 & \beta 22 \end{pmatrix} \begin{pmatrix} Y1t-1 \\ Y2t-1 \end{pmatrix} + \begin{pmatrix} \gamma 11 & \gamma 12 \\ \gamma 21 & \gamma 22 \end{pmatrix} \begin{pmatrix} Y1t-2 \\ Y2t-2 \end{pmatrix} + \begin{pmatrix} \delta 11 & \delta 12 \\ \delta 21 & \delta 22 \end{pmatrix} \begin{pmatrix} Y1t-3 \\ Y2t-3 \end{pmatrix} + \begin{pmatrix} \phi 11 & \phi 12 \\ \phi 21 & \phi 22 \end{pmatrix} \begin{pmatrix} Y1t-4 \\ Y2t-4 \end{pmatrix} + \begin{pmatrix} \lambda 11 & \lambda 12 \\ \lambda 21 & \lambda 22 \end{pmatrix} \begin{pmatrix} Y1t-5 \\ Y2t-5 \end{pmatrix} + \begin{pmatrix} \mu 11 & \mu 12 \\ \mu 21 & \mu 22 \end{pmatrix} \begin{pmatrix} Y1t-6 \\ Y2t-6 \end{pmatrix} + \begin{pmatrix} u1t \\ u2t \end{pmatrix} \quad (2)$$

Where $\mathbf{Y_{1t}}$ and $\mathbf{Y_{2t}}$ are the real economic debt and the public debt as percentage of GDP. The final form was estimated using R software. Interpreting all these parameters is not been simple, so for analyzing the relationship of the two variables and their causality, the Granger-causality test and the Impulse Response Analysis were used.

Table 5. Granger Causality test results

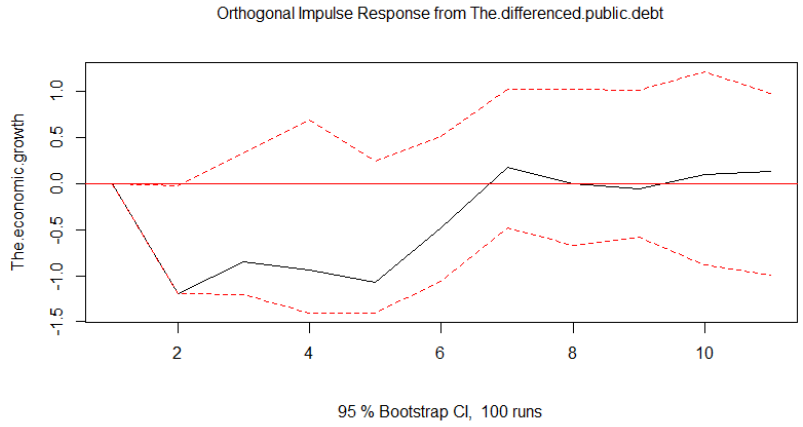
	Hypothesis	p-value
1	H_0: The E. G do not Granger cause the P. D	0.8573
2	H_0: The P. D do not Granger cause the P. D	0.6572
3	H_0: No instantaneous causality between E. G and P. D	0.01355
4	H_0: No instantaneous causality between P. D and E. G	0.01355

Source: own calculations

The results show an instantaneous causality between economic growth and public debt from 1994 to 2017. This means that adding observation of economic growth from the period t+1 helps improve the forecast of public debt at t+1. This also works for the reverse direction: adding public debt at t+1 helps improve the forecast of economic growth at time t+1. The null hypothesis of Granger-causality is not been rejected for big value of p-value.

On the graph of IRF analysis, the responses of the Economic growth is represented, after the shocks on the Public debt.

Figure 3. Graphic analysis of IRF



Source: own preparation

For SVAR model, restrictions based on the theory are imposed on the relations between the variables. In a simple VAR no restrictions are imposed in advance and the coefficients of the lagged values of the variables included are identified.

So in one sentence, in a SVAR restrictions are imposed on the variable dynamics beforehand and the rest is considered exogenous shocks, while in the VAR the coefficients of the lags are identified.

The diagnostic tests are verified (the heteroscedasticity, the normality of the residuals and the autocorrelation). The heteroskedasticity has been verified by ARCH-LM test and the null hypothesis has not been rejected (p-value=0.8287>0.05). The normality of the residuals has been verified by Jarque-Bera (p-value=0.5408), Skewness (p-value= 0.3875) and Kurtosis (p-value=0.547) tests. The autocorrelation has been verified by the ACF and PACF graphs.

SUMMARY

This study, conducted for Albania, shows that public debt and economic growth are two parameters that affect each other. High debt levels make the country lose reputation, have difficult access to international markets, not be favorable to foreign investors, etc. It is very important not only the level of debt but also the reason why it is taken and why will be used. The coverage of both indicators is closely related to the political events in the country. It is linked to the monetary and fiscal plot.

The study has shortcomings related to the small number of surveys and the fact that different sources give different data. The results indicated that an

instantaneous increase in real economic growth might increase the public debt and vice versa.

REFERENCES

Baum A., Checherita-Westphal C., Rother P. (2012) Debt and Growth: New Evidence for the Euro Area. European Central Bank, Working Paper Series, 1450.

Clements B., Bhattacharya R., Nguyen T. Q. (2003) External Debt, Public Investment, and Growth in Low-Income Countries. IMF Working Paper, 03/249.

Egbetunde T. (2012) Public Debt and Economic Growth in Nigeria: Evidence from Granger Causality. American Journal of Economics, 2(6), 101-106.

El-Mahdy M. A., Torayeh M. N. (2009) Debt Sustainability and Economic Growth in Egypt. International Journal of Applied Econometrics and Quantitative Studies, 6(1), 21-55.

IMF Data. http://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD/ALB.

Reinhart C., Rogoff K., Savastano M. (2003) Debt Intolerance. Working Paper, 9908, National Bureau of Economic Research, Cambridge.

Reinhart C., Rogoff K. (2011) A Decade of Debt. Working Paper, 16827, National Bureau of Economic Research, Cambridge.

Reinhart C., Reinhart V., Rogoff K. (2012) Debt Overhangs: Past and Present. Working Paper, 18015, National Bureau of Economic Research, Cambridge.

Schclarek A. (2004) Debt and Economic Growth in Developing and Industrial Countries. http://project.nek.lu.se/publications/workpap/Papers/WP05_34.pdf.

Sheikh M. et al. (2010) Domestic Debt and Economic Growth in Pakistan: An Empirical Analysis. Pakistan Journal of Social Sciences (PJSS), 30(2), 373-387.

Sims C. A. (1980) Macroeconomics and Reality. Econometrica, 48, 1-48.

Uzun A. et al. (2012) The Impacts of External Debt on Economic Growth in Transition Economies. Chinese Business Review, 11(5), 491-499.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 339 – 346

Received: 19.07.2018
Accepted: 21.12.2018

SOME PROPOSAL OF THE TEST FOR A RANDOM WALK DETECTION AND ITS APPLICATION IN THE STOCK MARKET DATA ANALYSIS

Marcin Dudziński https://orcid.org/0000-0003-4242-8411
Konrad Furmańczyk https://orcid.org/0000-0002-7683-4787
Arkadiusz Orłowski https://orcid.org/0000-0002-6755-1830
Faculty of Applied Informatics and Mathematics
Warsaw University of Life Sciences – SGGW, Poland
e-mail: marcin_dudzinski@sggw.pl; konrad_furmanczyk@sggw.pl; arkadiusz_orlowski@sggw.pl

Abstract: According to the numerous groups of theoreticians and practitioners, who act in the area of financial markets, changes in the stock prices are random and it is almost infeasible to predict them correctly using historical data. This approach is based on the random walk theory, which states that the price of financial instrument in the subsequent time point is the sum of its price in the previous time point and some random variable with a finite variance, i.e. it is modeled with the use of a stochastic process called a random walk. The random walk hypothesis stands in contradiction to the beliefs of the ordinary technical analysis followers, where the prediction is carried out on the grounds of existing trends, and furthermore, this hypothesis regards such a modeling of financial markets as incorrect. In our work, we construct statistical test for a random walk detection, which is based on the first arcsine law. We also present simulation results that allow to check the quality of the proposed test, as well as we show the application of the introduced test in the stock exchange data analysis.

Keywords: random walk, arcsine law, test for a random walk detection, stock market data analysis

JEL classification: C10, C12, C15, C19

https://doi.org/10.22630/MIBE.2018.19.4.32

INTRODUCTION

Random walk theory states that the price of financial instrument in the subsequent time point is the sum of its price in the previous time point and some random variable with a finite variance, i.e. it is modeled with the help of a stochastic process called a random walk. We say that a stochastic process $(Y_0, Y_1, \dots, Y_n, \dots)$ is a random walk (RW), if the following relations hold (see [Żak 2012]):

$$\begin{aligned} Y_0 &= y_0, \\ Y_1 &= y_0 + \varepsilon_1, \\ Y_2 &= y_0 + \varepsilon_1 + \varepsilon_2, \\ &\vdots \\ Y_n &= y_0 + \varepsilon_1 + \varepsilon_2 + \cdots + \varepsilon_n, \end{aligned}$$

where $\varepsilon_1, \varepsilon_2, \dots, \varepsilon_n, \dots$ form a sequence of independent and identically distributed (iid) random variables with a finite variance.

In our considerations, we deal with a symmetric Gaussian RW. Thus, we assume that $\varepsilon_i's$ have a standard normal distribution ($\varepsilon_i \sim N(0;1)$), and additionally that $y_0 = 0$. Thus, our RW process may be written as follows:

Thus, our RW process may be written as follows:

$$Y_t = \sum_{i=1}^{t} \varepsilon_i\,, \quad t = 1,2, \dots, \text{ where } \varepsilon_i - \text{iid} \sim N(0;1).$$

Consequently, we may write that:

$$Y_t = Y_{t-1} + \varepsilon_t, \text{ where } \varepsilon_t - \text{iid} \sim N(0;1),\ t = 1,2, \dots \tag{1}$$

Obviously, the relation in (1) is equivalent to:

$$\varepsilon_t = Y_t - Y_{t-1}, \text{ where } \varepsilon_t - \text{iid} \sim N(0;1),\ t = 1,2, \dots \tag{2}$$

From the economical point of view the RW process (Y_t), $t = 1,2, \dots$, may be interpreted as follows. Namely, if Y_t stands for the stock price in time t, then the difference between the stock prices in the periods t and $t-1$ – given by the relation in (2) – determines an increase or a decrease in the stock price in the period between $t-1$ and t.

As far as we are concerned, there are not many statistical tests devoted to a random walk identification. To the best of our knowledge, the main tools that have been applied in this context so far are the two celebrated tests – an augmented Dickey-Fuller test (see [Dickey, Fuller 1979]) and the Runs test, and through our work, we attempt to fill in a gap related to this field of research.

Our primary objective is to construct a new test for a random walk detection, the idea of which is based on the so-called first arsine theorem. We also check the quality of the proposed test by conducting some simulation studies. For more

detailed information regarding the theory of RW processes, we refer to [Maddala 2001] and [Montanari 1997].

Our paper is organized as follows. In Section 1, we present a general idea leading to the construction of our test for a random walk identification. In Section 2, we describe the construction of our test. Additionally, in Section 3 we check the efficiency of the introduced test, while in Section 4 we apply our test procedure to a dataset containing the daily returns of the WIG index at the Warsaw Stock Exchange. Finally, Section 5 summarizes our study.

A GENERAL IDEA OF THE PROPOSED TEST

Let (Y_t) denote a stochastic process given by:

$$Y_0 = 0,\ Y_t = Y_{t-1} + \varepsilon_t,\ \text{where } \varepsilon_t - \text{iid}{\sim}N(0;1),\ t = 1,2,\dots$$

We define a sequence $(\tilde{\varepsilon}_t)$ as follows:

$$\tilde{\varepsilon}_t = \begin{cases} +1, & \text{if} \quad \varepsilon_t = Y_t - Y_{t-1} > 0, \\ -1, & \text{if} \quad \varepsilon_t = Y_t - Y_{t-1} \le 0. \end{cases}$$

Since $\varepsilon_t{\sim}N(0;1)$, we have that $\varepsilon_t's$ are symmetric and so are $\tilde{\varepsilon}_t's$. Consequently, a sequence $(\tilde{\varepsilon}_t)$ is distributed in the way as below:

$$P(\tilde{\varepsilon}_t = +1) = P(\tilde{\varepsilon}_t = -1) = 1/2,\ t = 1,2,\dots$$

Let moreover, a sequence $\left(\tilde{Y}_t\right)$ be such that:

$$\tilde{Y}_t = \tilde{\varepsilon}_1 + \tilde{\varepsilon}_2 + \cdots + \tilde{\varepsilon}_{t-1} + \tilde{\varepsilon}_t = \tilde{Y}_{t-1} + \tilde{\varepsilon}_t,\ t = 1,2,\dots$$

The construction of our test is strictly connected with *the first arcsine law*, which states that if we denote by T_n^+ the proportion of those among $\left(\tilde{Y}_1, \tilde{Y}_2, \dots, \tilde{Y}_n\right)$ (i.e. among $(\tilde{\varepsilon}_1, \tilde{\varepsilon}_1 + \tilde{\varepsilon}_2, \dots, \tilde{\varepsilon}_1 + \tilde{\varepsilon}_2 + \cdots + \tilde{\varepsilon}_n)$), which are non-negative, then the following property is satisfied (see [Qiang, Jiajin 2018] and [Feller 1968, 79-82], for further details):

$$P(T_n^+ \le x) \to \frac{2}{\pi} arc\ sin\left(\sqrt{x}\right) \text{ for any } x\epsilon\langle 0;1\rangle,\ as\ n \to \infty. \tag{3}$$

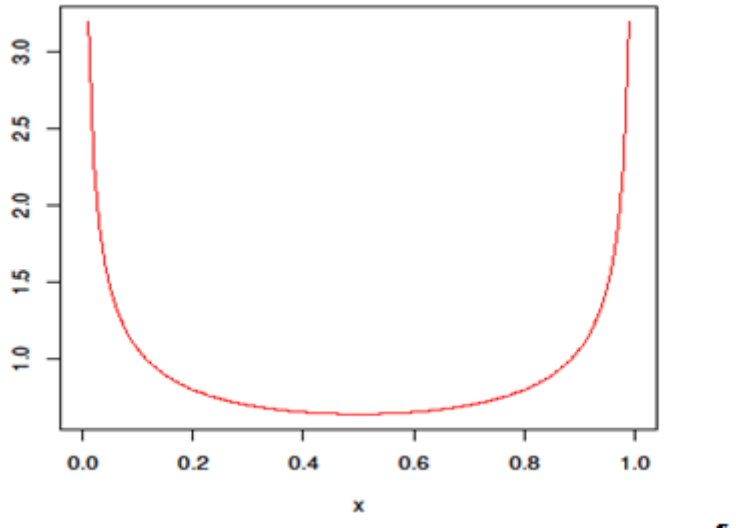
Thus, we may say that a sequence of proportions (T_n^+) converges in distribution to the arcsine distribution. The cumulative distribution function (cdf) F and the density function (df) f, of the arcsine distribution, are given by the formulas, respectively:

$$F(x) = \begin{cases} 0, & \text{if} \quad x < 0, \\ \frac{2}{\pi} arc\ sin\left(\sqrt{x}\right), & \text{if} \quad x\epsilon\langle 0;1\rangle, \\ 1, & \text{if} \quad x > 1; \end{cases} \tag{4}$$

$$f(x) = \frac{1}{\pi\sqrt{x(1-x)}}\mathbf{I}_{(0;1)} = \begin{cases} \frac{1}{\pi\sqrt{x(1-x)}}, & \text{if} \quad x\epsilon(0;1), \\ 0, & \text{if} \quad x \notin (0;1). \end{cases} \tag{5}$$

The density f in the interval $(0;1)$ is depicted in the figure below:

Figure 1. The density function of the arcsine distribution in $(0; 1)$



Source: own elaboration

Conclusion (3), of the first arcsine law, may practically be used for $n \geq 20$, which means that:

$$P(T_n^+ \leq x) \approx \frac{2}{\pi} arc\, sin\left(\sqrt{x}\right) \text{ for } x\epsilon\langle 0; 1\rangle, \text{ if } n \geq 20. \tag{6}$$

It intuitively seems that the probability of reaching the value close to 0.5 by T_n^+ is the largest. However, the truth is quite the opposite, namely: the values close to 0.5 are the least probable and the most probable values for T_n^+ are close to 0 or 1 (see [Feller 1966, 81-82]). It may be seen from the graph of the density f in the figure above. Thus, if we denote by α the significance level of the test:

$$H_0\text{: } (\tilde{Y}_t) \text{ and consequently also } (Y_t) \text{ form the random walk processes,} \tag{7}$$

we look for a critical area (or otherwise, a set of rejections) of the form $K_{c(\alpha)} = \left(0.5 - c(\alpha);\ 0.5 + c(\alpha)\right)$, where $c(\alpha)$ is a certain number from the interval $(0;\ 1)$. Therefore, we may write that:

$$P\left(T_n^+ \in K_{c(\alpha)}\right) \approx \int_{0.5-c(\alpha)}^{0.5+c(\alpha)} f(x)\, dx = \alpha, \text{ if } n \geq 20,$$

which, due to the formula for a density f in (5) and the fact that $\left(0.5 - c(\alpha);\ 0.5 + c(\alpha)\right) \subset (0; 1)$, is equivalent to:

$$P\left(T_n^+ \in K_{c(\alpha)}\right) \approx \int_{0.5-c(\alpha)}^{0.5+c(\alpha)} \frac{1}{\pi\sqrt{x(1-x)}} dx = \alpha, \text{ if } n \geq 20. \tag{8}$$

It follows from (8) that:

$$\int_{0.5-c(\alpha)}^{0.5+c(\alpha)} \frac{1}{\pi\sqrt{x(1-x)}} dx = \frac{2}{\pi} arc\, sin\left(\sqrt{x}\right)\Big|_{0.5-c(\alpha)}^{0.5+c(\alpha)} = \alpha. \tag{9}$$

In view of (9), we have the following condition on $c(\alpha)$:

$$arc\,sin\sqrt{0.5 + c(\alpha)} - arc\,sin\sqrt{0.5 - c(\alpha)} = \frac{\pi\alpha}{2}. \quad (10)$$

The values of $c(\alpha)$, calculated numerically according to (10) for the chosen significance levels, are collected in the following table:

Table 1. Values of $c(\alpha)$ for some selected α

α	0.01	0.05	0.1
$c(\alpha)$	0.008	0.039	0.078

Source: own elaboration

Thus, for the significance level $\alpha = 0.05$, we obtain the following critical area of the test in (7):

$$K_{c(0.05)} = (0.5 - 0.039;\ 0.5 + 0.039) = (0.461;\ 0.539). \quad (11)$$

The presented idea plays a key role in the construction of our test.

BRIEF DESCRIPTION OF THE PROPOSED TEST

Below, we present the idea of our test for a random walk detection. The notations for $\tilde{\varepsilon}_t$ and $\tilde{Y}_t$ from Section 1 will also be used throughout the current section of our paper.

As has already been mentioned in Section 1, the first arcsine law states that, for sufficiently large n, a sequence of proportions (T_n^+), where – for recollection:

$$T_n^+ = \#\{1 \le t \le n\colon \tilde{Y}_t \ge 0\}/n = \#\{1 \le t \le n\colon \tilde{\varepsilon}_1 + \tilde{\varepsilon}_2 + \cdots + \tilde{\varepsilon}_t \ge 0\}/n,$$

has asymptotically arcsine distribution.

It follows from (8) and (11) that

$$P\left(T_n^+ \in K_{c(0.05)}\right) = P\left(T_n^+ \in (0.461;\ 0.539)\right)$$
$$\approx \int_{0.461}^{0.539} \frac{1}{\pi\sqrt{x(1-x)}}\,dx = 0.05, \text{ if } n \ge 20.$$

Thus, provided $n \ge 20$, T_n^+ is a test statistic of our test and therefore, if the calculated value of T_n^+ belongs to the interval $K_{c(0.05)} = (0.461;\ 0.539)$, we reject the hypothesis H_0 from (6). Obviously, if this value does not belong to $(0.461;\ 0.539)$, we accept the hypothesis H_0 stating that $\left(\tilde{Y}_t\right)$ and (Y_t) are the random walk processes.

QUALITY OF THE PROPOSED TEST

In order to check the quality of the proposed test, we carried out the following empirical studies. Firstly, we generated 1000 samples $\boldsymbol{y}^{(i)}$, each of the size 1000, according to the model of the investigated process $(Y) = (Y_t)$:

$$y^{(1)} = \left(y_1^{(1)}, \ldots, y_{1000}^{(1)}\right), y^{(2)} = \left(y_1^{(2)}, \ldots, y_{1000}^{(2)}\right), \ldots,$$
$$y^{(1000)} = \left(y_1^{(1000)}, \ldots, y_{1000}^{(1000)}\right).$$

Secondly, based on the given samples $y^{(i)}$, we obtained 1000 samples $\varepsilon^{(i)}$:

$$\varepsilon^{(1)} = \left(\varepsilon_1^{(1)}, \ldots, \varepsilon_{1000}^{(1)}\right), \ \varepsilon^{(2)} = \left(\varepsilon_1^{(2)}, \ldots, \varepsilon_{1000}^{(2)}\right), \ldots,$$
$$\varepsilon^{(1000)} = \left(\varepsilon_1^{(1000)}, \ldots, \varepsilon_{1000}^{(1000)}\right),$$

where, for $i = 1, \ldots, 1000$:

$$\varepsilon_t^{(i)} = \begin{cases} y_t^{(i)} - y_{t-1}^{(i)}, \text{ if } t = 2, \ldots, 1000, \\ y_t^{(i)}, \text{ if } t = 1. \end{cases}$$

Subsequently, based on the given samples $\varepsilon^{(i)}$, we obtained 1000 samples $\tilde{\varepsilon}^{(i)}$:

$$\tilde{\varepsilon}^{(1)} = \left(\tilde{\varepsilon}_1^{(1)}, \ldots, \tilde{\varepsilon}_{1000}^{(1)}\right), \ \tilde{\varepsilon}^{(2)} = \left(\tilde{\varepsilon}_1^{(2)}, \ldots, \tilde{\varepsilon}_{1000}^{(2)}\right), \ldots,$$
$$\tilde{\varepsilon}^{(1000)} = \left(\tilde{\varepsilon}_1^{(1000)}, \ldots, \tilde{\varepsilon}_{1000}^{(1000)}\right),$$

where, for $i = 1, \ldots, 1000$:

$$\tilde{\varepsilon}_t^{(i)} = \begin{cases} +1, & \text{if} \quad \varepsilon_t^{(i)} > 0, \\ -1, & \text{if} \quad \varepsilon_t^{(i)} \leq 0. \end{cases}$$

Next, we calculated the fractions:

$$T_{1000}^{+(1)} = \#\left\{1 \leq t \leq 1000: \tilde{\varepsilon}_1^{(1)} + \tilde{\varepsilon}_2^{(1)} + \ldots + \tilde{\varepsilon}_t^{(1)} \geq 0\right\}/1000,$$
$$T_{1000}^{+(2)} = \#\left\{1 \leq t \leq 1000: \tilde{\varepsilon}_1^{(2)} + \tilde{\varepsilon}_2^{(2)} + \ldots + \tilde{\varepsilon}_t^{(2)} \geq 0\right\}/1000,$$
$$\vdots$$
$$T_{1000}^{+(1000)} = \#\left\{1 \leq t \leq 1000: \tilde{\varepsilon}_1^{(1000)} + \tilde{\varepsilon}_2^{(1000)} + \ldots + \tilde{\varepsilon}_t^{(1000)} \geq 0\right\}/1000,$$

and finally, we checked the number of those among the values $T_{1000}^{+(i)}$, $i = 1, \ldots, 1000$, satisfying the condition $T_{1000}^{+(i)} \in K_{c(0.05)} = (0.461;\ 0.539)$, which is a number of rejections among 1000 iterations of our test procedure. It enabled us to investigate the quality of the proposed test. We analyzed it thoroughly in Section 3 of our work.

We verify the quality of our test for a random walk identification with the use of the following models: M1 – a Gaussian random walk, M2 – ARIMA(1,0,0) with: $ar = 0.99$, $\sigma = 3$, M3 – ARIMA(1,0,0) with: $ar = 0.999$, $\sigma = 3$.

Applying the R package, we carried out 1000 iterations of our test procedure and then, we computed the numbers of rejections of H_0 among those iterations, i.e. the number of those among $T_{1000}^{+(i)}$, $i = 1, \ldots, 1000$, which belong to $K_{c(0.05)} = (0.461;\ 0.539)$. Below, we present these numbers for the selected models.

Table 2. The numbers of rejections of H_0 in (7) among 1000 iterations

Model	The proposed RW test	ADF test	Runs test
M1	50	45	46
M2*	49	163	50
M3*	55	41	49

* Models close to random walks

Source: own elaboration

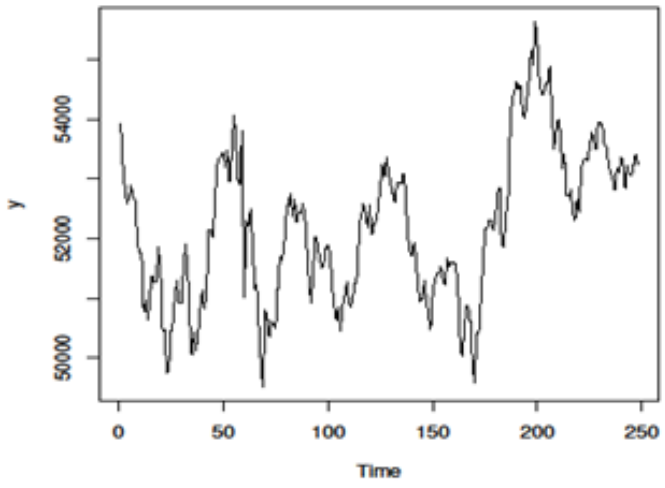
Comparing the numbers of rejections of our RW test with the numbers of rejections of the two earlier existing tests for a RW detection, we may see that the obtained fractions of rejections are close to a nominal significance level 0.05 for all of the considered tests and selected models except for the case of the ADF test and the model denoted by M2.

From the above depicted table, we may also observe that our test did not reject the hypothesis H_0: the processes $(\tilde{Y}_t)$ and (Y_t) form the random walks.

SOME APPLICATION IN THE STOCK EXCHANGE DATA ANALYSIS

In order to give an outlook on possible applications of our proposed test, we considered the daily stock exchange quotations of the WIG index from the period between December 2013 and November 2014. They are depicted in the figure below.

Figure 2. Daily stock returns for WIG from the period December 2013-November 2014



Source: own elaboration

It is supposed by a large number of academic people, primarily economists and statisticians, that the daily quotations of stock prices form a random walk process (see [Fama 2018]). Based on the given data, relating to this index in the

chosen space of time, we have carried out the proposed test procedure. As a result, we obtain a value of the test statistic 0.31 and, assuming a standard significance level of 0.05, we do not reject the null hypothesis that the daily returns of the WIG index come from a random walk process. This is in accordance with the real fact that the daily quotations of WIG form a random walk. It is also worthwhile to mention that the p-values of the earlier existing augmented Dickey-Fuller test and the Runs test (which are equal to 0.08 and 0.34, respectively) confirm that the considered sequence forms a random walk.

SUMMARY

The principal objective of our work was to construct a new test devoted to a random walk detection. The main idea applied in the construction of our test procedure was based on the conclusion from the first arcsine law. Except of introduction of our test, we also checked its quality by computing the numbers of rejections of the null hypothesis that the given process forms a random walk, for three selected models, after 1000 iterations of our test procedure. The conducted research shows that the proposed approach provides an effective tool leading to reasonable conclusions regarding the subject of a random walk identification. The results of our test, which has been designed by implementation of the arcsine principle, seem very optimistic and encourage us to further investigations in the direction of a random walk detection.

REFERENCES

Dickey D. A., Fuller W. A. (1979) Distributions of the Estimators for Autoregressive Time Series with a Unit Root. Jour. Amer. Stat. Assoc., 74, 427-431.

Fama E. F. (2018) Random Walks in Stock-Market Prices. Selected Papers, 16, Graduate School of Business, University of Chicago, https://www.chicagobooth.edu/ ~/media/ 34F68FFD9CC04EF1A76901F6C61C0A76.PDF [access date: 25.08.2018].

Feller W. (1966) Wstęp do rachunku prawdopodobieństwa. PWN, Warszawa (in Polish).

Feller W. (1968) An Introduction to Probability Theory and its Applications. Vol.1, 3rd Edition. Wiley.

Maddala G. S. (2001) Introduction to Econometrics. Wiley.

Montanari A., Rosso R., Taqqu M. S. (1997) Fractionally Differenced ARIMA Models Applied to Hydrologic Time Series: Identification, Estimation, and Simulation. Water Resources Research, 33(5), 1035-1044.

Qiang L., Jiajin L. (2018) Arcsine Laws and its Simulation and Application. Research Paper Available from: http://individual.utoronto.ca/normand/Documents/MATH5501/ Project-3/Arcsine_laws_and_simu.pdf [access date: 20.03.2018].

Żak T. (2012) Błądzenie losowe i cztery najważniejsze twierdzenia rachunku prawdopodobieństwa. Educational material available from: http://prac.im.pwr.edu.pl/ ~zak/ Spacery_losowe_Kolo_Studenckie_26_04_2012.pdf [access date: 26.04.2012].

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 347 – 354

Received: 12.11.2018
Accepted: 21.12.2018

CREDIT RATIONING AND FIRMS'SIZE: EXPLORATORY ANALYSIS OF THE EFFECT OF THE GREAT RECESSION (2010-2016) IN ITALY

Maria Ferrara https://orcid.org/0000-0002-3023-9851
Department of Economic and Legal Studies University of Naples Parthenope, Italy
e-mail: ferraramaria11@gmail.com
Elisabetta Marzano https://orcid.org/0000-0003-1838-0104
Department of Economic and Legal Studies University of Naples Parthenope and CESifo, Italy
e-mail: elisabetta.marzano@uniparthenope.it
Roberta Rubinacci https://orcid.org/0000-0002-0974-6509
Department of Economic and Legal Studies University of Naples Parthenope, Italy
e-mail: roberta.rubinacci@uniparthenope.it

Abstract: In this paper we investigate the evidence of credit rationing in Italy during the period 2010-2016 characterized by evere distress in the banking system. The role of banks in the Italian economic system is crucial, since the Italian financial system can be classified as a bank oriented one. In addition, Italian economy is characterized by a very large share of small and medium sized enterprises (SMEs). This aspect adds value to our analysis given that literature usually assumes that the smaller the firms size the larger they suffer from credit rationing. By using a unique data set, provided by Bank of Italy, we get a twofold result. First, in Italy, the last economic and financial crisis has reduced the access to banking loans for SMEs, since there is a clear hump-shaped pattern in the time series of our measures of credit rationing. Differently, for large firms, it seems to have caused a larger volatility rather than a veritable credit rationing. Second, and this is our main result, matching micro and macro data, we do find support to the intuition that different banking crises exert different effects on firms' financing conditions.

Keywords: credit rationing, small and medium-sized enterprises (SMEs), Italian Banking System, banking crisis

JEL classification: E44, G010

https://doi.org/10.22630/MIBE.2018.19.4.33

INTRODUCTION

In this paper we investigate the evidence of credit rationing in Italy during the period 2010-2016, aiming to ascertain whether there are statistically significant differences experienced by firms according to their size and the type of banking crisis episode. The issue of credit rationing to firms, according to their dimension, has come to the forefront of the recent empirical literature, especially in the aftermath of the recent financial crisis. This a crucial issue for the Italian economic system, as it can be considered a bank oriented economy, characterized by a very large share of small and medium sized firms (SMEs)[1]. Less attention has been paid so far to the nexus between banking crisis episodes (mostly examined in a macro perspective) and the cosnequences for credit rationing (mostly a micro founded analysis).

By using a survey run by Bank of Italy, it was examined the extent to which the financial crisis has affected Italian firms controlling for their size. In addition, thanks to a previous study on the classification of the banking crises, it had been investigated whether different types of banking crises impact differently on credit rationing.

The main result of the paper emphasizes that in Italy, over the period 2010-2016, the severity of credit rationing was affected by the type of turbolence in the financial markets. Following the definition of banking crises adopted by Bartoletto et al. [2018], it is found that only the most severe episode, related to the sovereign debt crisis, has seriously increased credit constraints, with remarkable increase in credit rationing experienced by large firms earlier compared to SMEs. This evidence might have a twofold explanation.

On the one hand, during periods of financial distress, large firms are less able to find financial resources in the equity/stock markets, and resort more intensively to the credit market. In this sense credit constraints might be increasingly binding, and the origin is in the increased demand of credit from large firms.

On the other hand, SME might severely reduce their demand for credit loans due to a relatively more intense investment downsizing in periods characterized by deep recession (lower adjustment costs). However, despite this observed pattern

[1] The OECD defines small- and medium-sized enterprises (SMEs) as "non-subsidiary, independent firms which employ fewer than a given number of employees. This number varies across countries. The most frequent upper limit designating an SME is 250 employees, as in the European Union. However, some countries set the limit at 200 employees, while the United States considers SMEs to include firms with fewer than 500 employees. Small firms are generally those with fewer than 50 employees, while micro-enterprises have at most 10, or in some cases 5, workers." See http://stats.oecd.org/glossary/detail.asp?ID=3123; last access on November the 10th.

during the banking crisis of 2011, throughout the investigated period of time, 2010-2016, the SMEs have suffered greater credit constraints than larger firms.

The rest of the paper is organized as follows. Section 2 provides the motivation of the paper and the related literature review, also focusing on the role of bank credit for Italian companies. Section 3 presents the different credit rationing definitions in the light of the two banking crises episodes under consideration. This section also describes the empirical study embodying data set description, some descriptive evidence, methodology and results. Finally, section 4 concludes the research.

MOTIVATION AND LITERATURE REVIEW

A large part of the literature attributes to small and medium-sized enterprises (SMEs) the inability to obtain loans, while it believes that large companies are able to more easily access to credit. The first contribution highlighting such a difference is Gertler and Gilchrist [1994]. They analyze the different behaviors of small and large manufacturing firms after monetary policy shocks, taking into account data of the Quarterly Financial Report for Manufacturing Corporations (QFRI) from 1958 to 1990. They show that, during credit squeeze periods, the SMEs significantly reduce short-term debts, sales and inventory. Differently, large companies increase their debts to accumulate warehouse stocks. In line with this viewpoint, Costa et al. [2012] reveal that SMEs are most negatively affected by the credit crunch than large companies and that the gap lately is even larger. Overall, according to this perspective, when bank credit shrinks SMEs tend to be more vulnerable than larger firms [Wehinger 2014].

In bank-oriented financial systems the effect of banking crises might be very severe, and one of the transmission mechanisms is credit provision to firms. Albeit there is ample literature investigating the effect of banking crises on real economy, suggesting that not all banking crises are alike, less attention has been paid to understand whether different banking crises can impinge differently on the transmission mechanism working through credit provision to firms.

Our paper contributes to clarisfy this interaction, emphasizing that credit rationing to firms shapes differently according to either firms' size and the specific features of the banking crisis episode.

To this scope we employ the classification of banking crises introduced by Bartoletto et al. [2018], who classify a banking crisis episode occurring in a specific year T_j as a "slow-down" crisis if the following condition holds:

$$\left|T_j - T_{peak}\right| \leq 1 \tag{1}$$

where T_{peak} is the date of the upward turning point. In other words, a "slow-down" crisis spreads its effects in one year time window around a business cycle peak. All the others are "inner-banking" crises, in the sense that they do not show any

evident real impact. The most severe category of banking crisis is referred to as boom-bust crisis, namely a subset of the slowdown ones, meeting the condition:

$$0 \leq T_j - T_{peak} \leq 1 \quad (2)$$

When coming to the period of interest in the present analysis, namely 2010-2016, Bartoletto et al. [2018] find that two different banking crisis episodes have occurred: 2011 and 2013-2016. While the former meets the requirements of a boom-bust crisis, the latter is classified as an inner-banking crisis.

As it is clear from Table 1, adapted from Bartoletto et al. [2018], the boom-bust crisis did exert negative and permament effects either on the rate of growth of GDP and on that of credit. Conversely, the period of turbolence in the banking system occurring in 2013-2016, when included in the VAR model estimated by Bartoletto et al. [2018], did not contribute to explain neither GDP nor credit dynamics.

Table 1. The effect of banking crises on the rate of growth of GDP and Loans, VAR model. Banking crisis episodes: 2011 and 2013-2016

VAR equation		Banking crisis 2001	Banking crisis 2013-2016
GDP	Estimated coefficient *current dummy*	-0.03**	-0.008
	Estimated coefficient *lagged dummy*	-0.01**	-0.0005
LOANS	Estimated coefficient *current dummy*	-0.06**	-0.04
	Estimated coefficient *lagged dummy*	-0.05*	0.002

*,**,***: statistically significant at 10, 5 and 1% respectively.

Source: adapted from Bartoletto et al. [2018]

THE DATA SET

In this article we employ the data set of the Survey of Industrial and Service Firms (Indagine sulle Imprese Industriali e dei Servizi), available through the Bank of Italy's remote processing system.[2] The survey is run annually by the Bank of Italy, and collects specific information on individual Italian firms, including several measures of credit restrictions which are the focus of our analysis, jointly with firm size (see http://www.bancaditalia.it/statistiche/indcamp/indimpser).

As to this latter aspect, firms are classified according to their size into 6 categories, on the basis on the number of employees:

[2] Users are not allowed to use microdata, they can only submit the program codes and receive back the results.

- Class 0: 20 – 49 employees;
- Class 1: 50 – 99 employees;
- Class 2: 100 – 199 employees;
- Class 3: 200 – 499 employees;
- Class 4: 500 – 999 employees;
- Class 5: 1000 – over employees.

Following Cenni et al. [2015], we differentiate among: firms who would like to borrow more (*weak rationing*), companies willing to offer more guarantees, even paying a higher interest rate (*medium rationing*), firms who are denied the loan by banks (*rationing strictly defined*). The interesting aspect of the this work is to investigate the trend of these variables over time and according to the firm' size, with respect to the evolution of the banking crisis episodes occuring in the period 2010-2016.

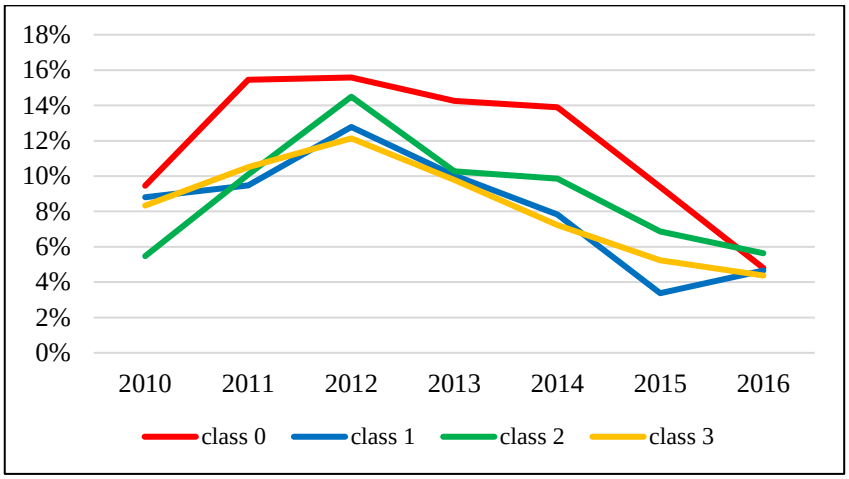
Following the standard approach in the literature [Angelini et al. 1998; Angelini, Generale 2008], a firm is considered rationed if it affirmatively answers to one of the following questions:

- Weak rationing: Please indicate whether in whole, to the currently agreed terms and conditions, would you like to have higher indebtedness with credit institutions or other financial intermediaries? (code FI53).
- Medium rationing: If you affermatively reply to previous question, please indicate whether you are willing to pay a higher interest rate, or equally, supply more guarantees, in order to have more funding (code FI54).
- Rationing striclty defined: Please indicate whether the financial intermediaries you have got in touch with were not avilable to provide more funding (code FI58).

The definition of "weak rationing" also includes those firms that are discouraged to borrow additional funds and those who need them but do not have the willingness/ability to pay a higher rate or more guarantees. Whereas the definition of "medium rationing" allows to explain the behavior of banks about the choice to finance manufacturing companies, generating therefore credit rationing.

Authors investigate whether credit rationing is consistent with the macro evidence about the real impact of banking crises in the period 2010-2016. During phases of financial distress it is expected tighten credit conditions, that could affect firms differently according to their size. In Figure 1 and 2 we focus on the definition of rationing strictly defined.

Figure 1. Credit rationing SMEs (FI58 from Class 0 to Class 3)

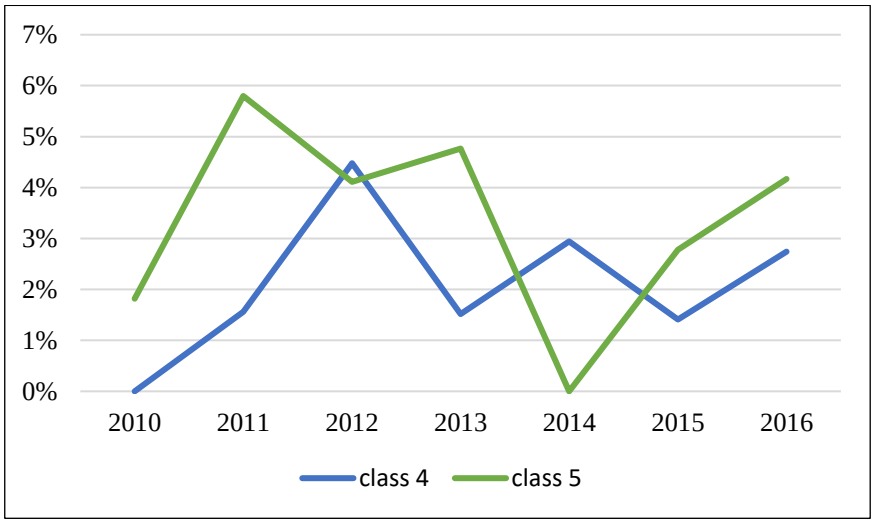


Source: own calculations (dataset: Bank of Italy, 2018)

Figure 1 shows that the extent to SME firms have experienced credit rationing strictly defined (that is they have asked for additional credit and have been denied it) follows a hump-shaped pattern, rising until 2012 and then decling. In particular class 0 (20 – 49 employees), experienced the largest share of credit rationing, reaching peaks above 15 percentage points between 2010 and 2011 and then slowly returning, in line with the other classes, to a rationing level around 5% in 2016. Also class 2 firms (100 – 199 employees) experienced many cases of credit rationing reaching a peak of 14,5% in 2012. Perentages slightly lower have been recorded for firms of classes 1 (50 – 99 employees) and 3 (200 – 499 employees), reaching peaks of about 12 percentage points in 2012. Overall, Figure 1 suggests that only the most severe episode of banking crisis, the boom bust one related to the sovereign debt crisis, has seriously increased credit rationing for SMEs.

Conversely, when turning the attention to medium and large firms, (Figure 2), it's immediate the evidence that the financial distress experienced during the period 2010-2016 has caused a larger volatility rather than a veritable credit rationing for large firms. In particular from 2010 to 2011 credit rationing for large firms, class 5 (1000 – over number of employees), rises from 2.0% to almost 6.0% and this dynamic is also observed for class 4 (500 – 999 number of employees).

Figure 2. Credit rationing and large firms (FI58 Class 4 and Class 5)



Source: our own calculations (dataset: Bank of Italy, 2018)

Then, the remarkable increase in credit rationing experienced by large firms compared to SMEs has a twofold explanation. On the one hand, during periods of financial distress, large firms are less able to find financial resources in the equity and stock markets, and they resort more intensively to the credit market. In this sense credit constraints might be increasingly binding, and the origin is in the increased demand of credit from large firms. On the other hand, SME might severely reduce their demand for credit loans due to a relatively more intense investment downsizing in periods characterized by deep recession (lower adjustment costs).

CONCLUSIONS

Literature on credit constraint has often enphasized that SME can suffer relatively more intensively from disruption in the supply of bank credit because of their opacity. In this paper we have found evidence for Italy which is consistent with the idea of flight to quality: during the last economic and financial crisis SMEs have experienced more severe credit constraints compared to large sized firms.

However, we have also find evidence that banking crises propagate their effects through credit provision to firms in a manner which is dependent upon the crises' characteristics. Moving from the classification borrowed from Bartoletto et al. [2018], we find that credit rationing increases only when boom-bust banking crises are involved. Interestingly, in this case the largest rise in credit rationing is observed for large firms, and not for SME.

The matching of micro and macro evidence, the former related to micro data on firms' credit rationing, and the latter referred to business and credit cycle dating, suggests that different banking crises exert different effects on firms' financing conditions. In other words, we find that the mechanisms of propagation of banking crises change according to the type of banking crisis, ingenerating not trivial results in terms of credit rationing and firm size.

REFERENCES

Angelini P., Di Salvo R., Ferri G. (1998) Availability and Cost of Credit for Small Businesses: Customer Relationships and Credit Cooperatives. Journal of Banking & Finance, 22, 925-954.

Angelini P., Generale A. (2008) On the Evolution of Firm size Distribution. American Economic Review, 98, 426-438.

Bank of Italy (2018) Survey of Industrial and Service Firms. https://www.bancaditalia.it/statistiche/basi-dati/bird/.

Bartoletto S., Chiarini B., Marzano E., Piselli P. (2018) Banking Crises and Business Cycle: Evidence for Italy (1861-2016). Journal of Financial Economic Policy, doi: 10.1108/JFEP-03-2018-0055.

Cenni S., Monferrà S., Salotti V., Sangiorgi M., Torluccio G. (2015) Credit Rationing and Relationship Lending. Does Firm Size Matter? Journal of Banking & Finance, 249-265.

Costa S., Malgarini M., Margani P. (2012) Access to Credit for Italian Firms: New Evidence from the ISTAT Confidence Business Surveys. MPRA Paper 41389, University Library of Munich, Germany.

Gertler M., Gilchrist S. (1994) Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms. The Quarterly Journal of Economics, Oxford University Press, 109(2), 309-340.

Wehinger G. (2014) SMEs and the Credit Crunch: Current Financing Difficulties, Policy Measures and a Review of Literature. OECD Journal: Financial Market Trends, 2013/2, https://doi.org/10.1787/fmt-2013-5jz734p6b8jg.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 355 – 365

Received: 19.06.2018
Accepted: 21.12.2018

THE PORTFOLIO OF FINANCIAL ASSETS OPTIMIZATION. DIFFERENT APPROACHES TO ASSESS RISK

Petro Hrytsiuk https://orcid.org/0000-0002-3683-4766
Institute of Economics and Management
The National University of Water and Environmental Engineering, Rivne, Ukraine
e-mail: gritsukp@ukr.net

Abstract: Modern research has led to the rejection of the hypothesis of a normal distribution for financial asset returns. Under these conditions, the portfolio variance loses part of its informativity and can not serve as a good risk measure. The central aim of this work is the development and justification of a new technique of portfolio risk measure. We analyzed weekly stock returns of four largest German concerns: Deutsche Telekom, Siemens AG, Bayer AG and BMW. It is shown that asset returns are not normally distributed, but with good precision follow Laplace distribution (double exponential distribution). Using Laplace distribution function, we obtained the analytical expressions for VaR and CVaR risk measures and made calculations of risk measure using these approaches. Using modified Markowitz model the efficient frontiers of portfolios were constructed.

Keywords: portfolio of assets, expected return, risk measure, variance, Value-at-Risk, conditional Value-at-Risk

JEL classification: G11

INTRODUCTION

Due to its complexity, economic systems are constantly in a state of uncertainty. This uncertainty always gives rise to the risk [Vitlinskyy 1996]. This may be the risk of profit loss, risk of expenses, the risk of unused opportunities, etc. The causes of uncertainty and the resulting risk are accidental economic processes, inaccuracy, incompleteness and asymmetry of economic information.

One of the important tools for risk management is diversification [Sharpe et al. 1995; Bazylevych et al. 2011]. In practice, diversification is often realized by building a portfolio of financial assets. The portfolio theory originates from the

https://doi.org/10.22630/MIBE.2018.19.4.34

works of H. Markowitz [Markowitz 1952; Markowitz 1991]. The main characteristics of portfolio in this theory are mathematical expectation of return and variance (as a risk measure). This method, known as the classical theory of portfolio, relies on hypotheses about the normality of returns distribution for assets included in the portfolio, and their non-autocorrelation.

The hypotheses of classical portfolio theory are criticized in modern financial research. In works by R. Blattberg, T. Bollerslev, R. Engle the presence of "heavy tails" was discovered in the distribution of financial assets [Bollerslev 1990; Engle 1995]. Under these conditions, variance loses some part of its informativity. At present, VaR is considered a more reliable indicator of risk and its expansion to a coherent risk of CVaR and its modification [Hohlov 2012; Baumol 1963; Pflug 2000]. The question of the choice of a rational structure of the portfolio of financial assets on the basis of these measur'es is considered in the works by Alexander G. J., Baptista M. A. [Alexander, Baptista 2004] and Zabolotskyy T. [Zabolotskyy 2016a, 2016b]. Thus, the problem of optimizing financial assets portfolio remains relevant due to the openness of the question of an adequate method for measuring risk.

USED DATA

The main goal of this work is to perform a comparative analysis of financial portfolio optimization using different risk assessment techniques. We investigated the portfolio formed by stocks of four German companies: Deutsche Telekom, Siemens AG, Bayer AG, BMW. There are several approaches to determining the stock returns. We use the definition of stock returns as the ratio of the stock price by the end of the time interval to the stock price of its start. As the most adequate stock price, we considered the closing price (Adj Close). The series of stock returns will look like

$$r_t = \frac{y_{t+1}}{y_t}, \ t = 1,2,\ldots,T-1. \tag{1}$$

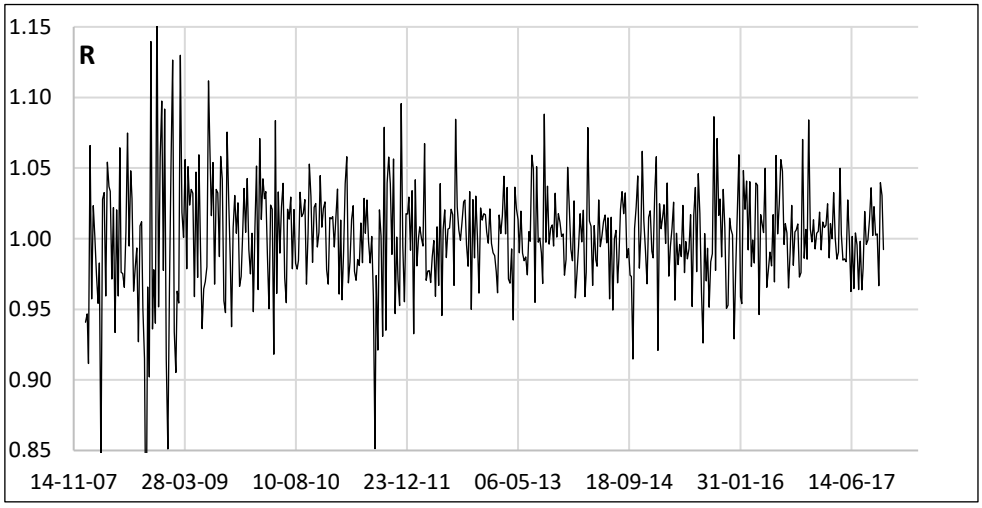
Siemens AG stock returns, calculated by the equation (1) and statistics (https://finance.yahoo.com/) are presented in Figure 1. Similarly, it is possible to characterize the stock returns of other three corporations included in the portfolio. Using the weekly price data from 01 January 2008 to 06 November 2017, we obtained statistical characteristics for stock returns of all four corporations (Table 1).

Table 1. Statistical characteristics of stock returns

	Bayer AG	BMW	Deutsche Telecom	Siemens AG
minimum	0.811	0.759	0.778	0.766
maximum	1.129	1.175	1.262	1.177
average	1.002	1.003	1.000	1.001
standard deviation	0.038	0.047	0.037	0.040

Source: https://finance.yahoo.com/

Figure 1. Stock returns of Siemens AG



Source: own preparation

IDENTIFICATION OF THE STOCK RETURNS DISTRIBUTION

Markowitz model is based on the assumption of a normal distribution of financial assets. The probability density of the normal distribution is

$$f(r) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(r-\mu)^2}{2\sigma^2}}, \tag{2}$$

where μ is the mean or expectation of the stock returns distribution, σ is the standard deviation, and σ^2 is the variance. To test the hypothesis of the normal distribution of stock returns, we used Pearson's criterion of agreement and Kolmogorov-Smirnov criterion. For applying the first criterion, it is necessary to calculate Pearson statistics using the formula

$$Q^2 = \sum_{i=1}^{k} \frac{(n_i - m_i)^2}{m_i}, \tag{3}$$

and compare it with tabular values $\chi^2_{kp}(\alpha, k-3)$. Here k is the number of intervals, m_i - the theoretical number of the random variable values in the i-th interval, n_i - the actual number of the random variable values in the i-th interval, α = 0.05 - the level of significance of the test. In our case $\chi^2_{kp}(0.05, 7-3) = 9.49$, $Q^2 = 119.12$. Since $Q^2 > \chi^2_{kp}$, the hypothesis of normal distribution is rejected. A similar conclusion was obtained using Kolmogorov-Smirnov criterion.

The investigation of the stock returns of three other corporations also led to the rejection of normal distribution hypothesis. The main reason for the deviation from the normal distribution is the presence of "heavy tails" in stock returns distribution. This means that the probability of occurrence of extreme (very large or very small) values of stock returns is much higher than assumed by the normal distribution. Consequently, we can not apply Markowitz model to optimize the stock portfolio.

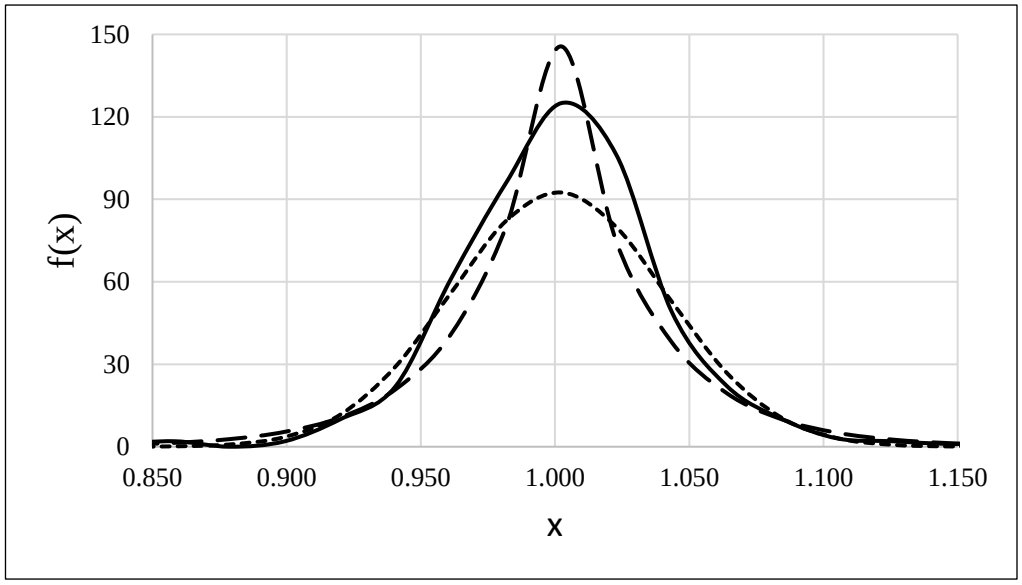
To construct a new portfolio model, it is necessary to identify stock retutns distribution and choose an adequate risk measure. Computer experiments showed that the stock returns of all four corporations are described with good precision by Laplace distribution (double exponential distribution) [Lapach et al. 2002].

The random variable with Laplace distribution has a density:

$$f(r) = \frac{b}{2}\exp\left(-b\left|r-\mu\right|\right). \tag{4}$$

Here r - stock return, μ - the mathematical expectation of the stock return, b - the coefficient that determines the excess distribution. Laplace distribution density is similar to normal distribution, but Laplace distribution has thicker tails compared with normal distribution (Figure 2). The graph is based on calculations performed using statistical data (https://finance.yahoo.com/). The task of the distribution identification is reduced to the optimal choice of parameter b. The parameter b of Laplace distribution has been selected by minimizing Pearson statistics (3).

Figure 2. Identification of Siemens AG return distribution. Solid line - actual distribution, dashed line - Laplace distribution, dotted line - normal distribution



Source: own preparation

The integral Laplace distribution function has the following form

$$F(r)=\begin{cases}\frac{1}{2}e^{b(r-\mu)}, r \le \mu \\ 1-\frac{1}{2}e^{-b(r-\mu)}, r > \mu.\end{cases} \quad (5)$$

Checking the hypothesis about the Laplace distribution for stock returns according to Pearson criterion has confirmed the validity of the hypothesis (Table 2).

Table 2. Checking the hypothesis about Laplace distribution according to Pearson criterion

	Bayer	BMW	Deutsche Telecom	Siemens
b	32.14	27.06	33.97	32.15
μ	1.002	1.003	1.000	1.001
Q^2	22.66	21.91	26.50	25.12
χ_{kp}^2	27.59	26.30	27.59	27.59

Source: own study

RISK ASSESSMENT TECHNIQUE

Markowitz first pointed out that in constructing the portfolio of assets it is necessary to take into account not only the portfolio return but also the portfolio risk [Markowitz 1952]. In Markowitz model, the risk of i-th stock is considered as the mean-square deviation σ_i of return from its mathematical expectation. To assess the portfolio risk, it is necessary to evaluate the correlation between its components. Financial assets with high positive correlation increase the portfolio risk; financial assets, between which the correlation is weak or negative reduce the portfolio risk. The portfolio risk σ_p is determined by the function of mean-square deviation:

$$\sigma_p = \sqrt{\sum_{i=1}^{T}\sum_{j=1}^{T}\left(w_i \times \sigma_i \times w_j \times \sigma_j \times \rho_{ij}\right)} \tag{6}$$

where: w_i, w_j - the percentage of assets in the portfolio; σ_i, σ_j - risk of assets (standard deviation of return); ρ_{ij} - Pearson correlation coefficient between the return of two assets.

In our research we follow Markowitz techniques. But the rejection of the normal distribution requires a different risk measure, that is different from the variance. In modern financial practice better risk measures are quantile-based measures. The most popular of them is the so-called Value-at-Risk (VaR) [Hohlov 2012]. VaR shows the maximal level of losses with the probability α. The parameter α is known as a confidence level. The values for α which are usually chosen are 0.9; 0.95; 0.99. To calculate the exact quantile value, it is necessary to know the distribution function of stock return F(x) (Figure 3).

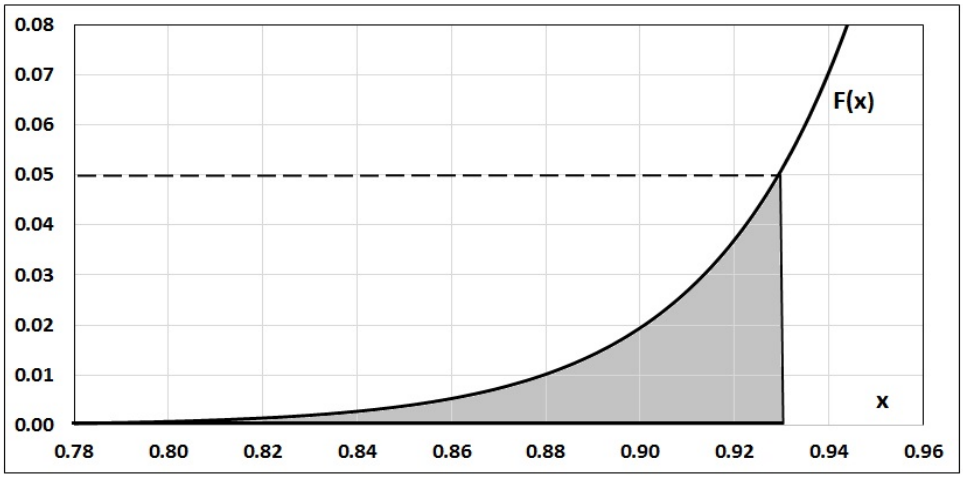
At a certain confidence level of α for VaR, the risk of a financial asset with a return of X_t is [Zabolotskyy 2016a]

$$VaR_\alpha(X_t) = -\sup\{x \in \Re : F_x \le 1-\alpha\}. \tag{7}$$

Using the form of Laplace distribution function (5), we can find an analytic expression for risk degree at a given comfidence level α. From equality $e^{b(x-\mu)} = 2\alpha$ we define

$$VaR_\alpha = \mu + \ln 2\alpha / b. \tag{8}$$

Figure 3. Determination of bound for risk zone VaR_α at level $\alpha = 5\%$ (Siemens AG)



Source: own preparation

The value VaR_α specifies the limit value of the random variable x, below which the risk zone is located. To estimate the risk measure, we chose the distance from the mathematic expectation of return to the limit of the risk zone

$$V = -\frac{\ln 2\alpha}{b}. \tag{9}$$

The disadvantage of *VaR* is that it is not subadditive. Therefore, it is often used in its improved version - the so-called conditional *VaR* (*CVaR*). $CVaR_\alpha$ represents average losses with a probability of $1-\alpha$. If the function of the density of distribution $f(r)$ for the return of financial asset is known, *CVaR* at the confidence level α can be calculated as follows:

$$CVaR_\alpha = \int_0^{VaR_\alpha} rf(r)dr \Big/ \int_0^{VaR_\alpha} f(r)dr. \tag{10}$$

Using the expression for the function of the density of distribution (4), equality (8) and after integrating, we obtained the following expression for $CVaR_\alpha$

$$CVaR_\alpha = \left(\alpha\left(\mu + \frac{\ln 2\alpha}{b} - \frac{1}{b}\right) - \frac{1}{2b}e^{-b\mu}\right) \Big/ \left(\alpha - \frac{1}{2}e^{-b\mu}\right). \tag{11}$$

By analogy with the previous case, to estimate the risk portfolio, we chose the distance from the mathematical expectation portfolio return to the bound of risk zone

$$V = \mu - CVaR_\alpha. \tag{12}$$

The values of the bound risk zone (Var, CVaR) and the risk measure V calculated by us are shown in Table 3.

Table 3. Estimation of stock risk by method of quantile zones ($\alpha = 0.95$)

	Bayer	BMW	Deutsche Telecom	Siemens
VaR	0.930	0.917	0.932	0.930
V var (%)	7.16	8.51	6.78	7.16
CVaR	0.900	0.881	0.903	0.899
V cvar (%)	10.15	12.16	9.69	10.18

Source: own study

PORTFOLIO OPTIMIZATION

Assuming that stock returns $r_i(t)$ are poorly stationary random processes, each of which is characterized by mathematical expectations μ_i and a degree of risk V_i, then for portfolio optimization, a modified Markovic model can be used. In this case, the mathematical description of the problem at the maximum portfolio return will have the form:

$$\begin{cases} R_p = w_i \times \mu_i \to \max; \\ V_p = \sqrt{\sum_{i=1}^{4}\sum_{j=1}^{4}\left(w_i \times V_i \times w_j \times V_j \times \rho_{ij}\right)} \le V_{req}; \\ w_i \ge 0; \sum w_i = 1. \end{cases} \tag{13}$$

We used an approach similar to the Markovits approach to assess portfolio risk V_p, but instead of a standard deviation of stock return on the risk measure V_i we got. In contrast to the mean square deviation that describes the average deviation of stock return from its mathematical expectation, the risk measure V_i evaluates the deviation of VaR (CVaR) from the mathematical expectation of stock return. The correctness of such approach to optimizing the portfolio is analyzed in detail in the monograph of Zabolotskyy [Zabolotskyy 2016a]. The mathematical description of the problem for a minimum portfolio risk will have the form:

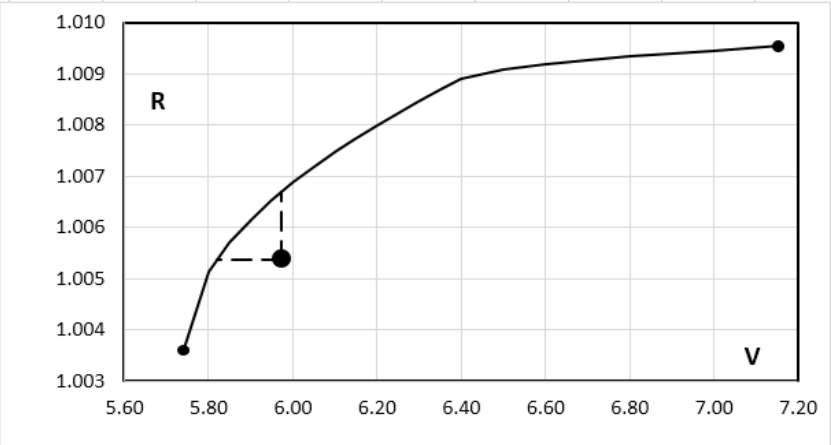
$$\begin{cases} V_p = \sqrt{\sum_{i=1}^{4}\sum_{j=1}^{4}\left(w_i \times V_i \times w_j \times V_j \times \rho_{ij}\right)} \to \min; \\ R_p = w_i \times \mu_i \ge R_{req}; \\ w_i \ge 0; \sum w_i = 1. \end{cases} \tag{14}$$

Here w_i is the weight of the i-th financial asset in portfolio, V_p - general portfolio risk, V_{req} - recommended portfolio risk, R_p - overall portfolio return, R_{req} - recommended portfolio return. To optimize the portfolio, we will use the average stock return $\mu_1, \mu_2, \mu_3, \mu_4$, previously found risk estimates V_1, V_2, V_3, V_4, and a pseudo-covariance $\mathrm{cov}(r_i, r_j) = p_{ij} \cdot V_i \cdot V_j$, where $\rho_{ij}, i = 1.4; j = 1.4$ is a Pearson correlation coefficient between the two time series of stock return.

Let's show the difference between a randomly formed portfolio and an optimal stock portfolio. Let us form portfolio within stocks of four companies (Deutsche Telekom, BMW, Bayer AG and Siemens AG), having the equal share of investment to them $w_1 = 0.25;\ w_2 = 0.25;\ w_3 = 0.25;\ w_4 = 0.25$. Such a portfolio (with the use of risk measure VaR) will have the following characteristics: $R_p = 1.0054;\ V_p = 5.97\%$ (the point on the graph – Figure 4). We will show that these characteristics will not be optimal. Indeed, using model (13) and recommended risk level $V_{req} = 5.97\%$, we get the maximum possible portfolio return $R_p = 1.0067$. If we use model (14) and recommended return level $R_p = 1.0054$, we obtain the minimum possible risk level $V_p = 5.82\%$.

Using the obtained above stock risk estimates (Table 3), we constructed the set of optimal portfolios (the efficient frontier). Each such portfolio gives maximum return at the established risk level. For the first time, the concept of optimal portfolios set was introduced by Markowitz [Markowitz 1952]. The technique for constructing the set of optimal portfolios was as follows. Initially, a portfolio structure with a minimum risk level and a minimum portfolio return was determined (model (14)). In the second step, we determined the portfolio structure with maximum portfolio return and maximum portfolio risk (model (13)). Then, by changing the risk value from the minimum to the maximum value in step 0.05 and using the model (13), we received the set of optimal portfolios. The graphic illustration of this set is shown in Figure 4.

Figure 4. The set of optimal portfolios (the risk measure Var)



A round point represents a portfolio with equal shares of investment

Source: own preparation

The Table 4 presents the portfolio structure for each of the optimal solutions obtained by us using stock weekly price data (https://finance.yahoo.com/). The graph and the table confirms the well-known statement that a higher return level always requires a higher risk degree.

Table 4. The set of optimal portfolios (the risk measure Var)

w_1	w_2	w_3	w_4	V_p	R_p
0.277	0.034	0.433	0.256	5.738	1.0035
0.326	0.035	0.301	0.337	5.800	1.0051
0.356	0.035	0.219	0.389	5.900	1.0061
0.378	0.035	0.160	0.427	6.000	1.0069
0.397	0.034	0.111	0.458	6.100	1.0075
0.413	0.034	0.068	0.485	6.200	1.0080
0.435	0.003	0.035	0.528	6.300	1.0085
0.435	0.003	0.000	0.563	6.400	1.0089
0.314	0.000	0.000	0.686	6.500	1.0091
0.244	0.000	0.000	0.756	6.600	1.0092
0.188	0.000	0.000	0.812	6.700	1.0093
0.140	0.000	0.000	0.860	6.800	1.0093
0.097	0.000	0.000	0.903	6.900	1.0094
0.000	0.000	0.000	1.000	7.162	1.0095

Source: own study

CONCLUSION

We have shown that the stock returns of Bayer AG, BMW, Deutsche Telekom, Siemens AG are not subject to normal distribution, but they can be described by Laplace distribution. Using the Laplace distribution function, we obtained the analytical expressions for VaR and CVaR risk measures and performed calculations of the risk assessment of considered stocks using two approaches: Var and CVaR. As a result of optimization, the set of optimal portfolios was constructed for both cases.

REFERENCES

Alexander G. J., Baptista M. A. (2004) A Comparison of VaR and CVaR Constraints on Portfolio Selection with the Mean-Variance Model. Management Science, 50(9), 1261-1273.

Baumol W. J. (1963) An Expected Gain-Confidence Limit Criterion for Portfolio Selection. Management Science, 10, 174-182.

Bazylevych V. D., Sheludko V. M., Kovtun N. V. (2011) Securities. Knowledge. Kiev.

Bollerslev T. (1990) Modeling the Coherence in Short-Run Nominal Exchange Rates: a Multivariate Generalized ARCH Model. The Review of Economics and Statistics, 72, 498-505.

Engle R. F. (1995) ARCH: Selected Readings. Oxford University Press.

Hohlov V. Yu. (2012) VaR and the Problem of "Large Tails" of the Profitability Distribution. Risk Management in a Credit Institution, 2, 35-49.

Lapach S. N., Chubenko A. V., Babych P. N. (2002) Statistics in Science and Business. Morion, Kiev.

Markowitz H. (1991) Foundations of Portfolio Theory. Journal of Finance, 7, 469-477.

Markowitz H. M. (1952) Portfolio Selection. Journal of Finance, 7(1), 77-91.

Pflug G. Ch. (2000) Some Remarks on the Value-at-Risk and Conditional Value-at-Risk. [in:] Uryasev S. (Ed.) Probabilistic Constrained Optimization: Methodology and Applications, Kluwer, 272-281.

Vitlinskyy V. V. (1996) Analysis, Evaluation and Modeling of Economic Risk. Demiur, Kiev.

Sharpe W. F., Alexander G. J., Bailey J. V. (1995) Investments. Prentice Hall.

Zabolotskyy T. (2016) Estimation of Confidence Level for Value-at-Risk: Statistical Analysis. Economic Annals – XXI, 158(3-4(2)), 83-87.

Zabolotskyy T. (2016) Modeling in the Management of the Portfolio of Financial Assets. Monograph, Lviv.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 366 – 376

Received: 02.09.2018
Accepted: 21.12.2018

PRODUCTIVITY PARADOX IN SELECTED SECTORS OF AGRI-FOOD PRODUCTION BRANCH IN POLAND

Piotr Jałowiecki https://orcid.org/0000-0002-3610-2151
Michał Gostkowski https://orcid.org/0000-0003-3606-1182
Krzysztof Zmarzłowski https://orcid.org/0000-0001-5343-2163
Tomasz Woźniakowski https://orcid.org/0000-0002-0779-4769
Faculty of Applied Informatics and Mathematics
Warsaw University of Life Sciences – SGGW, Poland
e-mail: piotr_jalowiecki@sggw.pl; michal_gostkowski@sggw.pl;
krzysztof_zmarzlowski@sggw.pl; tomasz_wozniakowski@sggw.pl

Abstract: Results of studies on IT solutions advancement, financial situation, logistic costs, market position, and IT support for logistics quality level in Polish agri-food production companies are presented in the paper. This sector is very dispersed (98.9% are small and medium companies, and 69.7% with employment under 10 persons). Research was based on survey conducted among 511 food processing companies in 2010-2011. Results showed no correlation between IT solutions advancement and financial situation of company except for dairy and meat industries. In all industries an association between IT advancement level, market position and quality of computer support for company logistics was detected.

Keywords: productivity paradox, IT advancement, food production, financial situation

JEL classification: D22, L20, O12

INTRODUCTION

Both in modern society and economy information plays the role of a key economic resource. Company abilities to effective collection, processing, analysis and using of information most often determine the possibility to gain an competitive advantage. Therefore, information technologies (IT) play such a significant role in the modern economy, which is often referred to as the digital economy or electronic business. Without adequate access to IT and skills to use

https://doi.org/10.22630/MIBE.2018.19.4.35

them even on a basic level, it is not possible full participation in contemporary social life. A society in which information is both merchandise, the most valuable asset and the most precious good is called information society. Economic development further increases information importance and in consequence it increases the using and advancement of modern technologies. The best example of these processes is the role of Internet, which has become the primary global communication channel in present economy and society [Castells 2011].

In common perception, investments for implementation and upgrade of technology and IT systems have strongly positive influence on various functioning aspects of companies on present markets. The most frequently mentioned benefits are: quality of management information improvement, better relationships with business partners, better service and relations with customers, increasing of competence level, higher operational efficiency, cash flows acceleration. Much less frequently mentioned positive effects of modern IT technologies using are: operating costs reduction and reduction of inventory level [Khazanchi 2005]. Whereas for a long time no direct impact of IT expenditures on better financial results of companies. This lack of correlation is known as "Productivity Paradox", which was identified and indicated in the late 1980s and early 1990s [Strassmann 1990; Brynjolfsson 1993; Loveman 1994; Barua, Lee 1997]. Explanation of this contradiction were sought in direct impact of IT investments on better organizational efficiency, higher ability to redefine and define new business processes, better possibility of business cooperation extension, higher level of trust and willingness to cooperate with the company [Brynjolfsson, Hitt 2000; Croteau, Bergeron 2001; Melville et al. 2004; Ryssel et al. 2004]. As a consequence enhancing of IT solutions advancement increases the potential of innovation and competitiveness of the enterprise but not its financial results [Henderson et al. 2010; Lim et al. 2011; Masli et al. 2011; Khalaf 2012]. This problem is particularly apparent in the sector of Small and Medium Enterprises (SME). The main reasons are significant less financial abilities and often worse organizational readiness for new technologies [Kim 2004; Love, Irani 2004; Dozier, Chang 2006; Bohorquez, Estevez 2008].

The role of technology and IT systems to improve the competitiveness of enterprises in all sectors of the economy is beyond doubt. This also applies to those sectors that are not traditionally associated with a broad using of modern information technology, such as agriculture and food processing. It should be noted that in recent years, this general opinion is rapidly changing, the best example is the concept of digital agriculture implemented in many countries and using in a wide range technologies of wireless networks and GPS positioning [Buick 1997; Auernhammer 2001; Hagar, Haythornthwaite 2005; Koutsouris 2010] . In an even greater extent this applies to food production sector, which plays also in the Polish economy a very important role. Agri-food processing branch generates about 17% of sold industrial output in Poland and it is responsible for about 12% of the value of Polish industry export [Jałowiecki 2018]. Companies in this sector are

characterized by complex supply chains involving a large number of suppliers of agricultural products and consumers of food products [Jałowiecki, Jałowiecka 2013]. Among others therefore in this branch efficient management of supply chains and their associated flows of information plays such an important role. In addition, especially in large companies, it is not possible its practical implementation without broad application technology and IT systems.

Table 1. Structure of Polish food production sector according to enterprise employment size and branch

Sector	Large	Middle	Small	Micro	Total
Meat	89	439	1322	3767	5617
Fishes	17	60	141	399	617
Fruits and Vegetables	26	148	337	1277	1788
Oil and Fats	2	9	38	163	212
Milk	45	144	135	722	1046
Cereal and Starch	6	52	178	1386	1622
Bakery	28	362	3722	8207	12319
Other Groceries	46	119	335	1871	2371
Feed	8	31	181	590	810
Beverages	25	84	287	849	1245
Tobacco	8	4	5	10	27
Total	300	1464	6734	19541	28039

Source: own preparation

According to the REGON database, Polish agri-food industry consists of more than 28 thousand companies (see Table 1). 70% were microenterprises, which employed up to 9 employees, 24% are small enterprises with 10 to 49 employees, 5% are medium-sized companies with 50 to 249 employees, and only 1% are large enterprises with employment of 250 or more. Definitely the largest sector was 44.5% of bakeries. Significantly higher than other industries was also meat industry with 20.3% of companies. Other sectors include from 2 to 6% of the companies, except for the oil and fat, and tobacco industries, which had less than 1% of companies. Introduction of modern IT systems is connected with the necessity of fairly significant investments. Meanwhile 98.9% of agri-food companies are small or medium enterprises and they have generally significantly less financial opportunities than large enterprises. In this case, implementation of modern, highly integrated and expensive IT systems may be serious problem.

MATERIAL AND METHODS

The results presented in the paper are the part of a much larger research to diagnose the state of logistics and information solutions in the Polish food production industry. Objective of this part of study was to verify the existence of

productivity paradox in selected sectors of food production branch. Correlations between used information solutions advancement, and its financial situation, logistic costs level, market position against the whole branch, and quality of IT support for logistics were examined. Data from survey research conducted in 2009-2011 in Polish food production companies were used as a main data source. There were obtained responses from 511 companies.

Examined companies was divided into subgroups due to its production sector. Six sectors in which the number of responses was sufficiently large were selected to the study. There were sectors of: meat, fruit and vegetable, milk, cereal and starch, bakery and other groceries production. In studies on individual questions obtained different numbers of responses. Only such companies were taken into account. For example, when determining the strength of correlation between the used IT solutions advancement, and the financial situation of the company, only 493 companies were taken into account. The reason was the fact that 9 companies did not provide its sector, and 10 companies did not provide its financial situation too, including 1 company, which did not specify both parameters.

To determine the advancement of used IT solutions level proposed in the paper Jałowiecki and Jałowiecka [2013] coefficient was used. It was constructed on the basis of six components:

- comprehensive IT system using (values: 0 points for negative answer, 1 point for affirmative answer);
- five areas of logistics supporting by IT systems: transport, stocks, packaging and reverse logistics, storage management, order management and forecasting (values: 0.2 points for each affirmative answer, number of points possible to obtain from 0 to 1);
- information transfer principal method in internal circuit (values: 0 – any declaration, 1 – verbally, 2 – by paper documents, 3 – by phone, 4 – by fax, 5 – via e-mail and/or Internet communicators, 6 – via software and/or IT systems);
- information transfer principal methods in external circuit (values: the same as in the case of internal information circuit);
- used IT system proficiency level (values: 0 – any system, 0.2 – Financial and Accounting (FA) system and/or popular utility software, e.g. MS Excel spreadsheet, 0.4 – Electronic Data Interchange (EDI) system, 0.6 – Materiel Requirements Planning (MRP) or Manufacturing Resource Planning (MRP II) system, 0.8 – Enterprise Resource Planning (ERP or ERP II), 1 – system functioning due to Business Intelligence (BI) philosophy);
- using business forecasts building method (values: 0 – any formal forecasts, 0.2 – production based on the raw material supply, 0.4 – production depending on orders received, 0.6 – forecasting based only on data from company, 0.8 – forecasting based only on the market data, 1 – forecasting based both on company and market data).

This coefficient was categorized into five categories: very low, low, average, high and very high, by the fact that the other variables included in the studies also take categorized into five values. Its values were ranged from 0 to 5. Categorization of coefficient was carried out by a balanced sharing the range of values for five classes of equal width.

To assess the strength of the correlation between studied variables and the advancement of used IT solutions, Spearman's rank correlation coefficient was used. The use of Spearman's rank correlation coefficient was related to the fact that among examined variables, there is a logical sequence of values. The financial situation of the company was defined by four categories: 1 – very bad, 2 – rather bad, 3 – mediocre, 4 – rather good, 5 – very good. The costs related to logistics were defined as a share of total costs incurred by the company and have taken four categories: 1 – very high, 2 – rather high, 3 – average, 4 – rather low, 5 – very high participation. The position of company in the market was categorized on four categories: 1 – very weak, 2 – rather weak, 3 – average, 4 – rather strong, and 5 – very strong. The logistics IT support quality has four possible values: 1 – very poor, 2 – rather poor, 3 – mediocre, 4 – rather good, and 5 – very good. Only in one case, instead of the Spearman rank correlation coefficient and t-Student distribution test, χ^2 independence test and V-Cramer coefficient were used. χ^2 test and V-Cramer were used to examine the existence of statistically significant dependence between the advancement level of used IT solutions and companies belonging to the sector. There were used, because there was no logical order of studied sectors as in the cases of other variables.

RESULTS

At the beginning it was examined whether the company sector differentiates IT solutions advancement level statistically significant. According to the χ^2 test of independence, it was found that these two variables are dependent on each other. The value 0.23 of the V-Cramer coefficient indicated weak relationship between them.

Among the surveyed companies the highest average level of applied IT solutions advancement were found in the milk sector (average was 3.33), and fruit and vegetables (2.97), whereas the lowest in the bakery sector (2.24). In this case, an average level for all surveyed enterprises was 2.51. The highest average level of declared financial condition was found in bakery companies (2.16), while the lowest was in the milk (1.92), and cereal and starch production companies (1.97). In this case, an average level for all surveyed enterprises was 2.10. The lowest average level of declared logistic costs was found in cereal and starch (2.03), meat (2.07), and bakery (2.10) companies, the highest in other groceries (2.33) sector. In this case, an average level for all surveyed enterprises was 2.13. The strongest position on the market against the whole sector, was found in meat (2.76), and milk (2.75) production companies, the weakest position in cereal and starch (2.54)

enterprises. The highest level of IT support for logistics was found in companies from milk sector (2.54), and the lowest level in cereal and starch (2.03), and bakery (2.05) enterprises. In this case, an average level for all surveyed enterprises was 2.12 (see Table 2).

Table 2. Average values and standard deviation of IT solutions advancement coefficient, and declared financial condition, logistic costs level, company's market position against the sector, and quality of IT support for logistics level indicators

Sector	IT solutions adv. coefficient	Declared financial condition	Declared logistic costs level	Declared market position of company	Declared logistics IT support quality level
Meat	2.59 ± 1.01	2.06 ± 0.48	2.07 ± 0.89	2.76 ± 0.53	2.10 ± 0.92
Fruits and Vegetables	2.97 ± 1.03	2.12 ± 0.65	2.16 ± 0.77	2.68 ± 0.52	2.27 ± 0.79
Milk	3.33 ± 0.91	1.92 ± 0.28	2.17 ± 0.82	2.75 ± 0.50	2.54 ± 0.68
Cereal and Starch	2.47 ± 1.16	1.97 ± 0.54	2.03 ± 0.97	2.54 ± 0.75	2.03 ± 0.97
Bakery	2.24 ± 0.82	2.16 ± 0.53	2.10 ± 0.97	2.69 ± 0.58	2.05 ± 0.97
Other Grocery	2.76 ± 0.99	2.11 ± 0.53 ±	2.33 ± 0.84	2.66 ± 0.62	2.22 ± 0.94
Total*	2.51 ± 1.00	2.10 ± 0.54	2.13 ± 0.95	2.68 ± 0.61	2.12 ± 0.95

* Values for all surveyed companies belonging to all 10 sectors
Source: own preparation

The results of previous studies indicates no correlation between the used IT solutions advancement level, and the financial situation of the company (Spearman's correlation coefficient was 0.05). It was also found a weak but statistically significant, negative correlation between the used IT solutions advancement level and the level of logistics costs (0.17). Despite the absence of direct impact of modern IT technologies using on the financial results of companies, there was a significantly stronger correlations between the level of IT technologies advancement and market position the company (0.34) and the quality of IT support logistics (0.44). These correlations were growing stronger in increasing categories of company employment size [Jałowiecki, Jałowiecka 2013].

Analysis of the correlation between the level of used IT solutions advancement, and the financial situation of the company in different sectors,

indicates the division of the surveyed sectors on the two or three groups. The first group included companies from the meat and milk sector, which was a statistically significant, positive correlations. In the dairy industry correlation was almost twice as strong as in meat sector. The second group includes the other sectors in which there was no statistically significant correlation between studied variables. Third group may be determined for clearly visible, but statistical insignificant, negative correlation in fruits and vegetables sector.

It means that the growing of IT advancement level results the deterioration of the financial situation of the company (see Table 3).

Table 3. Spearman correlation between the level of used IT solutions advancement and the financial situation of company coefficient values depending on the branch (significance level α=0.05)

Sector	r_S	t	p-value	t_α
Meat	0.26	2.82	0.01	1.98
Fruits and Vegetables	-0.22	-1.26	0.22	-2.04
Milk	0.42	2.19	0.04	2.07
Cereal and Starch	0.01	0.05	0.96	-2.03
Bakery	0.10	1.39	0.17	1.97
Other Groceries	0.03	0.20	0.84	2.02

Source: own preparation

Taking into account the correlation between the advancement of used IT solutions, and the level of logistics costs, it was also the division of the surveyed industries into the 3 groups. The first group included only the meat sector, which a negative correlation was found. No statistically significant correlations were found in the other five sectors. For baking and other groceries sectors there were positive correlations, negative in other sectors (see Table 4).

Table 4. Spearman correlation between the level of used IT solutions advancement and the share of logistics costs in the total cost of the company coefficient values depending on the branch (significance level α=0.05)

Sector	r_S	t	p-value	t_α
Meat	-0.32	-3.29	<0.01	-1.98
Fruits and Vegetables	0.14	0.75	0.46	2.04
Milk	0.07	0.31	0.76	2.07
Cereal and Starch	0.16	0.91	0.37	2.03
Bakery	-0.14	-1.92	0.06	-1.97
Other Groceries	-0.19	-1.25	0.22	-2.02

Source: own preparation

In all industries there was a statistically significant positive correlation between the level of advancement of used IT solutions and market position of the

company. The strongest dependence was observed in the fruit and vegetable and milk sectors, and the weakest in bakery sector (Table 5).

Table 5. Spearman correlation between the level of used IT solutions advancement and the company position on the market against the sector coefficient values depending on the branch (significance level α=0.05)

Sector	r_S	t	p-value	t_α
Meat	0.37	4.29	<0.01	1.98
Fruits and Vegetables	0.55	3.55	<0.01	2.05
Milk	0.64	3.90	<0.01	2.07
Cereal and Starch	0.36	2.21	0.03	2.03
Bakery	0.28	4.13	<0.01	1.97
Other Groceries	0.43	3.06	<0.01	2.02

Source: own preparation

The situation is similar in the case of the correlation between used IT solutions advancement level, and the quality of IT support of logistic operations. Definitely the strongest relationship was found in the case of enterprises in the cereal and starch production. The weakest dependences were found in the sectors of other groceries and meat production companies (Table 6).

Table 6. Spearman correlation between the level of used IT solutions advancement and the quality level of IT support for logistics coefficient values depending on the branch (significance level α=0.05)

Sector	r_S	t	p-value	t_α
Meat	0.34	3.51	<0.01	1.98
Fruits and Vegetables	0.49	2.94	0.01	2.05
Milk	0.53	2.95	0.01	2.07
Cereal and Starch	0.66	4.93	<0.01	2.04
Bakery	0.36	5.13	<0.01	1.97
Other Groceries	0.47	3.13	<0.01	2.02

Source: own preparation

CONCLUSION

Among the analyzed six sectors of food processing, diversification of enterprise employment structure was similar to the structure of the whole sector: 1.08% of large enterprises, 5.25% middle, 24.4% small, and 69.53% microcompanies. Only among dairy enterprises significantly more large and medium enterprises were functioned (respectively 4.30% and 13.77%). In turn, in cereal and starchy and bakery sectors a share of large enterprises was significantly lower than the nationwide (more appropriately 0.37% and 0.23%).

Stimulating effect of higher advancement level of used IT solutions for better financial situation of enterprises was only found in the dairy and meat

sectors. In the first industry it was almost twice strong as in the second (Table 3). For both sectors among suppliers of agricultural raw materials dominates definitely individual farmers, and among recipients of food retail shops. Simultaneously, in both cases these are the sectors with the highest average number of suppliers and customers [Jałowiecki, Gostkowski 2013] . Most likely, this means that the use of suitably effective IT solutions can significantly improve a number of cooperative relations. A large number of logistic connections coupled with the fact that both industries were provided biggest investments necessary to adapt production base and food quality control systems to obligatory requirements in European Union.

Significant reduction of logistics costs was accompanied by a more advanced IT solutions only in the meat production sector (Table 4). This is a sector in which structure of employment size of companies, and the average level of advancement of IT solutions is very similar to the national average (Tables 1 and 2). Part of the explanation for this is definitely an advantage for individual farmers of agricultural raw materials suppliers and retail shops among food products recipients [Jałowiecki, Gostkowski 2013]. In this situation, a higher level of advancement of used IT systems, implies not only to their better efficiency of the systems themselves, but also for better opportunities to optimize logistics. This means undoubtedly reducing logistics costs. However, in the case of the dairy sector with a very similar structure of suppliers and recipients, such a relationship is not found. It seems that in this case a greater share of large companies is not a sufficient explanation for this difference.

In all studied sectors a statistically significant relationship between higher advancement level of used IT solutions and better market position and better quality of IT support logistics was identificated. Correlations were definitely strongest in the industries of dairy, fruit and vegetable production companies, and definitely weakest in meat and bakery. Only in the cereal and starch sector a little impact on the market position and at the same time the greatest impact on the quality of IT support for logistics were found.

REFERENCES

Auernhammer H. (2001) Precision Farming – the Environmental Challenge. Computers and Electronics in Agriculture, 30(1-3), 31-43.

Barua A., Lee B. (1997) The Information Technology Productivity Paradox Revisited: A Theoretical and Empirical Investigation in Manufacturing Sector. The International Journal of Flexible Manufacturing Systems, 9, 145-166.

Bohorquez V., Esteves J. (2008) Analyzing SMEs Size as a Moderator of ERP Impact in SMEs Productivity. Communications of the IMAA, 8(3), 67-80.

Brynjolfsson E. (1993) The Productivity Paradox of Information Technology. Communications oft the ACM, 35, 66-77.

Brynjolfsson E., Hitt L. M. (2000) Beyond Computation: Information Technology, Organizational Transformation and Business Performance. Journal of Economic Perspectives, 14(4), 23-48.

Buick R. D. (1997) Precision Agriculture: An Integration of Information Technologies with Farming. Proceedings of 50th New Zealand Plant Protection Conference, 176-184.

Castells M. (2011) The Power of Identity: The Information Age: Economy, Society and Culture. Vol. 2: The Information Age. Economy, Society, Culture. Wiley-Blackwell, Chichester, UK.

Croteau A. M., Bergeron F. (2001) An Information Technology Trilogy: Business Strategy, Technological Deployment and Organizational Performance. The Journal of Strategic Information Systems, 10(2), 77-99.

Dozier K., Chang D. (2006) The Effect of Company Size on the Productivity Impact of Information Technology Investments. Journal of Information Technology Theory and Application, 8(1), 33-47.

Hagar C., Haythornthwaite C. (2005) Crisis, Farming and Community. The Journal of Community Informatics, 1(3), 41-52.

Henderson B. C., Kobelsky K., Richardson V. J., Smith R. E. (2010) The Relevance of Information Technology Expenditures. Journal of Information Systems, 24(2), 39-77.

Jałowiecki P. (2018) Is Productivity Paradox Related to Logistics? Research on Polish Agri-Food Industry. Quantitative Methods in Economics, 19(1), 48-59.

Jałowiecki P., Gostkowski M. (2013) Productivity Paradox in Polish Food Production Industry. Information Systems in Management, 2(4), 263-273.

Jałowiecki P., Jałowiecka E. (2013) Struktura i koszty logistyki w wybranych branżach sektora rolno-spożywczego. [in:] Lichota E., Majewska K. (Ed.) Wybrane zagadnienia logistyki stosowanej. Wydawnictwo AGH, Kraków, 155-166, 2013 (in Polish).

Khallaf A. (2012) Information Technology Investments and Nonfinancial Measures: A Research Framework. Accounting Forum, 36(2), 109-121.

Khazanchi D. (2005) Information Technology (IT) Appropriateness: The Contingency Theory of „Fit" and it Implementation in Small and Medium Enterprises. The Journal of Computer Information Systems, 45(3), 88-95.

Kim J. (2004) Network Building Between Research Institutions and Small and Medium Enterprises (Smes) Dynamics of Innovation Network Building and Implications for a Policy Option. International Journal of Technology, Policy and Management, 2(3), 272-285.

Koutsouris A. (2010) The Emergence of the Intra-Rural Digital Divide: A Critical Review of the Adoption of ICTs in Rural Areas and the Farming Community. 9th European IFSA Symposium, Vienna, Austria, 23-32.

Lim J. H., Dehning B., Richardson V. J., Smith R. E. (2011) A Meta-Analysis of the Effects of IT Investment on Firm Financial Performance. Journal of Information Systems, 25(2), 145-169.

Love P. E. D., Irani Z. (2004) An Exploratory Study of Information Technology Evaluation and Benefits Management Practices of SMEs in the Construction Industry. Information and Management, 42(1), 227-242.

Loveman G. (1994) An Assessment of the Productivity Impact on Information Technologies. [in:] Allen T. J., Morton M. S. S. (Ed.) Information Technology and the Corporation of the 1990's: Research Studies. MIT Press, Cambridge, MS, USA.

Masli A., Richardson V. J., Sanchez J. M., Smith R. E. (2011) The Business Value of IT: A Synthesis and Framework of Archival Research. Journal of Information Systems, 25(2), 81-116.

Melville N., Kraemer K., Gurbaxani V. (2004) Review: Information Technology and Organizational Performance: an Integrative Model of it Business Value. Journal MIS Quarterly, 28(2), 283-322.

Ryssel R., Ritter T., Gemünden H. G. (2004) The Impact of Information Technology Deployment on trust, Commitment and Value Creation in Business Relationships. Journal of Business & Industrial Marketing, 19(3), 197-207.

Strassmann P. A. (1990) The Business Value of Computers. Information Economics Press, New Canaan, CT, USA.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 377 – 387

Received: 22.10.2018
Accepted: 21.12.2018

FACTORS DETERMINING POLAND – SOUTH KOREA TRADE IN SUGAR CONFECTIONERY[1]

Sebastian Jarzębowski https://orcid.org/0000-0002-9394-577X
Faculty of Applied Informatics and Mathematics
Warsaw University of Life Sciences – SGGW, Poland
e-mail: sebastian_jarzębowski@sggw.pl
Natalia Bezat https://orcid.org/0000-0001-6757-0911
e-mail: natalia.bezat@gmail.com

Abstract: The paper aimed to analyze factors that can have an impact on the volume of trade between EU and South Korea. The main point of the research was that the Free Trade Agreement (FTA) between the EU and the Republic of South Korea entered into force in July 2011 (first trade deal with an Asian country). In the focus of the paper was one of the product's sector, namely sugar confectionery. Within the conducted case study Poland is the investigated country. The value indices were used for analyzing changes occurring within the EU – South Korea trade before and after FTA entered into force.

Keywords: agricultural trade, sugar confectionery, EU, South Korea, Free Trade Agreement (FTA)

JEL classification: F13, F53, F55

INTRODUCTION

Trade agreements are a form of cooperation between two (bilateral trade agreements) or more countries (multilateral trade agreements) that agree on the terms of trade between them. Thanks to these kinds of cooperation, the following benefits can be realized: market access, time savings, cost reduction, economies of scale, access to know-how, risk reduction, and increasing competences (see [Porter,

[1] The paper was prepared within the research granted by European Commission: "Study on the impact on EU agriculture and agricultural trade of EU concluded Bilateral Trade Agreements", No. AFC PN 4289, 2016.

https://doi.org/10.22630/MIBE.2018.19.4.36

Fuller 1989; Vizjak 1990; Rupprecht-Däullary 1994]). A characteristic feature of cooperation is that it arises from explicit contractual agreements and that it exists only when both or more partners expect benefits [Jarzębowski 2013].
The Free Trade Agreement between the EU and the Republic of Korea (the EU-Korea FTA) is the first of a new generation of FTAs. The decision to launch negotiations on such FTAs with third countries was based on robust economic criteria with the objective of enhancing market access for European companies in the highly dynamic and competitive markets of Asia [The European Commission Trade 2011]. The EU-South Korea free trade agreement eliminates duties for industrial and agricultural goods in a progressive, step-by-step approach. The majority of import duties had been removed in 2011. The remaining ones – except for a limited number of agricultural products – were removed after five years on 1 July 2016.

There are various FTAs and trade negotiations worldwide that to some extent influence each other. Concerning the FTA between the EU and South Korea, there are two different FTAs that might affect this agreement or even vice versa. One is the Korea-US FTA (Korus) and the second is the Korea-China FTA. These FTAs are of particular interest as South Korea and one further big trading nation, more detailed USA and China, are involved in these agreements. Both countries can be perceived as competitors of the EU and Poland.
Having witnessed a virtual explosion in the number of FTAs among nations over the past two decades, one can expect that trade flows became higher thanks to them. However, international trade economists can claim small firm empirical support for reliable quantitative estimates of the average effect of an FTA on bilateral trade [Baier, Bergstrand 2007]. Tinbergen [1962] found that membership in the British Commonwealth [Benelux FTA] resulted only in a five percent increase in trade flows. Since then, research results have been mixed. For example, Aitken [1973], Abrams [1980], and Brada and Mendez [1985] stated that the European Community had a statistically and economically significant effect on members' trade flows. Baier and Bergstrand [2007] found that n FTA approximately doubles two members' bilateral trade after ten years. Nonetheless, Bergstrand [1985] and Frankel, Stein and Wei [1995] found insignificant effects on trade flows.

This research focuses on sugar confectionery trade. Sugar confectionery is defined as "sugar confectionery, including white chocolate, but not containing cocoa". Sugar confectionery is mainly based on sugar as the primary raw material. The world sugar production amounts to 187.6 million tonnes, whereas the global sugar confectionery market trade reached 55.5 million tones in 2017 [FAO 2019]. The EU is responsible for 24 % of global sales [KPMG]. The international trade of sugar confectionery is highly dominated by the U.S., whereas Germany is the leading sugar confectionery exporter in the world [UN Comtrade].
Europe shares nearly 70% of the global sugar beet production with Poland representing the third most important country for sugar beet production in the EU

(7th place in world ranking). Poland produces over 10 million tonnes of sugar beets per year putting the basis for a successful sugar confectionery production [FAOSTAT]. This symbolizes a basis for a successful sugar confectionery production. Since the Polish consumption and international trade (export) are rapidly increasing, primarily due to the FTA, the outlook for actors of the agricultural and food chain seems promising.

Since the Polish sugar confectionery market is continuously growing, it could be expected that more jobs will be available with increasing production and increasing exports to South Korea within the FTA. However, mechanization and robots are two of the most antagonists. The agricultural and food industry sectors are influenced more deeply by these two factors. The more technically educated farmers there are more and more investments in advanced technical machinery. As a consequence fewer farmers are needed. This leads to an agricultural intensification process.

METHODOLOGY AND DATA

The data used in the empirical analysis covered the period from 2004 to 2017 and presented the export/import dynamics of sugar confectionery trade between Poland and South Korea was obtained from UN Comtrade. The data were acquired from UN Comtrade in June 2018. Within the framework of the research the values, such as single-based indices, chain indices, and average rates of change have been evaluated to describe the dynamics of the analyzed phenomena.

Let y_t denote the level (value) of the analyzed phenomenon (variable) at successive moments of time $t \in T_0$, where $T_0=\{0,1,\ldots,n-1\}$ is a set of time numbers. The value string $y_t(t \in T_0)$ creates a time series. The variable y_{t*} denotes the level of the analyzed phenomenon at the base period [Sobczyk 2011].
The single-base index defines the ratio of absolute increment in the period considered (t) to its level in the period taken as the basis for the comparison (t^*). A single-based index is defined by

$$d_{t,t*} = \frac{y_t - y_{t*}}{y_{t*}}.$$

The chain index is an index number in which the value of any given period is related to the value of its immediately preceding period (resulting in an index for the given period expressed against the preceding period = 100); this is distinct from the fixed-base index, where the value of every period in a time series is directly related to the same value of one fixed base period. A chain index is defined by

$$d_{t,t-1} = \frac{y_t - y_{t-1}}{y_{t-1}}.$$

The average rate of change of phenomena in time, which is expressed by the following equations:

$$r(0, n-1) = \bar{\imath_g} - 1$$

$$\overline{\iota_g} = \sqrt[n-1]{\frac{y_{n-1}}{y_{t*}}}$$

where:
r – average rate of change,
n – number of observations,
$\overline{\iota_g}$ – geometric mean of chain index values in the analyzed period.

The second part of the analysis aimed at evaluating the positive and negative impacts of the FTA on the sugar confectionery market. A survey was conducted within the framework of the study on the impact on EU agriculture and agricultural trade of EU concluded Bilateral Trade Agreements[2]. The survey aimed to find out and assess the main areas for improvement of cooperation between Poland and South Korea. The method for data collection included personal interviews, email interviews, and telephone interviews. The respondents evaluated i.a. the importance of non-tariff barriers or the impact on European and Polish sugar confectionery regarding rising employment, income, production, and investments.

The respondents, involved in the sugar confectionery market (e.g. Producers/exporters of sugar confectionery in Poland, The Ministry of Development in Poland), have indicated if they agree with the statements presented in the survey or not, or if they see any improvement or no changes in the processes connected with the FTA's implementation. The survey was conducted in 2016.

EMPIRICAL RESULTS

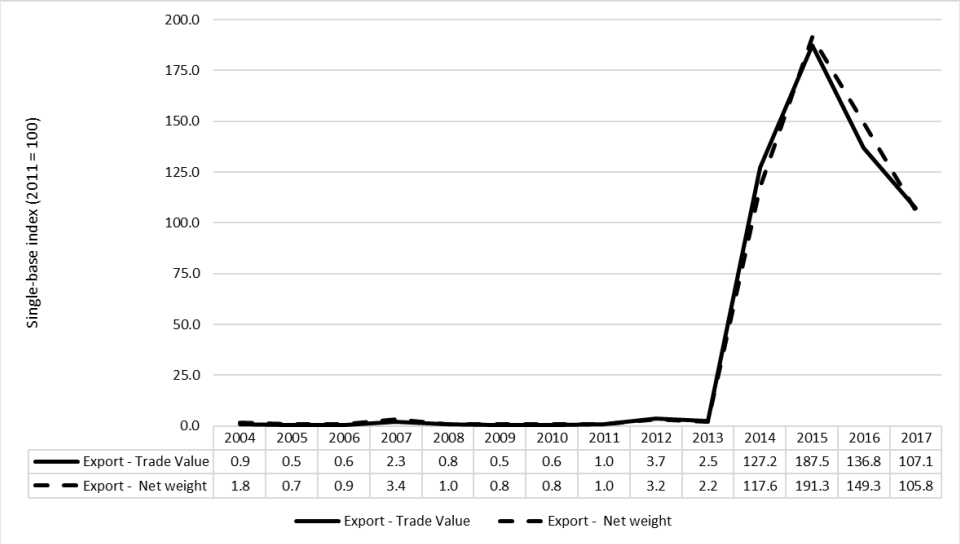
The purpose of the study was to present the situation regarding exports/imports of sugar confectionery between Poland and South Korea, highlighting the dynamic changes before and after the FTA implementation. Furthermore, the questionnaire, conducted among the entities involved in the sugar confectionery market, is an undeniable added value of the research.

Within the framework of the research, the Polish export/import trade value and net weight with South Korea were analyzed and evaluated using statistic indices.

Figure 1 presents the single-based indices with the year 2011 as a reference[3]. It can be stated that before the FTA was implemented the international trade value with South Korea was stable. The first changes were noticed in 2014 when the trade value increased by 27.2% and net weight by 17.6%. In 2015 the export trade value and net weight reached the highest level in comparison to 2011, they increased respectively by 87.5% and 91.3%.

[2] European Commission, No. AFC PN 4289, 2016.
[3] The FTA between EU and South Korea has been implemented in 2011.

Figure 1. Single-based indices for export trade value (US$) and net weight (kg) of sugar confectionery from Poland to South Korea within 2004-2017 (2011 = 100)



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Export - Trade Value	0.9	0.5	0.6	2.3	0.8	0.5	0.6	1.0	3.7	2.5	127.2	187.5	136.8	107.1
Export - Net weight	1.8	0.7	0.9	3.4	1.0	0.8	0.8	1.0	3.2	2.2	117.6	191.3	149.3	105.8

Source: own work based on UN Comtrade

- According to the data included in Table 1 the chain index had the highest value in 2014 for the analyzed variables. In 2014 in comparison with 2013, the export trade value increased by over 5000%, from the level of almost $40 thousand to over $2 million.

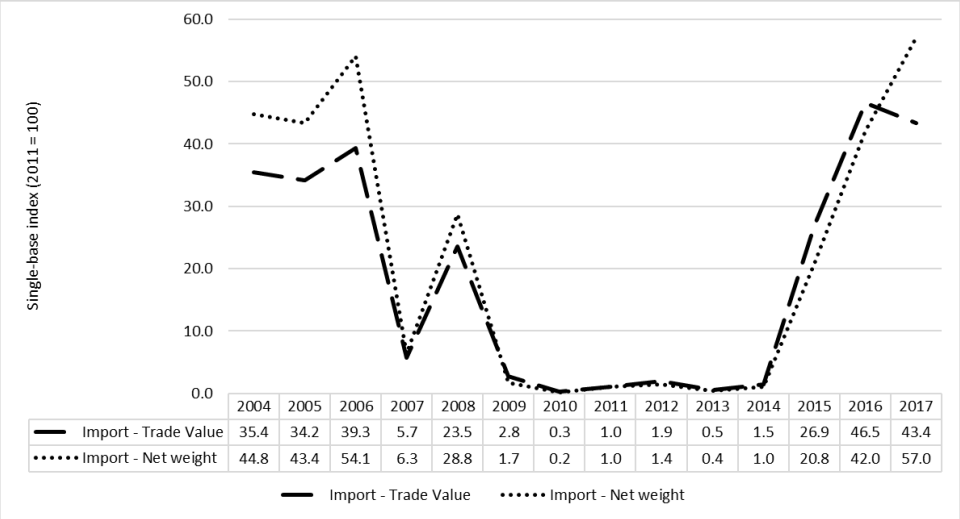
Table 1. Chain indices for export trade value (US$) and net weight (kg) of sugar confectionery from Poland to South Korea within 2004-2017

Year / Chain Index	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Trade Value	0.49	1.26	5.04	1.44	0.23	0.79	0.44	3.67	0.68	50.67	1.47	0.73	0.78
Net weight	0.42	1.28	4.62	1.09	0.22	0.79	0.29	3.16	0.69	54.05	1.63	0.78	0.71

Source: own work based on UN Comtrade

Figure 2 illustrates the dynamics of the import trade value and net weight of sugar confectionery from South Korea to Poland. Between 2011 and 2014 there was a stagnation in imports. In comparison to 2011, the import trade value significantly increased in 2015 and 2016, respectively by 26.9% and 46.5%. The trade value remained at a high level of over $14 thousand in 2017.

Figure 2. Single-based indices for import trade value (US$) and net weight (kg) of sugar confectionery from South Korea to Poland within 2004-2017 (2011 = 100)



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Import - Trade Value	35.4	34.2	39.3	5.7	23.5	2.8	0.3	1.0	1.9	0.5	1.5	26.9	46.5	43.4
Import - Net weight	44.8	43.4	54.1	6.3	28.8	1.7	0.2	1.0	1.4	0.4	1.0	20.8	42.0	57.0

Source: own work based on UN Comtrade

- According to the data included in Table 2 the chain index had the highest value in 2016 for the analyzed variables. In 2015 in comparison with 2014, the export trade value increased by over 1800%, from the level of almost $500 to $9 thousand.

Table 2. Chain indices for import trade value (US$) and net weight (kg) of sugar confectionery from South Korea to Poland within 2005-2017

Year / Chain Index	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Trade Value	1.0	1.1	0.1	4.2	0.1	0.1	3.8	1.9	0.3	2.8	18.3	1.7	0.9
Net weight	1.0	1.2	0.1	4.5	0.1	0.1	5.8	1.4	0.3	2.4	20.8	2.0	1.4

Source: own work based on UN Comtrade

In order to compare the dynamics of changes before and after the FTA implementation, the average rate of change in the value of exports and imports was analyzed (Table 3). In 2004-2010 a downward trend for all analyzed values was noticed. For example, the exported net weight of sugar confectionery decreased on average by 60% from year to year. However, after the FTA implementation, the same variable increased on average by 96% year to year. A similar relationship was noticed in the case of imports to Poland. The trade value of imported sugar confectionery diminished by 21% on average in 2004-2010, whereas the value

decreased by 88% on average in 2011 – 2017. These results strongly support the hypothesis that the FTA influenced positively trade flows between Poland and South Korea.

Table 1. Average rate of change of the Polish export and import of sugar confectionery from South Korea in given periods

Periods	Export		Import	
	Trade value	Net weight	Trade value	Net weight
2004 - 2010	-0.56	-0.60	-0.21	-0.46
2011 - 2017	0.87	0.96	0.88	1.46
2004 - 2017	0.02	0.02	0.24	0.18

Source: own work based on UN Comtrade

In order to find out the main areas for improvement of cooperation between Poland and South Korea, a survey has been conducted. The survey aimed at evaluating the impacts of the EU-Korea Free Trade Agreement on the Polish (European) export and production of sugar confectionery, as well as to analyze barriers, obstacles, opportunities, lessons, etc. Different types of stakeholders have been interviewed, such as producers/exporters of sugar confectionery in Poland, KOTRA - Commercial Section of the Embassy of the Republic of Korea in Warsaw (hereinafter abbreviated as KOTRA), The Ministry of Development in Poland, Advisory companies, Chambers of Commerce uniting the producers of sugar confectionery, Chief Inspectorate of Plant and Seed Protection – Agenda of Ministry of Agriculture in Poland, and Embassy of the Republic of Poland in Seoul. The summary of the survey is presented in Table 4 and 5.

One objective of the expert interviews conducted within the case study was to investigate the development of export due to FTA (see Table 4). Questions focused on the increase of exports directly after the implementation of FTA as well as barriers and opportunities for increasing export of sugar confectionery to South Korea in the future. The majority of the respondents stated that exports would rise in the long run as a result of the FTA. However, the interviewed exporters and Chambers of Commerce, as well as the advisor companies, assume that there will be no export increase in the short run. Furthermore, barriers such as restrictions on the quality and purity of products, and stringent health regulations were mentioned by KOTRA.

Table 2. Summary of the survey (part 1)

Questions from the survey		KOTRA, Embassy of the Republic of Korea	Ministry of Development	Producers / Exporters	Advisor companies	Chambers of Commerce	Chief Inspectorate of Plant and Seed Protection	Embassy of the Republic of Poland
Historical impact (2011-2015) on:	Increased export (volume)	Yes	Yes	No	No	No	Yes	
	Increased export (value)	Yes	Yes	No	No	No		Yes
	Reduced import tariffs			No	No	No		Yes
Export increase as a result of the FTA	In the short run	Yes	Yes	No	No	No		Yes
	In the long run	Yes	Yes	Yes	Yes	Yes		Yes
Major barriers for increasing export of sugar confectionery to Korea (in relation to FTA)		Yes	Yes	Yes	Yes	Yes		Yes
Major opportunities for increasing export of sugar confectionery to Korea (in relation to FTA)		Yes	No	Yes	Yes	Yes		

Yes – "I agree with the statement"; No – "I do not agree with the statement"

Source: own work based on UN Comtrade

Table 3. Summary of the survey (part 2)

Questions from the survey		KOTRA, Embassy of the Republic of Korea	Ministry of Development	Producers / Exporters	Advisor companies	Chambers of Commerce	Chief Inspectorate of Plant and Seed Protection	Embassy of the Republic of Poland
Changes in economic transactions due to the FTA	Business environment	↑	→	↑	↑	↑		↑
	Administrative formalities required?	↑	→	↑	↑	↑		↑
	Relationship with the local administration/bureaucracy	↑	→	↑	↑	↑	↑	→
	Advantages vis-à- vis exporters from third countries	↑	↑	→	→	→		
Other specific changes due to the FTA	Product specific rules (PSRs)?	↑	→	→	→	→	→	→
	Cumulation rules			→	→	→		
	Standards harmonization including harmonization of SPS standards and alignment with international standard bodies provision	→	→	↑	↑	↑	→	
	Administrative alignment	↑	→	↑	↑	↑	→	
	Simplification of import procedures and controls	↑	→	→	→	→	→	→
	Cooperation mechanisms	→	→	→	→	→	↑	
	Dispute settlement mechanisms	→	→	→	→	→		

↑ - improved; → - unchanged

Source: own work based on UN Comtrade

Producer/exporters, Advisor companies, Chambers of Commerce and KOTRA share the point of view that the FTA has had an impact on European and Polish sugar confectionery industry (see Table 5). According to their answers employment, income, production, and investments increased. Beyond KOTRA pointed out that if exports increase, production and employment increase as well, thus these changes are dependent on each other.

Further evaluation was investigated regarding FTA policies in general. The Ministry of Development recommends that more attention might be paid on the details when new agreements will be negotiated – for instance, regionalization (in some cases embargo should be imposed on the product for some region and not on the whole country). Producers/exporters, advisor companies and Chambers of Commerce propose further that the European Commission could support exporters and give them information on requirements on a given market.

CONCLUSIONS

This paper contributes to the evaluation of the impact of the Free Trade Agreement between South Korea and the EU on the example of the Polish sugar confectionery market. The FTA between South Korea and the EU has a substantial impact on the trade of different goods. The strength of the influence is dependent on the European country and its overall economic situation. Regarding Poland's sugar confectionery trade, after a first stagnation and adaptation period, the Polish sugar confectionery market started to overgrow.

It became evident that the immense increase of both, trade value and net weight of exported and imported sugar confectionery from Poland, results from the FTA between Korea and EU. The estimated average rates of change indicated undeniably a significant acceleration in trade of sugar confectionery between Poland and South Korea. The considerable increase of the Polish sugar confectionery exports and imports in 2014 and 2015 was caused by the fact that the Polish confectionery market came out of stagnation and started to grow. Polish companies have been actively looking for new markets and prepared for foreign expansion. This phenomenon was proved by the successful Polish accession to the EU implying a long-time preparation period.

The survey carried out as a part of this study suggest that there is a range of factors that are likely to impact the sugar confectionery market to benefit from the FTA. All respondents stated that exports would increase in the long run as a result of the FTA. The advantageous development is reflected by an increased sugar confectionery production that is followed by increased employment. The implementation of the FTA was aimed at an improvement in the economic transactions, decreasing trade barriers and abolishment of tariffs.

Significant influences in sugar confectionery production are political decisions made by European politicians such as sugar quota abolition in 2017. Sugar prices will have an impact on sugar confectionery production. Severe

forecasts, however, cannot be made since sugar prices are influenced by energy politics as well. It is questionable if bioethanol production will continue to grow thus decreasing the available amount of sugar or if new biofuels are preferred, and sugar that was used for bioethanol production is then available for white sugar production. Respondents of the survey fear that sugar production factories will move to Germany and France.

To sum up, the FTA has mainly a positive impact on the trade relation between Poland and South Korea regarding the sugar confectionery market. The export and import values might be further increased, political relations are stabilized, and innovations and product growth are successful. Nevertheless, it is essential for export-oriented companies to strengthen their competitiveness in sharing and improving knowledge and skills on foreign trade [Pietrzyck, Petersen, Jarzębowski 2018].

REFERENCES

Abrams R. K. (1980) International Trade Flows under Flexible Exchange Rates. Federal Reserve Bank of Kansas City. Economic Review, 65(3), 3-10.

Aitken N. D. (1973) The Effect of the EEC and EFTA on European Trade: A Temporal Cross-Section Analysis. American Economic Review, 5, 881-892.

Baier S. L., Bergstrand J. H. (2007) Do Free Trade Agreements Actually Increase Members' International Trade? Journal of International Economics, 71(1), 72-95.

Bergstrand J. H. (1985) The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence. Review of Economics and Statistics 67(3), 474-481.

Brada J. C., Mendez J. A. (1985) Economic Integration among Developed, Developing and Centrally Planned Economies: a Comparative Analysis. Review of Economics and Statistics, 67(4), 549-556.

Euromonitor (2017) Confectionery in Poland.

FAO (2018) Food Outlook. Biannual Report on Global Food Markets. Food and Agriculture Organization of the United Nations.

Frankel J. A., Stein E., Wei S. J. (1995) Trading Blocs and the AMERICAS: the Natural, the Unnatural, and the Super-Natural. Journal of Development Economics, 47(1), 61-95.

Jarzębowski S. (2013) Integracja łańcucha dostaw jako element kształtowania efektywności sektora przetwórstwa rolno-spożywczego. Wydawnictwo SGGW, Warszawa (in Polish).

KPMG (2014) KPMG in Poland – Confectionery Market in Poland.

Pietrzyck K., Petersen B., Jarzębowski S. (2018) The Role of Quality Management in the Context of the Transatlantic Trade and Investment Partnership (TTIP): The Case of the Polish Agri-Food Sector. Problems of Agricultural Economics, 3(356), 94-110.

Porter M. E., Fuller M. B. (1989) Koalitionen und globale Strategien. [in:] Porter M. E.: Globaler Wettbewerb: Strategien der neuen Internationalisierung. Gabler, Wiesbaden.

Rupprecht-Däullary M. (1994) Zwischenbetriebliche Kooperation. Gabler, Wiesbaden.

Salkind N. J. (2015) Excel Statistics. A Quick Guide. Age Publications Ltd.

Sobczyk M. (2011) Statystyka. Wydawnictwo Naukowe PWN, Warszawa (in Polish).

The European Commission Trade (2011) The EU-Korea Free Trade Agreement. Publications Office of the European Union.

Tinbergen J. (1962) Shaping the World Economy. The Twentieth Century Fund, New York.

Vizjak A. (1990) Wachstumspotentiale durch strategische Partnerschaften. B. Krisch, Herrsching.

FAOSTAT http://www.fao.org/faostat/en/#home (acquired on 10.10.2018).

UN Comtrade https://comtrade.un.org/ (acquired on 10.10.2018).

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 388 – 397

Received: 25.06.2018
Accepted: 21.12.2018

ON STOCK TRADING WITH STOCK PRICE DRIFT AND MARKET IMPACT

Marek Andrzej Kociński https://orcid.org/0000-0002-7669-6652
Faculty of Applied Informatics and Mathematics
Warsaw University of Life Sciences – SGGW, Poland
e-mail: marek_kocinski@sggw.pl

Abstract: The drift in the stock price and the occurring of the transaction costs in the stock market can significantly affect the profitability of the investment in the stock. In the article the model of the market is described with the stock price drift and two sources of the transaction costs: bid-ask spread and market impact. In the considered model, the trading strategy which maximizes the expected amount of money received from selling the shares of the stock of the market participant subject to the constraint of the constant trading velocity is explicitly determined. The numerical example is also included.

Keywords: transaction cost, market impact, stock price drift, trading speed

JEL classification: C6, G11

INTRODUCTION

Liquidity risk is one of the categories of the financial risk. The degree of liquidity is an important parameter of a stock traded on the stock exchange. It refers to the ease with which the transactions on the market can be executed. A good measure of the market liquidity is the level of transaction costs (trading costs, costs of trading) which occur on the market. The major sources of transaction costs usually taken into consideration in financial investment management are commissions (and similar payments) , bid-ask spreads and market impact [Elton et al. 1999]. An important source of transaction cost is a bid-ask spread which can be defined as the difference between the highest bid price of the stock and the stock lowest ask price. The bid-ask spread is used as proxy for the stock liquidity [Barucci 2003]. Another important source of transaction costs is

https://doi.org/10.22630/MIBE.2018.19.4.37

a market impact (price impact). In case of stock trading, it can be defined as a change in a price of the stock, induced the transaction execution. This change is unfavourable to the initiator of the trade. If the initiator of the trade is a buyer of the stock, then the trade execution can cause the increase in the stock price. If the trade initiator is a stock seller, than the effect of the transaction can decrease the price of the stock. The empirical study of the market impact is shown, for example, in [Zarinelli et al. 2014]. In theoretical finance market impact modelling can be used to build realistic financial market models and explain the empirical phenomena which seem to contradict the efficiency of the financial market [Czekaj et al. 2001].

Transaction cost is an important factor determining the financial profit of the investment in the stock market. Another important factor determining the financial effect of the investment in the stock can be the stock price drift.

In the article, the trading strategy which maximizes the expected amount of money obtained from selling the shares of the stock of the market participant with the constraint of the constant trading velocity is explicitly determined. The theoretical formulas are implemented in numerical computations.

THE MARKET PRICE OF THE STOCK

Denote by $S(t)$ the market price of the stock at time t. Consider the market participant (the stock seller) who expects that there will be drift μ in the market price of the stock and this expectation is expressed as follows:

$$E(S(t)) = S_0(1+\mu t) \text{ for } t \in [0,T] \tag{1}$$

where $E(S(t))$ denotes the expected value of $S(t)$ and T is a parameter such that $T > 0$. The cause of the drift μ can be the effect of the reaction of the stock market investors on the information regarding the financial condition of the company that issued the stock shares, or the forecast of its future profits. For example, the positive drift may be generated by the information that the financial perspectives of the considered company are better than it was expected by the market investors. The negative drift may be, for example, generated by the announcement that the stock dividend will be lower than it was predicted by the stock investors. The market price of the stock can be calculated as the following average:

$$S(t) = \frac{S^{bid}(t) + S^{ask}(t)}{2} \tag{2}$$

where $S^{bid}(t)$ denote the highest bid price of the stock at time t by and $S^{ask}(t)$ symbolizes the lowest bid price of the stock at time t. Assume that the bid-ask spread $S^{bid}(t) - S^{ask}(t)$ is given as follows:

$$S^{bid}(t) - S^{ask}(t) = 2\lambda S(0) \tag{3}$$

where λ is the non-negative coefficient.
The discrete time model of the market impact and the drift in the stock market can be found in [Almgren, Chriss 2000].

THE MODEL OF THE STOCK SELLING

Assume that the market participant has Y shares of the stock. The parameter Y can be expressed as the fraction of the stock average traded volume in time T. The stock seller wants to maximize the amount of money obtained from selling the stock between the moments 0 and T. The selling strategy of the market participant which is executed in the time interval (t_1, t_2) is characterized by the non-random and non-decreasing function of time x such that $x(t_1) = 0$ and $x(t_2) \leq Y$. The value $x(t)$ denotes the number of the shares of the stock sold up to time t. Assume that x is differentiable and denote the derivative of x at time t by $x'(t)$. Denote by $S^{trade}(t)$ the trade price at time t when the strategy x is executed. If the selling strategy x is implemented, then $S^{trade}(t)$ satisfies the formula:

$$S^{trade}(t) = S(t) - \lambda S(0) - S(0)cx'(t) \tag{4}$$

where c is the non-negative proportionality ratio which can be estimated, provided the suitable data sets of transactions and the stock prices are available .

The formula (4) means that the stock seller realizing the trading strategy $x(t)$, pays for selling one share of the stock the cost which is the sum of the half of the spread $\lambda S(0)$ and the market impact cost given by $S(0)cx'(t)$.

The described here influence of the trade speed on the trading price of the stock seems to be similar to the dependence between the trade price and the trade velocity from [Almgren et al. 2005].

Assume that the strategy x satisfies the following constraint:

$$1 - \lambda + \mu t - cx'(t) > 0 \text{ for each } t \in (t_1, t_2). \tag{5}$$

The constraint (5) is imposed in order the value of the expected value of $S^{trade}(t)$ in the equality (4) to be positive. Moreover, assume that the value of $S^{trade}(t)$ defined by (4) is positive with probability 1. When executing x at an infinitesimal time interval dt from the interval (t_1, t_2) starting from the moment $t \in (t_1, t_2)$, the trade price of one share of the stock is $S^{trade}(t)$ and the number of the stock shares

sold equals to $x'(t)dt$. In consequence, by (1) and (4) the expected amount of money $a(x)$ received by executing the selling strategy x is given as follows:

$$a(x) = S_0(1-\lambda)X + S_0\mu\int_{t_1}^{t_2} tx'(t)dt - S_0c\int_{t_1}^{t_2} x'(t)x'(t)dt. \tag{6}$$

Let $X = x(t_2)$.

Consider the problem of finding the selling strategy x such that that the value of $a(x)$ is maximized, with the constraint:

$$x'(t) = \frac{X}{t_2 - t_1} \text{ for each } t \in (t_1, t_2). \tag{7}$$

The constraint (7) simplifies the problem of maximizing $a(x)$. Moreover, on the market where the realized trading speed can be different from the trade velocity intended by the stock seller, the negative influence of the constraint (7) on the maximization of empirical value of $a(x)$ can be moderate in practice.

By (6) and (7) it follows that

$$a(x) = S_0(1-\lambda)X + S_0\mu X\frac{t_2 + t_1}{2} - S_0c\frac{X^2}{t_2 - t_1}. \tag{8}$$

Define the function $f(t_1, t_2, X)$ as follows:

$$f(t_1, t_2, X) = S_0(1-\lambda)X + S_0\mu X\frac{t_2 + t_1}{2} - S_0c\frac{X^2}{t_2 - t_1}. \tag{9}$$

Denote by $\tilde{x}$ the selling strategy $\tilde{x}$ maximizing $a(x)$ subject to the constraint (7). Moreover, let $\tilde{t}_1$ symbolize the start of the execution of the selling strategy $\tilde{x}$ and $\tilde{t}_2$ denote the end of the execution of the trading strategy $\tilde{x}$.

By (5), (7) and (8), $\tilde{t}_1$, $\tilde{t}_2$ and the number of the stock shares $\tilde{x}(\tilde{t}_2)$ sold by the market participant executing the selling strategy $\tilde{x}$ are the values of t_1, t_2 and X, respectively which maximize $f(t_1, t_2, X)$ with the constraints:

$$0 \le t_1 < t_2 \le T, \tag{10}$$

$$0 \le X \le Y, \tag{11}$$

$$1 - \lambda + \mu t - c\frac{X}{t_2 - t_1} > 0 \text{ for each } t \in (t_1, t_2). \tag{12}$$

The inequality $X \le Y$ follows from the assumption that the number of shares of the stock sold is not bigger than Y which symbolizes the number of the stock possessed by the market participant at the start of the selling strategy. If the constraint (12) is not satisfied then, there exists $t^* \in (t_1, t_2)$ such that $1-\lambda+\mu t - c\frac{X}{t_2-t_1} < 0$ for $t \in (t_1, t^*)$ and because $a(x) = S_0 \int_{t_1}^{t_2} (1-\lambda+\mu t - c\frac{X}{t_2-t_1})\frac{X}{t_2-t_1} dt$, the strategy determined by of t_1, t_2 and X is not optimal. Consequently, if the values of t_1, t_2 and X maximize $f(t_1, t_2, X)$ with the constraints (10) and (11) then the constraint (12) is also satisfied. Thus, the values of t_1, t_2 and X maximizing $f(t_1, t_2, X)$ under the constraints (10) and (11) characterize the selling strategy maximizing $a(x)$ with the constraint (7).

The strategy $\tilde{x}$ can be determined by using some functions derivatives.

THE CASE $\mu > 0$

If the drift μ is positive then the selling strategy maximizing $a(x)$ with the constraint (7) is such that

$$t_2 = T. \tag{13}$$

Thus, $\tilde{x}$ is obtained by finding the values of t_1 and X such that the value of $f(t_1, T, X)$ is maximized with the constraints:

$$0 \le t_1 < T \tag{14}$$

and (11).

Let $g(t_1, X) = f(t_1, T, X)$. By (9) and (13) it follows that

$$g(t_1, X) = S_0(1-\lambda)X + S_0\mu X\frac{T+t_1}{2} - S_0 c\frac{X^2}{T-t_1}. \tag{15}$$

Denote by $g_{t_1}(t_1, X)$ the derivative of $g(t_1, X)$ with respect to t_1.

Denote by $t_1^g(X)$ the value of t_1 maximizing (15) with the constraint (14) for the fixed value of X. It is easily seen that $t_1^g(X)$ is given as follows:

$$t_1^g(X)=\left(T-\sqrt{\frac{2cX}{\mu}}\right)^+. \tag{16}$$

Let $h(X)=g\left(t_1^g(X),X\right)$. The value of $\tilde{x}(T)$ equals to the value of X such that the value of $h(X)$ is maximized with the constraint (11).

By (15) and (16) the function $h(X)$ is given as follows:

$$h(X)=\begin{cases} S_0(1-\lambda)X+\mu TS_0X-\sqrt{2\mu c}S_0X^{\frac{3}{2}} \text{ for } X\le\dfrac{\mu T^2}{2c} \\ S_0(1-\lambda)X+S_0X\dfrac{\mu T}{2}-S_0c\dfrac{X^2}{T} \text{ for } X>\dfrac{\mu T^2}{2c} \end{cases}. \tag{17}$$

Denote by X^h the value of X maximizing $h(X)$ in the interval $[0,\infty)$. It is not difficult to calculate that:

$$X^h=\begin{cases} X^h=\dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{for } \mu T\le 2(1-\lambda) \\ X^h=\dfrac{2}{\mu c}\left(\dfrac{1-\lambda+\mu T}{3}\right)^2 \text{ for } X>\dfrac{\mu T^2}{2c} \end{cases}. \tag{18}$$

Consequently, $\tilde{x}(\tilde{t}_2)$ is characterized as follows:

$$\tilde{x}(\tilde{t}_2)=\begin{cases} Y \text{ for } Y\le\dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{and } \mu T\le 2(1-\lambda) \\ \dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{for } Y>\dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{and } \mu T\le 2(1-\lambda) \\ Y \text{ for } Y\le\dfrac{2}{\mu c}\left(\dfrac{1-\lambda+\mu T}{3}\right)^2 \text{ and } \mu T>2(1-\lambda) \\ \dfrac{2}{\mu c}\left(\dfrac{1-\lambda+\mu T}{3}\right)^2 \text{for } Y>\dfrac{2}{\mu c}\left(\dfrac{1-\lambda+\mu T}{3}\right)^2 \text{ and } \mu T>2(1-\lambda) \end{cases}. \tag{19}$$

Moreover, by (16):

$$\tilde{t}_1=\left(T-\sqrt{\frac{2c\tilde{x}(\tilde{t}_2)}{\mu}}\right)^+. \tag{20}$$

THE CASE $\mu=0$

It is easily seen that in case $\mu=0$:

$$\tilde{t}_1 = 0, \tag{21}$$

$$\tilde{t}_2 = T. \tag{22}$$

and by (9), (21) and (22) , the number of shares $\tilde{x}(T)$ is equal to X which maximizes $f(0,T,X)$ with the constraint (11).

Denote by X^0 the value of X maximizing $f(0,T,X)$ in the interval $[0,\infty)$.

The value of X^0 is given by the following formula:

$$X^0 = \frac{(1-\lambda)T + \frac{\mu T^2}{2}}{2c} \tag{23}$$

Consequently, the number of shares $\tilde{x}(\tilde{t}_2)$ is given as follows:

$$\tilde{x}(\tilde{t}_2) = \begin{cases} Y \text{ for } Y \le \dfrac{(1-\lambda)T + \frac{\mu T^2}{2}}{2c} \\ \dfrac{(1-\lambda)T + \frac{\mu T^2}{2}}{2c} \text{ for } Y > \dfrac{(1-\lambda)T + \frac{\mu T^2}{2}}{2c} \end{cases}. \tag{24}$$

In the considered model the number of stocks can be non-integers.

THE CASE $\mu < 0$

If the drift μ is negative then the selling strategy maximizing $a(x)$ subject to the constraint () is such that

$$\tilde{t}_1 = 0. \tag{25}$$

Thus, the strategy x such that $a(x)$ is maximized with the constraint (7) is obtained by finding the values of t_2 and X such that the value of $f(0,t_2,X)$ is maximized subject to the constraints:

$$0 < t_2 \le T \tag{26}$$

and (11).

Let $k(t_1,X) = f(0,t_2,X)$. By (9) and (25) it follows that

$$k(t_1,X) = S_0(1-\lambda)X + S_0\mu X\frac{t_2}{2} - S_0 c\frac{X^2}{t_2}. \tag{27}$$

Denote by $t_2^k(X)$ the value of t_2 maximizing (27) subject to the constraint (26) for the fixed value of X. It is easily seen that $t_2^k(X)$ is given as follows:

$$t_2^k(X)=\begin{cases}\sqrt{-\dfrac{2cX}{\mu}} \text{ for } X \le -\dfrac{\mu T^2}{2c} \\ T \text{ for } X > -\dfrac{\mu T^2}{2c}\end{cases}. \tag{28}$$

Let $l(X)=k\left(t_2^k(X),X\right)$. The value of $\tilde{x}(T)$ can equals to the value of X such that the value of $l(X)$ is maximized with the constraint (11).

By (27) and (28) the function $l(X)$ is given as follows:

$$l(X)=\begin{cases} S_0(1-\lambda)X-\sqrt{-2\mu c}S_0X^{\frac{3}{2}} \text{ for } X \le -\dfrac{\mu T^2}{2c} \\ S_0(1-\lambda)X+S_0X\dfrac{\mu T}{2}-S_0c\dfrac{X^2}{T} \text{ for } X > -\dfrac{\mu T^2}{2c}\end{cases}. \tag{29}$$

Denote by X^l the value of X maximizing $l(X)$ in the interval $[0,\infty)$. It is not difficult to obtain that:

$$X^l=\begin{cases}\dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{for} -\mu T \le \dfrac{2}{3}(1-\lambda) \\ X^l=-\dfrac{2}{\mu c}\left(\dfrac{1-\lambda}{3}\right)^2 \text{ for} -\mu T > \dfrac{2}{3}(1-\lambda)\end{cases}. \tag{30}$$

Consequently, $\tilde{x}(\tilde{t}_2)$ is characterized as follows:

$$\tilde{x}(\tilde{t}_2)=\begin{cases} Y \text{ for} Y \le \dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{and - } \mu T \le \dfrac{2}{3}(1-\lambda) \\ \dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{for} Y > \dfrac{T}{2c}\left(1-\lambda+\dfrac{\mu T}{2}\right) \text{and - } \mu T \le \dfrac{2}{3}(1-\lambda) \\ Y \text{ for} Y \le -\dfrac{2}{\mu c}\left(\dfrac{1-\lambda}{3}\right)^2 \text{ and - } \mu T > \dfrac{2}{3}(1-\lambda) \\ -\dfrac{2}{\mu c}\left(\dfrac{1-\lambda}{3}\right)^2 \text{for} Y > -\dfrac{2}{\mu c}\left(\dfrac{1-\lambda}{3}\right)^2 \text{ and - } \mu T > \dfrac{2}{3}(1-\lambda)\end{cases}. \tag{31}$$

Moreover,

$$\tilde{t}_2 = \begin{cases} \sqrt{-\dfrac{2c\tilde{x}(\tilde{t}_2)}{\mu}} \text{ for } \tilde{x}(T) \le -\dfrac{\mu T^2}{2c} \\ T \text{ for } \tilde{x}(T) > -\dfrac{\mu T^2}{2c} \end{cases}. \tag{32}$$

NUMERICAL EXAMPLE

In the Table 1 there are the results of computing $a(\tilde{x})$ for 300 pairs of (μ, Y) for the following exemplary values of the parameters T, S_0, λ and c: $T = 1, \lambda = 0.01,\ S_0 = 1$ and $c = 1$. The parameter Y^* is expressed as the fraction of the stock average traded volume in time T ($Y^* = \dfrac{Y}{V}$ where V is the average traded volume of the stock).

Table 1. The values of $a(\tilde{x})$ as the function of Y^* and μ

		μ										
		-0.5	-0.4	-0.3	-0.2	-0.1	0.0	0.1	0.2	0.3	0.4	0.5
Y^*	0.1	0.089	0.090	0.091	0.093	0.095	0.098	0.105	0.113	0.121	0.130	0.139
	0.2	0.170	0.173	0.176	0.180	0.185	0.194	0.205	0.220	0.236	0.253	0.270
	0.3	0.245	0.251	0.257	0.264	0.274	0.288	0.304	0.324	0.347	0.371	0.395
	0.4	0.316	0.324	0.334	0.345	0.360	0.380	0.400	0.425	0.454	0.484	0.516
	0.5	0.383	0.395	0.408	0.424	0.445	0.470	0.495	0.524	0.558	0.595	0.633
	0.6	0.447	0.463	0.480	0.501	0.528	0.558	0.588	0.621	0.660	0.703	0.747
	0.7	0.508	0.527	0.550	0.576	0.609	0.644	0.679	0.716	0.760	0.807	0.858
	0.8	0.566	0.590	0.617	0.649	0.688	0.728	0.768	0.809	0.857	0.910	0.966
	0.9	0.621	0.650	0.682	0.720	0.765	0.810	0.855	0.900	0.952	1.010	1.071
	1	0.674	0.707	0.745	0.790	0.840	0.890	0.940	0.990	1.045	1.107	1.174
	1.1	0.724	0.763	0.806	0.858	0.913	0.968	1.023	1.078	1.136	1.203	1.274
	1.2	0.772	0.816	0.866	0.924	0.984	1.044	1.104	1.164	1.226	1.296	1.372
	1.3	0.818	0.868	0.924	0.988	1.053	1.118	1.183	1.248	1.314	1.388	1.468
	1.4	0.862	0.917	0.980	1.050	1.120	1.190	1.260	1.330	1.400	1.477	1.562
	1.5	0.904	0.965	1.035	1.110	1.185	1.260	1.335	1.410	1.485	1.565	1.654

Source: own computation

The arithmetic average of bid-ask spreads at the Warsaw Stock Exchange in years 2011-2013 was not very far from 2% [Kociński 2014]. Thus, in the considered example, the half of the bid-ask spread λ (expressed at the fraction of the stock price) is 0.01. The price impact cost seems to be more difficult to quantify than the bid-ask spread and the value of c equal to 0.1 is one of the reasonable choices to the exemplary calculations.

SUMMARY

In the article the model of the market, with the drift in the stock price, bid-ask spread and the market impact induced by trading, is described. In a framework of this model the problem of determining the trading strategy which maximizes the expected amount of money received from selling the shares of the stock of the market participant under the constraint of the constant trading speed is explicitly solved. From the numerical example included in the article it follows that the drift in the stock price may have a significant impact on the financial profitability of investing in the stock market. It is not difficult to see that in case $\mu > 0$ it may be advantageous for the market participant to buy the stock shares when maximizing $a(x)$. The trading strategy with purchasing and selling the shares of the stock may be more profitable for the market participant than the strategy such that x is a non-decreasing function of time. Moreover, the trading strategies which are random processes with the possibility of varying trading speed can be more profitable than the strategies where x is a non-random function of time.

REFERENCES

Almgren R., Chriss N. (2000) Optimal Execution of Portfolio Transactions. Journal of Risk, 3, 5-39.

Almgren R., Thum C., Hauptmann E., Li H. (2005) Direct Estimation of Equity Market Impact. Risk, 18, 58-62.

Barucci E. (2003) Financial Markets Theory – Equilibrium, Efficiency and Information. Springer-Verlag, London.

Czekaj J., Woś M., Żarnowski J. (2001) Efektywność giełdowego rynku akcji w Polsce. Z perspektywy dziesięciolecia, Warszawa, Wydawnictwo Naukowe PWN (in Polish).

Elton R. J., Gruber M. J., Brown S. J., Goetzmann W. N. (2010) Modern Portfolio Theory and Investment Analysis. John Wiley & Sons, Hoboken.

Kociński M. (2014) Transaction Costs and Market Impact in Investment Management. e-Finanse, 10, 28-35.

Zarinelli W., Treccani M., Doyne Farmer J., Lilo F. (2014) Beyond the Square Root: Evidence for Logarithmic Dependence of Market Impact on Size and Participation Rate. http://arxiv.org/pdf/1412.2152v1.pdf.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 398 – 410

Received: 23.11.2018
Accepted: 21.12.2018

FX-LINKED STRUCTURED TIME DEPOSITS VERSUS BARRIER AND STANDARD OPTIONS: A COMPARATIVE STUDY

Monika Krawiec https://orcid.org/0000-0002-4765-244X
Faculty of Applied Informatics and Mathematics
Warsaw University of Life Sciences – SGGW, Poland
e-mail: krawiec.monika@gmail.com

Abstract: The paper provides a short description of barrier options together with an analysis of their performance compared to the performance of standard options and structured time deposits that incorporate the element of barrier in their construction. The results obtained show that some of considered structured time deposits linked to the foreign exchange rates and standard options could bring some profits unlike the majority of coressponding barrier options. The disadavantage of barrier options is they can stay inactive or a "spike" in the underlying asset price can cause the option to be knocked-out.

Keywords: structured time deposits, barrier options, foreign exchange rates

JEL classification: G10, G13

INTRODUCTION

Options are popular instruments widely used for hedging in the commodity and financial markets. They give their holders the right to receive certain cash payoffs under certain conditions. For this privilage the holders pay premiums to the writers of the options. Traditional options (sometimes called vanilla options) have been traded for hundreds of years. The earliest recorded account of options can be traced back to the ancient Greek philosopher and mathematician – Tales. During winter, when there was little demand, he negotiated for the use of olivepresses for the following spring. The demand was contingent on having great harvest [Ong 1996]. In the first half of the 17th century, options were intensively used in Holland during the tulip bulb craze called also tulipomania (Dash [1999] presents an interesting study of this phenomenon). In the United States, options first appeared in the 1790s. Much newer innovations are non-standard options. For example, down-

https://doi.org/10.22630/MIBE.2018.19.4.38

and-out call options, members of the barrier options family, have been sporadically available in the U.S. over-the-counter (OTC) market since 1960s. Initially, these non-standard instruments were called "boutique" or "designer" options, however since the publication of the working paper "Exotic options" by Mark Rubinstein and Eric Reiner [Rubinstein, Reiner 1992], they are commonly called exotic options.

The range of exotic options being offered in the market is very wide, but the interest in the options centres mainly on barrierr options, average rate options, basket options, digital options, and rainbow options. Their applicability may be found in the commodity, foreign exchange, equity, and interest rate markets. In addition, some elements of exotic options are used in construction of structured time deposits. These instruments are regularly offered to individual investors by numerous banks in Poland. The profit fom the structured time deposit is conditional and depends upon the performance of some underlying asset (equity, currency, commodity) during the investment period. The most often these deposits incorporate barriers that are the elements of barrier options and they are usually linked to the foreign exchange (FX) rates. Thus the aim of the paper is to present the description of barrier options, methods for their pricing and analysis of their performance in relation to the performance of structured time deposits with barrier mechanism. The empirical study is based on structured time deposits linked to the foreign exchange rates that the biggest banks in Poland have offered to their clients within last few years.

BARRIER OPTIONS DESCRIPTION

Standard barrier options

Barrier options are similar in some ways to ordinary options. There are puts and calls, as well as European and American varieties[1], but there is an additional element to barrier option, which is the barrier level set in the contract. In general, barrier options fall into two broad cathegories: "in" and "out" options. "In" options start their lives worthless and only become active in the event a predetermined knock-in barrier price is reached. "Out" options start their lives active and become null and void in the event a certain knock-out barrier price is breached [Chriss 1997].

Given the spot underlying asset price, the barrier can be placed either above or below it. If the barrier is below the spot price, the option is called a "down" option, if the barrier is above the spot price, the option is called an "up" option. Table 1 shows basic types of barrier options and their properties.

[1] Call options give to their holders the right to buy some underlying asset, whereas puts give the right to sell the underlying asset. European options can be exercised only on the day of expiration, whereas American options can be exercised anytime during their lives.

Table 1. Basic types of barrier options and their properties

	Down	Up
Out	Down-and-out dies if the underlying crosses the barrier coming down	Up-and-out dies if the underlying crosses the barrier coming up
In	Down-and-in becomes activated if the underlying crosses the barrier coming down	Up-and-in becomes activated if the underlying crosses the barrier coming up

Source: [Nelken 2000], p. 134

All this permits eight types of options [Kolb,Overdahl 2007]:
– down-and-in call,
– up-and-in call,
– down-and-in put,
– up-and-in put,
– down-and-out call,
– up-and-out call,
– down-and-out put,
– up-and-out put.

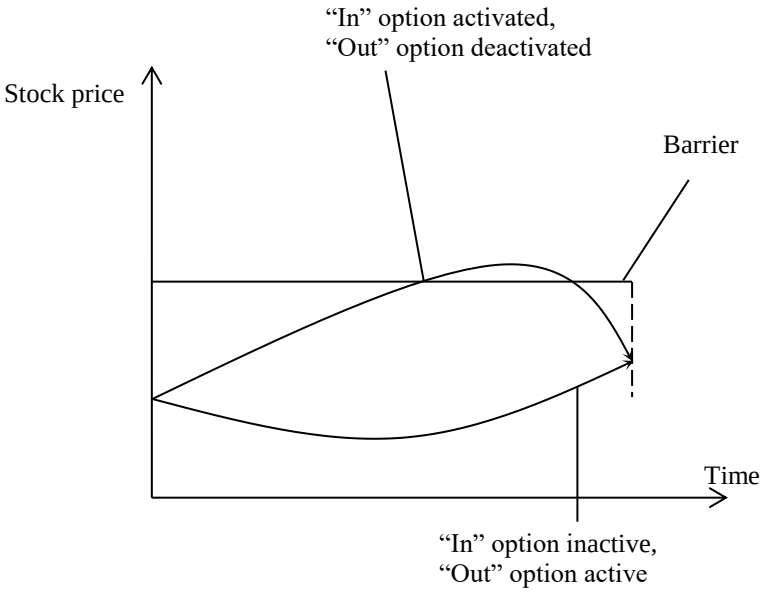
In the absence of rebate payments[2], the following decomposition always holds:

vanilla = knock-out + knock-in.

The idea is that simultaneously holding the "in" and the "out" options, guarantees that one and only one of the two will pay off. The argument, called "in-out" parity, only works for European options. In Figure 1, we can see an example, where a barrier is denoted by the heavy horizontal line, an expiration date by the vertical dashed line, and there are the two price paths (one that crosses the barrier and one that does not cross the barrier). The one that crosses the barrier simultaneously activates the knock-in option and deactivates the knock-out option. Conversly, the path that does not cross the barrier behaves in the opposite manner: the knock-in option is never activated, while the knock-out option is never deactivated. The expected payout of holding the "in" and "out" portfolio is therefore always the same: at expiration, the portfolio has exactly the same payout as holding a simple option [Chriss 1997].

[2] If a knock-out option gets knocked out or fails to materialize, the investor can receive a cash rebate. With a knock-out option, the rebate can be paid immediately upon being knocked out. With a knock-in option, we have to wait until expiration to know either or not the option was knocked in [Nelken 2000].

Figure 1. An "in-out" portfolio



Source: [Chriss 1997], p. 438

According to Kolb and Overdahl [2007], barrier options may be viewed as conditional plain vanilla options. "In" barrier options become plain vanilla options if the barrier is hit. "Out" barrier options are plain vanilla options, with the condition that they may pass out of existence if the barrier is hit. These conditions make barrier options inferior to unconditional plain vanilla options, so barrier options will be cheaper than otherwise identical plain vanilla options. This cheapness gives the barrier options a special usefulness in hedging applications.

Non-standard barrier options

Besides the standard barrier options, there are many variations of single barrier options, that are called exotic or non-standard barrier options. According to Zahng [2006], these are:

– floating barrier options, called also curvilinear barriers, where the barrier is no longer assumed to be constant throughout the life of the option, but may change with time in many applications (it may either increase or decrease with time, or follow some other deterministic paths);

– forward-start barrier options, where barriers are not effective immediately after the contracts are signed, but become effective at time t_1 ($t_0<t_1<T$), where t_0 and T represent current and maturity time, respectively;

– early-ending barrier options with barriers stopping to be effective at time t_e before the expiration of the option ($t_0<t_e<T$);

– window barrier options, where the barriers are effective only within one or more than one prespecified periods during the options lives (actually, the former two options – the forward-start and the early-ending barrier options are special window barrier options).

There are also multiple barrier options with two or more barrier levels H_i ($i = 2, 3, \ldots, n$). The most commonly traded in the market are double-barrier options. The upper and lower tresholds can either be knock-in or knock-out or a combination of both. It makes no difference whether the up-barrier or the low-barrier is touched, or which is touched first and the direction of approaching the barrier is no longer a factor affecting the option value. Therefore, there are four basic types of double-barrier options:
– out calls,
– out puts,
– in calls,
– in puts.

METHODS FOR PRICING STANDARD BARRIER OPTIONS

Barrier options are options where the payoff depends on whether the underlying asset price reaches a certain level during a certain period of time. A down-and-out call is a regular call option that ceases to exist if the asset price reaches a certain barrier level H. The barrier level is below the initial asset price (S_0). The corresponding knock-in option is a down-and-in call. This is a regular call that comes into existence only if the asset price reaches the barrier level. If H is less than or equal to the strike price K, the value of a down-and-in call at time zero is:

$$c_{di} = S_0 e^{-qT} (H / S_0)^{2\lambda} N(y) - K e^{-rT} (H / S_0)^{2\lambda - 2} N(y - \sigma\sqrt{T}), \tag{1}$$

where:

$$\lambda = \frac{r - q + \sigma^2 / 2}{\sigma^2}, \tag{2}$$

$$y = \frac{\ln[H^2 / (S_0 K)]}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T}, \tag{3}$$

and r is the continuously compounded risk-free rate, σ is the underlying asset price volatility, q is the dividend yield, and T is the time to maturity of the option. Because the value of regular call equals the value of a down-and-in call plus the value of a down-and-out call, the value of a down-and-out call is given by:

$$c_{do} = c - c_{di}. \tag{4}$$

If $H >= K$, then:

$$c_{do} = S_0 N(x_1) e^{-qT} - K e^{-rT} N(x_1 - \sigma\sqrt{T}) - S_0 e^{-qT} (H/S_0)^{2\lambda} N(y_1) + K e^{-rT} (H/S_0)^{2\lambda-2} N(y_1 - \sigma\sqrt{T}) \quad (5)$$

and

$$c_{di} = c - c_{do} \ , \quad (6)$$

where

$$x_1 = \frac{\ln(S_0/H)}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T} \ , \quad (7)$$

$$y_1 = \frac{\ln(H/S_0)}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T} \ . \quad (8)$$

An up-and-out call is a regular call option that ceases to exist if the asset price reaches a barrier level H that is higher than the current asset price. An up-and-in call is a regular call option that comes into existence only if the barrier is reached. When H is less than or equal to K, the value of the up-and-out call (c_{uo}) is zero and the value of the up-and-in call (c_{ui}) is c. When H is greater than K:

$$c_{ui} = S_0 N(x_1) e^{-qT} - K e^{-rT} N(x_1 - \sigma\sqrt{T}) - S_0 e^{-qT} (H/S_0)^{2\lambda} [N(-y) - N(-y_1)] + K e^{-rT} (H/S_0)^{2\lambda-2} [N(-y + \sigma\sqrt{T}) - N(-y_1 + \sigma\sqrt{T})] \quad (9)$$

and

$$c_{uo} = c - c_{ui} \ . \quad (10)$$

Put barrier options are defined similarly to call barrier options. An up-and-out put is a put option that ceases to exist when a barrier H that is greater than the current asset price is reached. An up-and-in put is a put that comes into existence only if the barrier is reached. When the barrier H is greater than or equal to the strike price K, their prices are:

$$p_{ui} = -S_0 e^{-qT} (H/S_0)^{2\lambda} N(-y) + K e^{-rT} (H/S_0)^{2\lambda-2} N(-y + \sigma\sqrt{T}) \quad (11)$$

and

$$p_{uo} = p - p_{ui} \ . \quad (12)$$

When H is less than or equal to K:

$$p_{uo} = -S_0 N(-x_1) e^{-qT} + K e^{-rT} N(-x_1 + \sigma\sqrt{T}) + S_0 e^{-qT} (H/S_0)^{2\lambda} N(-y_1) - K e^{-rT} (H/S_0)^{2\lambda-2} N(-y_1 + \sigma\sqrt{T}) \quad (13)$$

and

$$p_{ui} = p - p_{uo} \ . \quad (14)$$

A down-and-out put is a put option that ceases to exist when a barrier less than the current asset price is reached. A down-and-in put is a put option that comes into existence only when the barrier is reached. When the barrier is greater than the strike price, p_{do}=0 and p_{di}=p. When the barrier is less than the strike price:

$$p_{di} = -S_0 N(-x_1)e^{-qT} + Ke^{-rT} N(-x_1 + \sigma\sqrt{T}) + S_0 e^{-qT}(H/S_0)^{2\lambda}[(N(y) - N(y_1)] - Ke^{-rT}(H/S_0)^{2\lambda-2}[N(y - \sigma\sqrt{T}) - N(y_1 - \sigma\sqrt{T})] \quad (15)$$

and

$$p_{do} = p - p_{di}. \quad (16)$$

All of these valuations make the usual Black-Scholes assumption that the probability distribution for the asset price at a future time is lognormal. Another important issue for barrier options is the frequency with which the asset price (S) is observed for purposes of determining whether the barrier has been reached. The analytic formulas given above assume that S is observed continuously [Hull 2012]. According to Ravindran [1998], barrier options can be also valued using multivariate integrals, binomial method, and Monte Carlo method. In recent years, numerous papers presenting alternative approaches to barrier options pricing have been published (see for example Chiarella et al. [2012], Hong et al. [2015], Rashidi Ranjbar and Seifi [2015], Kirkby et al. [2017], or Nouri and Abbasi [2017]). The majority of the papers focus on double-barrier options pricing.

COMPARATIVE ANALYSIS OF THE FX-LINKED STRUCTURED TIME DEPOSITS, BARRIER AND STANDARD OPTIONS

This section of the paper provides an analysis comparing the performance of structured time deposits with the performance of corresponding barrier and standard options on foreign exchange rates. The research is based on real market data on deposits that have been offered to individual investors in Poland within last few years. None of the time deposits guarantees final investment profit. They only offer the 100% payback of invested capital.

Case 1

The investment starts on June 1, 2011 and lasts util May 30, 2012. It offers the conditional profit that depends upon the performance of EUR/PLN exchange rate. The contingent profit is calculated in the following manner:

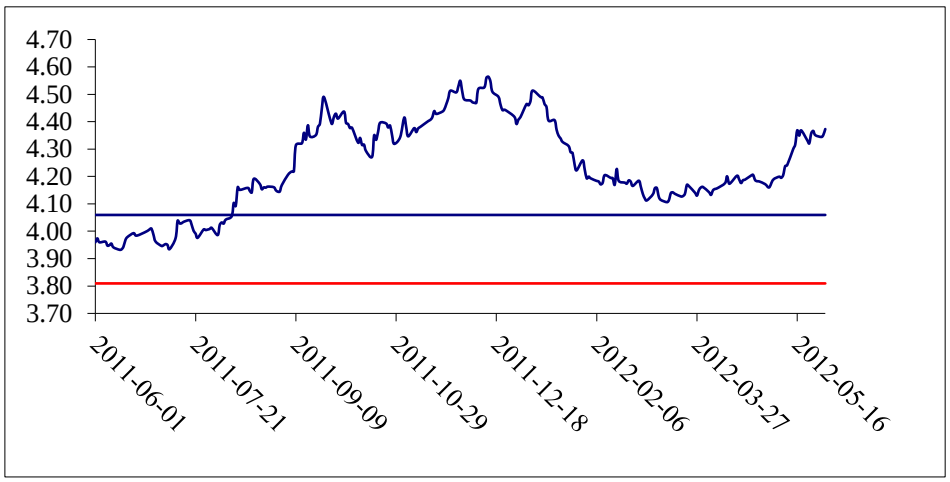
$$8\% \times n/N,$$

where n – number of the days when the exchange rate ranges between two barriers, N – number of exchange rate observations.

A lower barrier (L) = EUR/PLN exchange rate on June 1, 2011 (3.9595) minus 0.15 PLN, which is 3.8095. An upper barrier (U) = EUR/PLN exchange rate on June 1,

2011 (3.9595) plus 0.10 PLN, which is 4.0595. Figure 2 shows the performance of the EUR/PLN exchange rate during the investment period. The detailed analysis of the data on the exchange rate enables us to detect the days when its values range between the barriers. We have $n = 48$ observations. Thus, the investment provides the profit of: $8\% \times 48 / 253 = 1.52\%$.

Figure 2. EUR/PLN exchange rate from June 1, 2011 to May 30, 2012



Source: own preparation

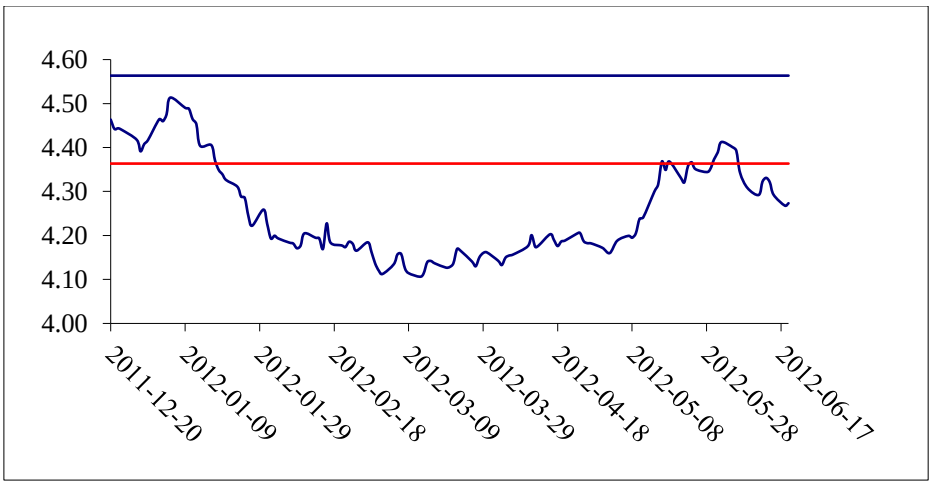
An alternative to the time deposit could be purchase of two barrier options: up-and-out call and down-and-out put with $K = S_0 = 3.9595$, time to maturity $T = 1$ (one year), and the barriers respectively: 4.0595 for a call, and 3.8095 for a put. On the base of formulas given in the previous section (with q replaced by r_f – the foreign risk-free rate), the up-and-out call premium $c_{uo} = 0.0005$, and the down-and out put premium $p_{do} = 0.0021$. Figure 2, enables us to find out that on the day of expiration of the options (May 30, 2012) the up-and-out call is not active. The down-and-out put is active, however taken into account the level of the exchange rate $S_T = 4.3889$, an investor should not exercise the contract, so his (her) total loss from the portfolio of the two options reaches 0.0026 PLN per 1 EURO[3]. Standard call and put options with analogous parameters would cost respectively: $c = 0.1575$ and $p = 0.0569$. On the day of expiration the call option pays off: $S_T - K = 4.3889 - 3.9595 = 0.4294$ and brings the net profit of: $0.4294 - 0.1575 = 0.2719$. It allows to cover the premium for the put and still gain 0.2150 PLN per 1 EURO.

[3] In practice, the currency options traded in the Polish market, usually cover the amounts of 10 000 or 50 000 Euros and 10 000 or 50 000 U.S. dollars.

Case 2

The time deposit starts on December 20, 2011 and lasts until June 19, 2012. It offers three scenarios. Each of them is dedicated to investors with different expectations about future behavior of the EUR/PLN exchange rate. Its initial value equals 4.4635 PLN per 1 EURO. Scenario A is dedicated to investors hoping that the exchange rate will increase. It guarantees a 5% profit if on the day of expiration the exchange rate is higher or equal to the level of 4.5635. Scenario B is dedicated to investors hoping that the exchange rate will decrease and guarantees a 5% profit if on the day of expiration the exchange rate is lower or equal to the level of 4.3635. Finally, scenario C is recommended to investors expecting stable exchange rates over time. It offers a 5% profit if on the day of expiration the exchange rate will range between 4.3635 and 4.5635. Figure 3 shows the performance of the exchange rate during the investment period.

Figure 3. EUR/PLN exchange rate from December 20, 2011 to June 19, 2012



Source: own preparation

Figure 3 enables us to find out that scenario B is the one to be realized, so after six months the investor who expected the exchange rate to fall down, is the winner with 5% profit from the time deposit. The three scenarios could be replaced by purchasing corresponding barrier options. The alternative to scenario A could be an up-and-in call, the alternative to scenario B could be a down-and-in put, and the alternative to scenario C would be a portfolio of one up-and-out call and one down-and-out put. All of them with the following input parameters: $K = S_0 = 4.4635$, $T = 0.5$, and barriers respectively: 4.3635 for "down" options, and 4.5635 for "up" options. Applying proper formulas presented in the previous section of the paper, we obtain:
– $c_{ui} = 0.1614$,
– $p_{di} = 0.0904$,

– c_{uo} = 0.00037,
– p_{do} = 0.00038.
On the day of expiration, the up-and-in call, substituting scenario A, is not active, so the investor's loss is equal to the premium paid (0.1614 PLN per 1 EURO). The down-and-in put, substituting scenario B, is active and pays off: $K - S_T = 4.4635 - 4.2733 = 0.1902$, providing the net profit of 0.0998 PLN per 1 EURO. The two options constituting the alternative for scenario C (up-and-out call and down-and-out put) together bring the total loss of 0.00075 (the former should not be exercised, the latter is not active). Standard call and put options with analogous parameters would cost respectively: $c = 0.1650$ and $p = 0.0919$. On the day of expiration only the put pays off 0.1902 and provides the net profit of $0.1902 - 0.0919 = 0.0983$ which is less than the value of the premium for call. This is why the loss from the portfolio of two standard options equals 0.0667 PLN per 1 EURO.

Case 3

The time deposit is linked to the USD/PLN exchange rate. The investment starts on April 30, 2014 and ends on July 30, 2015. Here, the conditional profit is calculated in the following manner:

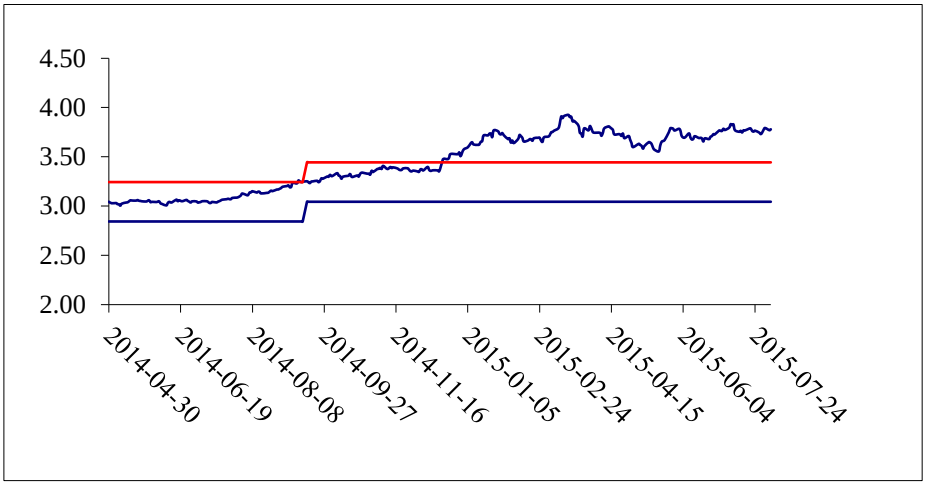
- If the exchange rate does not reach any of the two barriers: L_A = initial exchange rate minus 0.20 and U_A = initial exchange rate plus 0.20, the deposit provides 8% profit.
- If the exchange rate crosses the lower barrier (L_A), the new barriers are set. They are: L_B = initial exchange rate minus 0.40, U_B = initial exchange rate. If the exchange rate does not touch any of the new barriers, L_B and U_B, interest rate equals 8%.
- If the exchange rate crosses the upper barrier U_A, the new barriers are set to L_C = initial exchange rate, U_C = initial exchange rate plus 0.40. If none of the new barriers is touched, 8% interest rate is guaranteed.
- In all other cases, the time deposit generates 0% interest.

The initial exchange rate $S_0 = 3.0440$ determines $L_A = 2.8440$ and $U_A = 3.2440$. Figure 4 shows the USD/PLN exchange rate performance during the investment period. As on September 12, 2014, the upper barrier is crossed, the new barriers are set: $L_C = 3.0440$ and $U_C = 3.4440$ (the barriers shift is visible in Figure 4). Unfortunately, the upper barrier U_C is crossed again, which reslults in 0% profit from the investment.

Some alternative to the time deposit could be purchase of two barrier options: an up-and-out call and a down-and-out put with the following input parameters: $K = S_0 = 3.0440$, $T = 1.25$, and barriers: 3.2440, 2.8440 for the call and put respectively. Their premiums are: $c_{uo} = 0.0075$ and $p_{do} = 0.0073$. On the day of expiration, the call option is inactive. The put is active, however its exercise is unreasonable as the exchange rate level is $S_T = 3.7792$. So the portfolio of the two options generates the loss of 0.0148 PLN per 1 USD. Comparable standard call and

put options would cost respectively: $c = 0.1507$ and $p = 0.0672$. On the day of expiration the call option pays off: $S_T - K = 3.7792 - 3.0440 = 0.7352$ and gives the net profit of $0.7352 - 0.1507 = 0.5845$. It is enough to cover the ammount paid for the put and to earn 0.5173 PLN per 1 USD from the portfolio of the two standard options.

Figure 4. USD/PLN exchange rate from April 30, 2014 to July 30, 2015



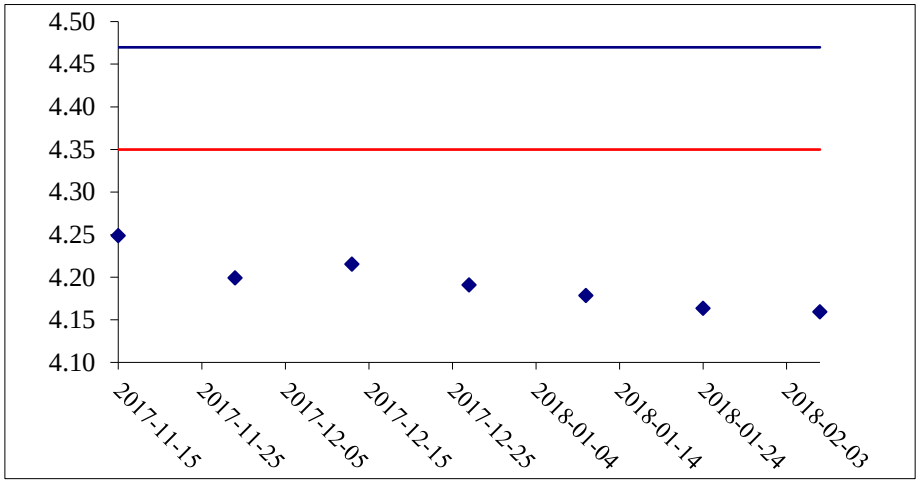
Source: own preparation

Case 4

The time deposit is linked to the EUR/PLN exchange rate and starts on November 12, 2016. The investment lasts until February 7, 2018. There are two barriers: a lower one L = the exchange rate on the reference day (November 15, 2016) minus 0.06 (4.4098 – 0.06 = 4.3498) and an upper barrier U = the exchange rate on the reference day (November 15, 2016) plus 0.06 (4.4098 + 0.06 = 4.4698). The investment profit is: $N \times 0.25\% + 1\%$, where N denotes the number of observations – days, when the exchange rate ranges between the two barriers. There are the following dates of observations: November 15, 2017, November 29, 2017, December 13, 2017, December 27, 2017, January 10, 2018, January 24, 2018, and February 7, 2018. Figure 5 shows the exchange rates on the days of interest together with the two barriers. In this figure, we can see that none of the observations is located between the barriers, so the investment profit equals: $0 \times 0.25\% + 1\% = 1\%$. An attempt to replace the time deposit with the portfolio of two barrier options: up-and-out call and down-and-out put with $K = S_0 = 4.4098$, $T = 1.25$, $L = 4.3498$, and $U = 4.4698$, provides the total loss of 0.00012. This is so, because on the day of expiration the put with the premium $p_{do} = 0.00006$ is not active. Moreover, the call with the similar premium (0.00006) that is active, expires worthless as the exchange rate $S_T = 4.1593$. Its owner should not exercise it. Analogous standard call and put options would cost

respectively: $c = 0.1782$ and $p = 0.0736$. Exercising of the put option generates the net profit amounting 4.4098 – 4.1593 – 0.0736 = 0.1769. It is not enough to cover the already paid premium for the call. The total loss from the portfolio of the two standard options is 0.0013 PLN per 1 EURO.

Figure 5. EUR/PLN exchange rate from November 15, 2017 to February 7, 2018



Source: own preparation

CONCLUDING REMARKS

Barrier options are probabely the oldest of all exotic options. They have been traded sporadically in the U.S. market since 1967. That is six years before the publication of the seminal paper by Black and Scholes entitled "The pricing of options and corporate liabilities" [Black, Scholes 1973] and six years before the Chicago Board of Options Exchange came into being in 1973. Nowadays, barrier options are among the few most popular exotic options in the OTC marketplace because they are cheaper than vanilla options in general.

Besides the standard barrier options, other modifications of barrier options have been designed to increase the flexibility of vanilla barriers or to capture some more general features. These are, for example, floating barrier options, partial barrier options or double barrier options. What is more, barrier options are often combined with other exotic options, so we have for example Asian barrier options, look barrier options, digital barrier options, or two-asset barrier options (see [Haug 2007]).

The mechanism of barriers is often inconporated into financial products such as structured time deposits. According to Jagielnicki [2011], usually the terms set in these investment vehicles are hardly met in practice, so it is important that investors understand the nature of the transactions. That is why the paper provides a short description of barrier options and a comparative analysis of their performance

against the performance of structured time deposits with barrier mechanism. Surprisingly, some of the time deposits linked to the foreign exchange rates, that have been analyzed in the paper, perform better than the barrier options that could be considered certain alternatives to the deposits. Vanilla options also performed better than their barrier counterparts, even though barrier options are cheaper than standard contracts. However, their disadvantage is they can stay inactive or a "spike" in the underlying asset price can cause the barrier option to be knocked-out. Thus, the analysis presented in the paper may be helpful in estimating possible chances for gaining profits from the investments of this kind.

REFERENCES

Black F., Scholes M. (1973) The Pricing of Options and Corporate Liabilities. Journal of Political Economy, 81, 637-654.

Chiarella C., Kang B., Meyer G. H. (2012) The Evaluation of Barrier Option Prices under Stochastic Volatility. Computers and Mathematics with Applications, 64, 2034-2048.

Chriss N. A. (1997) Black-Scholes and Beyond: Option Pricing Models. McGraw-Hill, New York.

Dash M. (1999) Tulipomania. Three Rivers Press, New York.

Haug E. G. (2007) Option Pricing Formulas. McGraw-Hill, New York.

Hong Y., Lee S., Li T. (2015) Numerical Method of Pricing Discretely Monitoring Barrier Option. Journal of Computational and Applied Mathematics, 278, 149-161.

Hull J. C. (2012) Options, Futures, and Other Derivatives. Prentice Hall, Boston.

Jagielnicki A. (2011) Inwestycje alternatywne. Helion, Gliwice.

Kirkby J. L., Nguyen D., Cui Z. (2017) An Unified Approach to Bermudan and Barrier Options under Stochastic Volatility Models with Jumps. Journal of Economic Dynamics and Control, 80, 75-100.

Kolb R. W., Overdahl J. A. (2007) Futures, Options, and Swaps. Blackwell Publishing, Malden.

Nelken I. (2000) Pricing, Hedging, and Trading Exotic Options. McGraw-Hill, New York.

Nouri K., Abbasi B. (2017) Implementation of the Modified Monte Carlo Simulation for Evaluate the Barrier Option Prices. Journal of Taibah University for Science, 11, 233-240.

Ong M. (1996) Exotic Options: the Market and Their Taxonomy. The Handbook of Exotic Options, IRWIN, Chicago, 3-44.

Rashidi Ranjbar H., Seifi A. (2015) A Path-Independent Method for Barrier Option Pricing in Hidden Markov Models. Physica A, 440, 1-8.

Ravindran K. (1998) Customized Derivatives. McGraw-Hill, New York.

Rubinstein M., Reiner E. (1992) Exotic Options. IBER Finance Working Paper, 20, University of California at Berkley.

Zahng P. G. (2006) Exotic Options. World Scientific Pub., Singapore.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 411 – 418

Received: 28.08.2018
Accepted: 21.12.2018

UNCERTAINTY ANALYSES IN ALBPETROL COMPANY

Blerta Mjeda https://orcid.org/0000-0001-7767-5741
Faculty of Economy
University of Tirana, Albania
e-mail: brrjolli@yahoo.com

Abstract: Large companies like Albpetrol often deal with big projects. The decision to invest is based on the evaluation of the project profitability. But how certain is the calculated profitability? What if the costs overrun during implementation of the project? What if the reservoir performance is less than estimated? And what if the project completion is delayed?
The focus will be on how to make people more aware of the risks and uncertainties in economic evaluations and to show the influence of these uncertainties on the economic indicators. Economic evaluations in the oil industry are carried out with cash flow models.
Traditionally, these evaluations are carried out with the estimated (most likely) set of parameters. Usually some parameters, such as project costs or reserves, are varied manually as 'sensitivities' to show the potential impact on profitability. In this report, it is proposed to treat the uncertainties by defining stochastic parameters with carefully specified supports based on inputs from discipline experts. In this manner a better insight is gained in the distribution of the project profitability. Some of the key uncertainties in oil and gas investments have been investigated in detail. Thinking in terms of scenarios will help to take better decisions (e.g. about field development concepts) that are robust against a range of scenarios.

Keywords: uncertainty, simulation, evaluation, forecasting, scenarios.

JEL classification: C53, D81, D86, G32

INTRODUCTION

The risk analyses

The risk analysis is designed to meet the needs of organization, integration and communication. The danger is everywhere and we need to consider making

https://doi.org/10.22630/MIBE.2018.19.4.39

decisions for projects that are very important. If we use data to solve problems, make predictions, develop strategies, or make decisions, then we should definitely consider doing risk analysis based on [Rose 2009]. The purpose of each of these methods is to use quantitative or qualitative techniques to help policy makers choose an action course, having a better understanding of possible outcomes that may occur. We may wonder if what we do would be appropriate for Risk Analysis. Uncertainties can be addressed more effectively through various risk analysis techniques [Cendrowski, Mair 2009].

The risk analysis generally consists of three components: risk assessment, risk management and risk communication. Risk analysis, in addition to risk assessment and risk management, is part of the concept of risk assessment [Kerlinger 1986].

Components of risk analysis

Risk assessment is a process within a risk analysis that involves identifying a risk that can cause a negative impact and characterizes the risk posed by that risk [Simkins, Fraser 2010]. The risk is characterized in qualitative or quantitative terms. This includes the assessment of:

a) Probability of a negative event occurring due to the identified risk;
b) The magnitude of the impact of the negative event;
c) Reviewing the uncertainty of the data used to assess the probability and impact on the risk components.

Simulation method, by using Crystal Ball program at Albpetrol Company

For over 20 years Albpetrol has used scenarios, rather than forecasts, to explore ways in which the future may behave. An important benefit of this approach with scenarios is that it makes us realize that the future is uncertain, that it may evolve in a number of different ways, and that decisions must be made within this context [Murck, Skiner, Porter 1998].

The idea of scenario thinking is the search for flexibility in our decisions. When just one path is adopted with no alternatives, any deviation between forecast and reality can mean a big loss [Graf 2005]. If the costs are higher in a certain year or the production is lower than estimated, things do not eventuate in the way we expected and the project may fail. Recognizing and managing possible negative scenarios should avoid this situation. It will allow us to think in advance about possible alternative scenarios and decisions to manage a negative impact on the project [Pedgen, Shanon, Sadowski 2005].

Crystal Ball is one of the software packages used to quantify the impact of uncertainties through Monte Carlo Simulation [Fishman 2000, 2008].

In this research data was collected through Albpetrol Comapny.The engineer noted that the data gathered through the research would result in some benefits. In

the oil and gas industry, quantitative risk analysis is usually undertaken at different stages of a project, shifting the focus to the specific tasks at hand:

Integrated project risk analysis forecasts the risks surrounding the oilfield projects and considers the probability distribution of the project's Net Present Value as its main output [Hubbert 2012].

Cost risk analysis focuses on the cost structure of the project, explores the deeper details of cost inputs and provides the probability distribution of the CAPEX as its main output[Waters 2011].

Schedule risk analysis focuses on the time required to complete each task, and its main outputs are the probability distribution of the project's first oil and its possible critical paths [Oakshott 2007].

Project risk analysis in Albpetrol Company

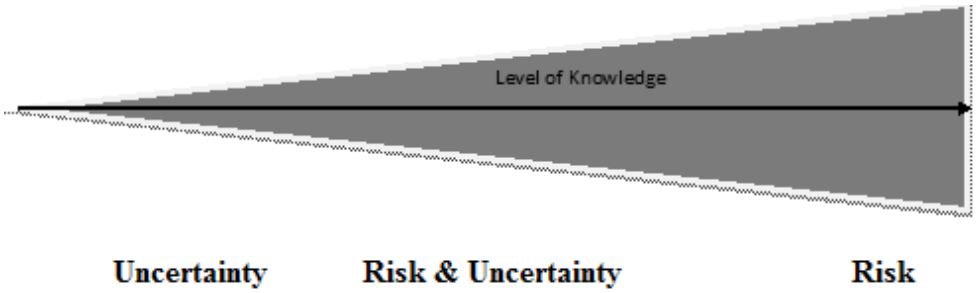
A project risk analysis can be a separate analysis, but it is often an important and integrated part of project management. The purpose of a project's risk analysis is to optimize the resources and outcome - time and budget - of the project by constantly checking the risks. In the risk analysis of the project identify the risks and uncertainties in the different phases of the project, from the dangers identified develop alternative risk innovations. An optimal project strategy is designed by combining responses by reducing risk and increasing profitability [Simpson, Lamb, Finch, Dinnie 2000]. A project risk analysis gives an overview of project risk profile, showing for example what activities and phases that involve the highest risks in the project and what risk responses reduce the most effective risk [Haataja 2000].

In a continuous project risk analysis, project and company risk awareness increases, giving a lot of positive effects. A project risk analysis is kept up-to-date through the project to detect new risks and uncertainties. Strength in project risk analysis is the strategy of using the same activities in the analysis - regardless of the level of detail. Keeping the central parts of the same analysis provides a powerful method. A project risk analysis is a central part of project management. A well-planned management project is needed and provides the opportunity to achieve project goals and requirements [Fraser 2005].

There are some important parameters in project management. Below are listed the most critical parameters for project success:

- Identification of different stakeholders and their responsibilities;
- Awareness of project impact on different actors;
- Constant assessment and updating of the necessary resources;
- Guarantee of key persons;
- Drafting future changes to the project;
- Freedom and responsibility for project members - as well as
- Tracking.

Figure 1. Level of knowledge about Risk and Uncertainty



Source**: [**Yoe 2011]

Risk management

There are three ways to manage the risk:

1. Avoiding-Assessing some risks may indicate that potential loss is greater than potential gain. This may require removal of some high risk investment opportunities or termination of certain ventures that have adverse risk / reward relationships [Miller 2013].
2. Reduction - There may be certain actions that can be taken to reduce the loss if an incident occurs. Actions to reduce the loss may require modifications or improvements in engineering designs or strengthening structural components to withstand the greatest forces.
3. Transfer - It may be possible to transfer a loss to a third party or spread the loss over a period of time to reduce its negative impact. You will eventually pay for that loss, as insurance premiums are designed to cover all losses along with administrative costs and earnings to the insurer. Increasing losses will be reflected in premium growth, so the best one can expect is to cover a high percentage of premiums paid over a long period of time. In the oil industry this can be done by a third party that takes all the risk of dry wells or fragmentation of labor where some parties proportionally share the risk of loss from a joint venture [Economides 2008].

Steps in the simulation study

The steps in a simulation study refer by [Sadowski, Sadowski, Kelton 1998] are as follows:

Problem formulation: Every study should start with a statement of the problem. If the statement is provided by policy-makers or those with problems, the analyst must ensure that the problem described is clearly understood. If a problem analysis is being developed by the analyst, it is important that policy-makers understand and agree with the wording. There are times when the problem needs to be

reformulated as the study progresses or walks. In many cases, policy makers and analysts are aware that there is a problem long before the nature of the problem is known.

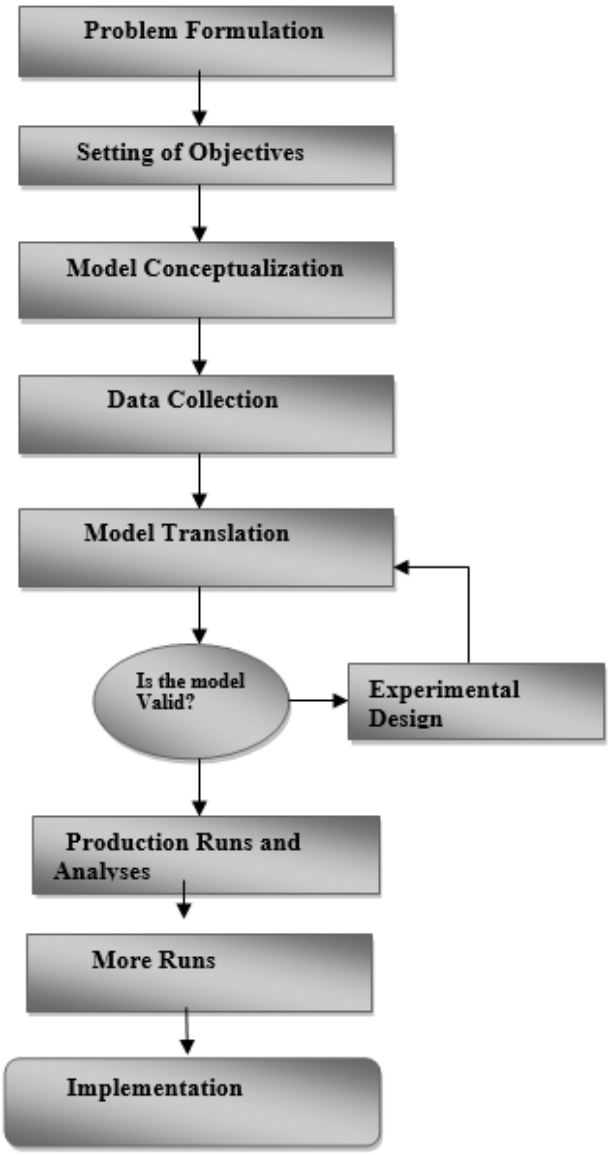
Setting the objectives and overall project plan: The objectives show questions to answer the simulation. At this point, a determination should be made whether the simulation is the appropriate methodology for the formulated problem and the defined objectives. Assuming that the simulation is appropriate, the overall project plan should include a statement of alternative systems to be considered and a method for assessing the effectiveness of these alternatives. It should also include study plans about the number of people involved, the study cost, and the number of days needed to complete each stage of the work with the predicted results at the end of each stage.

Conceptual modeling: Building a model of a system is perhaps just as art as science gives a full discussion of this step. "Although it is not possible to provide a set of guidelines that will lead to successful and successful model building in any case, there are some general guidelines that can be followed." The art of modeling increases from the ability to abstract the essential features of a problem, to select and modify the basic assumptions characterizing the system, and then to enrich and process the model until a useful approximation is achieved. Thus, it is better to start with a simple model and build towards greater complexity. However, the complexity of the model should not exceed what is required to meet the purposes for which the model is foreseen. Violating this principle will only add to the cost of building the model. There is no need to have a one-on-one map between the model and the real system. Only the very essence of the system is really needed.

Data collection: There is a continuous interaction between model building and collection of necessary input data. While the complexity of the pattern changes, the required data elements may also change. Also, since data collection takes up a large part of the total time needed to perform a simulation, it is necessary to start as early as possible, usually along with the early stages of model building. Objectives The study presents to a large extent the type of data to be collected. In a bank's survey, if the desire is to learn about the length of waiting lines as the number of indicators varies, the types of data needed would be the distribution of the arrival time (at different times of the day) the distributions at the service time for traders and historical distributions at the length of waiting lines under different conditions. This latter data will be used to validate the simulation model.

Translation of the model: Since most real-world systems result in models that require a great deal of storage and computing information. The model should be included in a familiar computer format. We use the term "program", although it is possible to achieve the desired result in many cases with little or no actual coding. The model should decide whether to program the model in a simulation language, or use special purpose simulation software.

Figure 2. Steps in a Simulation Study



Source: [Sadowski, Sadowski, Kelton 1998]

The validity: Validity is determining that a pattern is a true representation of the true system. Validity is usually achieved through calibration of the model, a repeating process of comparing the model with the current behavior of the system

and the use of discrepancies between the two, and acquired knowledge, to improve the model. This process is repeated until the model's accuracy is assessed. In the example of a bank mentioned above, data on the length of waiting lines are collected at current conditions. Does the simulation model repeat this mass of the system? This is a tool of validity.

Experimental Design: The alternatives to be simulated should be determined. Often, the decision about the alternatives they can simulate can be a function of the directions that are completed and analyzed. For each design of the simulated system, decisions should be made regarding the length of the starting period, the length of the simulation and the number of repeats to be made for each time period.

Production and analysis: Their production and subsequent analysis are used to evaluate performance measures for system designs that are simulated.

More simulation: Based on the analysis of the directions that are completed, the analyst determines whether additional scripting is needed and what designation should follow these additional experiments.

Implementation: The success of the implementation phase depends on how well the previous steps have been taken. It is also dependent on how thoroughly the analyst has included the latest model users throughout the simulation process. If the user of the model is fully involved and understands the nature of the model and its outcomes, the possibility of implementation has increased. Conversely, if the model and its basic assumptions are not properly communicated, implementation will probably suffer, regardless of the validity of the simulation model.

CONCLUSIONS

In this paper it was presented the importance of taking into the consideration analysing the risk, and the uncertainty, forecasting the future.

The simulation process, involve to run an initial set of values, analyze the result, change one more values, re-run the simulation, and repeat the process until finding a satisfactory solution [Hubbard 2009].

For any oil and gas development project the decision to implement the project needs a clear view of the project’s profitability and of the presented results [Mian 2002]. Cash flow models are often used to evaluate the profitability of a project. Economists often enter values given by the domain specialists in the cash flow models and ignore the influence of the uncertainties that are hidden in the assumed values [Heikki, Ilkka 2000].

As the Albpetrol company, faced with risk, the importance was dealing and taking into account the steps, making a simulation, by different scenarios.

REFERENCES

Cendrowski H., Mair W. C. (2009) Risk Management and COSO. A Guide for Directors, Executives and Practitioners, p. 17.

Economides J. M., Hill A. D., Economides E. C., Zhu D. (2012) Petroleum Production Systems (2nd Edition) p. 12.

Fishman G. S. (2000) Monte Carlo. 112-150, 204-233, 404-436.

Fishman G. S. (2008) Monte Carlo: Concepts, Algorithms, and Applications. Springer-Verlag, 18-26.

Fraser A. (2005) Economics of Worldwide Petroleum Production. OGCI Publications, 12-18.

Graf T. (2005) Shifting the Gaussian Curve to the Right – A Fully Stochastic Approach to Marginal Offshore Field Development. SPE, EAGE.

Haataja J. (2000) The Ten Most Important Algorithms of the Century. CSC News, 12(3), p. 15.

Heikki H., Ilkka T. (2000) Mathematical Aspects in the Modeling of Novel Unit Processes. Centre for Process Systems Engineering Workshop, London, p. 5.

Hubbard W. D. (2009) The Failure of Risk Management: Why It's Broken and How to Fix It. p. 46.

Hubbert S. (2012) Essential Mathematics for Market Risk Management. Wiley Finance, 67-80.

Kerlinger F. N. (1986) Foundations of Behavioral Research (3rd Edition). Holt, Rinehart & Winston.

Mian M. A. (2002) Project Economics and Decision Analysis. Deterministic Models. PennWell Corp, p. 18.

Miller B. M. (2013) Mathematics and Statistics for Financial Risk Management. Wiley, p. 274

Murck W. B., Skiner J. B., Porter C. S. (1998) Dangerous Earth: An Introduction to Geologic Hazards. Wiley, 20-22.

Oakshott L. (2007) Business Modelling and Simulation. Pitman Publishing, 546-574.

Pedgen C. D., Shanon R. E., Sadowski R. P. (2005) Introduction to Simulation Using Simon (2nd Edition). 33-57.

Rose P. R. (2009) Dealing with Risk and Uncertainty in Exploration: How Can we Improve? AAPG Bulletin, 71(1), 46-62.

Sadowski R. P., Sadowski D., Kelton D. W. (1998) Simulation with Arena. McGraw Hill.

Simkins J. B., Fraser J. (2010) Enterprise Risk Management: Today's Leading Research and Best Practices for Tomorrow's Executives. 420-465.

Simpson,G. S., Lamb F. E., Finch J. H., Dinnie N. C. (2000) The Application of Probabilistic and Qualitative Methods to Asset Management Decision-Making. Journal of Petroleum Technology, 23-41.

Waters C. D. (2011) Quantitative Methods for Business. 120-131, 147-160.

Yoe Ch. (2011) Principles of Risk Analysis: Decision Making under Uncertainty. 150-167, 421-423.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 419 – 429

Received: 02.11.2018
Accepted: 21.12.2018

APPLICATION OF AR_{MAX} MEASURE FOR ANALYSIS OF FOOD PREFERENCE CHANGES IN ASIAN COUNTRIES 2001-2013

Luiza Ochnio https://orcid.org/0000-0001-8875-7945
Grzegorz Koszela https://orcid.org/0000-0003-4175-4450
Faculty of Applied Informatics and Mathematics
Warsaw University of Life Sciences – SGGW, Poland
e-mail: luiza_ochnio@sggw.pl; grzegorz_koszela@sggw.pl
Pornsiri Suebpongsang https://orcid.org/0000-0002-1769-9255
Faculty of Agriculture
Chiang Mai University, Thailand
e-mail: pornsiri73@gmail.com

Abstract: The research of food preferences has, besides a sociological aspect, an economic aspect and is a good starting point for estimating the willingness to incur expenditures on the consumption of individual products. In the paper, the authors compared food preferences on the Asian market for 9 product groups. Due to the complexity of the problem, the study included 17 selected countries of Central and Southeast Asia (China, Mongolia, Japan, India, Thailand, Indonesia, Kazakhstan, Uzbekistan, Tajikistan, Malaysia, Myanmar, the Philippines, Pakistan, Cambodia, Vietnam, Laos, Sri Lanka). The research was carried out on data from 2001 to 2013 with the use of the methods of gradual data analysis. In some countries there were no major changes in nutrition and food consumption, which can be explained by the stabilized political and socio-economic situation. The best example is Thailand.

Keywords: consumer preferences in Asia, food products, multidimensional data analysis, GCA, ar measure, overrepresentation map, ranking, grouping of objects

JEL classification: F6, C43, Q1

INTRODUCTION

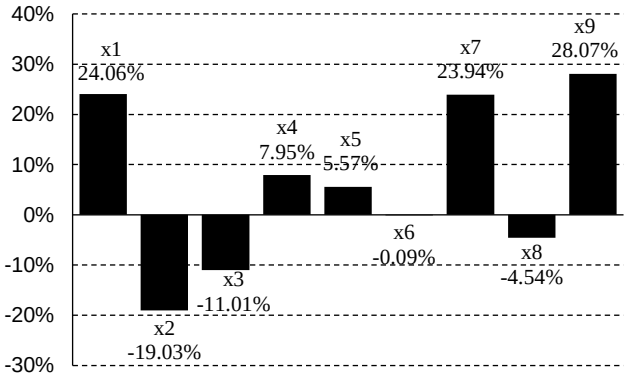
In Asian countries, changes in food preferences remain subtle for years, which is a consequence of the tradition, culture and religion. Nevertheless, the spread of supermarket chains throughout the world also has a large impact on changes in the proportion of demand for food products and the diversification of

https://doi.org/10.22630/MIBE.2018.19.4.40

diets in this region [Reardon at al. 2003; Kuhnlein, Receveur 1996]. Especially rapid growth in the number of supermarkets was observed in the early 2000s in China, Indonesia, Malaysia and Thailand and later in India and Vietnam [Reardon at al. 2010]. Asian agriculture is following an irreversible path leading away from its traditional pre-occupation with cereal crop production, especially rice, towards a production system that is becoming increasingly commercialized and diversified [Prabhu 2007]. In South-East Asian countries, the nutrition transition may be due to increasing food availability and food purchasing power rather than to a shift in food preferences towards modern Western foods [Lipoeto 2013]. People in China who live in megacities or highly urbanized neighbourhoods and have higher incomes and educational achievements consume more processed foods [Zhou at al. 2015]. With growing prosperity and urbanization, the per capita rice consumption has started to decline in the middle- and high-income Asian countries, like Japan, Taiwan and the Republic of Korea. However, nearly one-quarter of the Asian population is still poor and has a considerable unmet demand for rice, such as Afghanistan, North Korea, Nepal and Vietnam [Abdullah at al. 2006].

As an example, the differences between the consumption of food products in Thailand in 2001-2003 and that in Thailand in 2011–2013 can be measured. The average of 3 years for both extreme time periods in 9 product groups was taken: x1 - eggs, x2 - fish and seafood, x3 - fruits, x4 - pigmeat, x5 - poultry meat, x6 - rice (milled equivalent), x7 - sugar (raw equivalent), x8 - vegetables and x9 - wheat and products. Such changes take place, although this is a slow process that can only be observed with a significant time interval. In this article, it was decided that a sufficient period for all comparisons is a period of 10 years. For example, in Figure 1, the changes in food preferences in Thailand can be observed. It shows the relative changes in the preferences of the corresponding product groups for the 2 extreme 3-year sub-periods from 2001 to 2013.

Figure 1. Relative changes in the consumption of food products in Thailand between 2011-2013 and 2001-2003



Source: own preparation on the basis of FAO data

According to Figure 1, the most significant changes in Thailand occurred in such products as x1 - eggs, x2 - fish and seafood, x7 - sugar (raw equivalent) and x9 - wheat and products.

METHODS AND DATA SOURCES

The data used in the study come from FAO databases [FAOSTAT 2018] and concern the size of the annual consumption in 17 Asian countries for 9 groups of food products in kg per capita. The study covered the period 2001 - 2013, and consumption was defined as the arithmetic mean of the extreme 3-year time periods. To examine the changes in food preferences for these countries, multidimensional comparative analysis tools were used.

The similarities in the nutrition preferences can be measured on the basis of the measures of the non-similarity of structures that are widely described in the literature [Kowalczyk at al. 2004; Szczesny 2002; Koszela 2016]. The 'sensitivity' of some of these measures, and indeed the lack of certain subtleties, can often be the subject of discussion.

In this paper, an attempt was made to examine the non-similarity of structures in the formulation of the '*ar*' measure, which is one of the tools of grade data analysis. The method of determining this measure is based on the Gini index [Gini 1914; Glasser 1962], which is the doubled field between the diagonal of the square representing the egalitarian distribution and the Lorentz curve [Arnold 1987; Gastwirth 1971; Gini 1914].

To build the 'ar' measure, let us assume that we have two structures:

$$\mathbf{x} = (x_1, \ldots, x_n), \mathbf{y} = (y_1, \ldots, y_n) \in \Re_+^n ,$$

where: $x_i, y_i \geq 0$ and $\sum_{i=1}^{n} x_i = \sum_{i=1}^{n} y_i = 1$

Based on these structures, a broken curve, $L_{[\mathbf{x},\mathbf{y}]}$, can be determined by points that will be cumulative structures of subsequent (in this case) product groups. These points can be defined as follows [Binderman at al. 2014]:

$$P_0 = (0,0),\ P_j = \left(x_j^{\wedge}, y_j^{\wedge}\right) \quad \text{for } j = 1, 2, \ldots, n$$

where: $x_j^{\wedge} := \sum_{i=1}^{j} x_i$, $y_j^{\wedge} := \sum_{i=1}^{j} y_i$ and $x_n^{\wedge} = \sum_{i=1}^{n} x_i = 1, y_n^{\wedge} = \sum_{i=1}^{n} y_i = 1$

For example, in Table 1, such points were determined for all the product groups, given in a set and natural order from x1 to x9 (in accordance with the designations adopted at the beginning) for food preferences in Thailand, in 2001-2003 and 2011-2013, respectively.

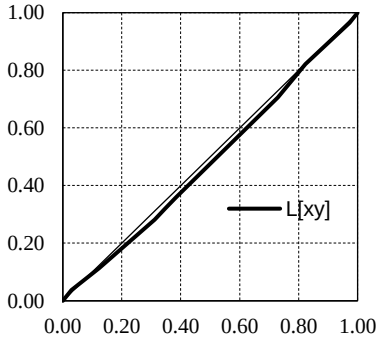
Table 1. Consumption of nine groups of food products and their structures and cumulative structures in Thailand for the period 2001-2013

	THA_2001–2003			THA_2011–2013		
Product	kg/ca	x_i (%)	$x_j^{\wedge}$	kg/ca	y_i (%)	$y_j^{\wedge}$
x1	9.84	2.98%	2.98%	12.20	3.71%	3.71%
x2	30.76	9.32%	12.30%	24.91	7.57%	11.28%
x3	62.45	18.91%	31.21%	55.57	16.89%	28.17%
x4	12.03	3.64%	34.85%	12.99	3.95%	32.12%
x5	12.09	3.66%	38.51%	12.76	3.88%	36.00%
x6	113.85	34.48%	72.99%	113.75	34.58%	70.58%
x7	30.63	9.28%	82.27%	37.96	11.54%	82.11%
x8	49.49	14.99%	97.26%	47.24	14.36%	96.47%
x9	9.06	2.74%	100.00%	11.60	3.53%	100.00%
Total	330.19	100.00%		328.98	100.00%	

Source: own calculations

The broken curve $L_{[\mathbf{x},\mathbf{y}]}$, defined by points with coordinates $\left(x_j^{\wedge}, y_j^{\wedge}\right)$, is shown in Figure 2.

Figure 2. Broken curve L[x,y] of cumulative structures for 9 food products in Thailand in 2001-2003 and 2011-2013



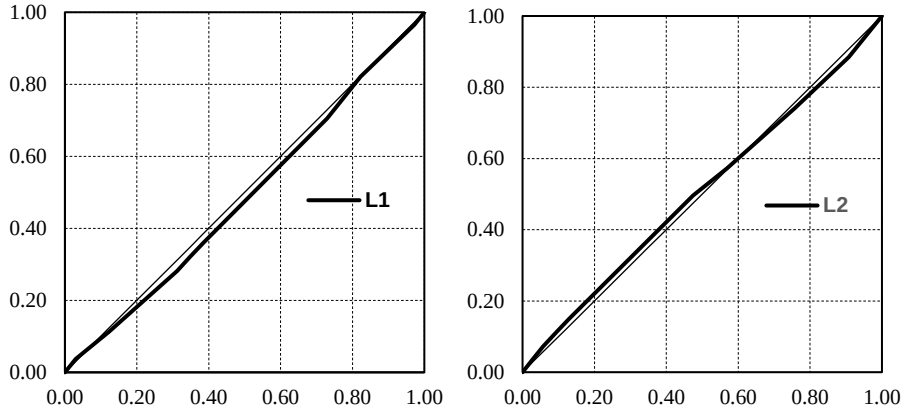
Source: own preparation

The curve $L_{[\mathbf{x},\mathbf{y}]}$ uniquely defines a certain non-fragmentary linear function, $C_{[\mathbf{y}::\mathbf{x}]}(t)$. The function is the basis for determining the *ar* measure of differentiation for the two considered (for the ordered data) structures, x and y:

$$ar(\mathbf{y}:\mathbf{x}) = ar\left(C_{[\mathbf{y}:\mathbf{x}]}\right) = 1 - 2\int_0^1 C_{[\mathbf{y}:\mathbf{x}]}(t)dt \tag{1}$$

Formula (1) shows that the *ar* measure takes values in the range [-1,1] and $ar(\mathbf{y}:\mathbf{x}) = -ar(\mathbf{x}:\mathbf{y})$. In the case of ordering product groups from x1 to x9, the *ar* measure of non-similarity between food preferences in Thailand in 2011–2013 and those in 2001–2003 is 0.033. Because the value of the *ar* measure is determined by the course of the broken L, and the shape of this broken curve is determined by co-ordinate points that are the accumulation of consecutive structures, it is natural that, depending on the order that we assign to individual food product groups, the *ar* measure will change. Figure 3 shows two different broken lines. Curve L1 is designated (as in Figure 2) according to the order of the constituent structures from x1 to x9 (see Table 1), and the broken L2 is determined in accordance with another, random order of these components.

Figure 3. Polylines L1 and L2 of the cumulative structures for nine groups of food products in Thailand in 2001-2003 and 2011-2013 for two different arrangements of these structures



Source: own preparation

Polylines L1 and L2 have different shapes, although they are designated on the basis of the same data set (in this case, data on dietary preferences in Thailand in 2001-2003 and 2011-2013, respectively). The shape of the broken L1 and L2 is determined only by the order in which the individual product groups are given. This order determines the coordinates of points $\left(x_j^{\wedge}, y_j^{\wedge}\right)$ (being the accumulation of consecutive partial structures) that allow us to draw the broken curves (see Table 2).

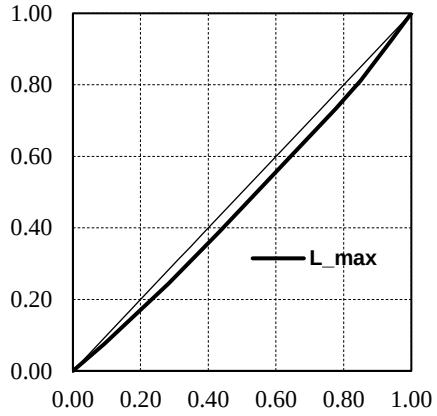
Table 2. Structures of yearly consumption for nine groups of food products and their cumulative values in Thailand in 2001-2003 and 2011-2013 for two different orderings of the data

	Polyline L1					Polyline L2				
Lp.	Product	THA_2001–2003		THA_2011–2013		Product	THA_2001–2003		THA_2011–2013	
		x_i	$x_j^{\wedge}$	y_i	$y_j^{\wedge}$		x_i	$x_j^{\wedge}$	y_i	$y_j^{\wedge}$
1	x1	2.98%	2.98%	3.71%	3.71%	x9	2.74%	2.74%	3.53%	3.53%
2	x2	9.32%	12.30%	7.57%	11.28%	x1	2.98%	5.72%	3.71%	7.24%
3	x3	18.91%	31.21%	16.89%	28.17%	x4	3.64%	9.37%	3.95%	11.18%
4	x4	3.64%	34.85%	3.95%	32.12%	x5	3.66%	13.03%	3.88%	15.06%
5	x5	3.66%	38.51%	3.88%	36.00%	x6	34.48%	47.51%	34.58%	49.64%
6	x6	34.48%	72.99%	34.58%	70.58%	x2	9.32%	56.82%	7.57%	57.21%
7	x7	9.28%	82.27%	11.54%	82.11%	x3	18.91%	75.74%	16.89%	74.10%
8	x8	14.99%	97.26%	14.36%	96.47%	x8	14.99%	90.72%	14.36%	88.46%
9	x9	2.74%	100.00%	3.53%	100.00%	x7	9.28%	100.00%	11.54%	100.00%

Source: own preparation

The consequence of the different courses of the two broken polylines are the different values of the non-similarity of the structures' *ar* measures determined in accordance with formula (1). In the case of polyline L1, the non-similarity *ar* index is equal to 0.033 (as mentioned earlier), while the same index determined for polyline L2 is equal to -0.010. The change of order assigned to individual constituent structures (in this case, food product groups) decides the value (and even the sign) of the non-similarity measure. Therefore, if we want to compare the magnitude of changes in food preferences in a given country (e.g. Thailand, as shown in Table 2), the following question arises: 'For which order of constituent structures should such non-similarity be measured?' This question becomes even more valid if we want to compare the magnitude of these changes between individual countries. In this case, the best solution seems to be to find the right order of the individual components that will ensure such a course of broken curve L, on the basis of which the *ar* index of non-similarity of structures determined in accordance with formula (1) will reach its maximum value. The arrangement of the constituent structures ensures the sorting of food products in non-descending order of the ratio of corresponding structures, y_i to x_i (see Figure 4). The polyline is named L_max, and the measure of the non-similarity of structures determined for this broken curve is called ar_{max} in the literature [Szczesny 2002; Borkowski, Szczesny 2005]. Figure 4 shows the broken L_max and the ordering of the structures allowing such a broken curve to be designed for Thailand in the 2 extreme 3-year time periods for the considered interval.

Figure 4. Broken curve L_max of the cumulative structures of nine food product groups' consumption in Thailand in 2001-2003 and 2011-2013



No.	Product	Polyline L_max				y_i/x_i
		THA_2001-2003		THA_2011-2013		
		x_i	$x_j^{\wedge}$	y_i	$y_j^{\wedge}$	
1	x2	9.32%	9.32%	7.57%	7.57%	0.813
2	x3	18.91%	28.23%	16.89%	24.46%	0.893
3	x8	14.99%	43.22%	14.36%	38.82%	0.958
4	x6	34.48%	77.70%	34.58%	73.40%	1.003
5	x5	3.66%	81.36%	3.88%	77.28%	1.060
6	x4	3.64%	85.00%	3.95%	81.22%	1.083
7	x7	9.28%	94.28%	11.54%	92.76%	1.244
8	x1	2.98%	97.26%	3.71%	96.47%	1.245
9	x9	2.74%	100.00%	3.53%	100.00%	1.285

Source: own preparation

The ar index (based on formula 1) calculated on the basis of the broken L_max is equal to $ar_{max} = 0.066$. This is the largest possible non-similarity value that can be obtained by comparing Thailand in 2011-2013 with Thailand in 2001-2003. Measures of the non-similarity ar through appropriate rank of food products groups for individual countries, are maximized, creating a new measure of ar_{max}. On the basis of the measures of ar_{max} treated as the largest possible dissimilarity, the ranking of countries is created in terms of the size of changes in food preferences. Classical measures (e.g. Minkowski's measure) due to they insensitiveness to the order, measure only the distance between countries, which does not give full information about the countries non-similarities in terms of all studied features. Therefore, a method based on the ar_{max} measure has been chosen.

RESULTS

To compare the magnitude of changes in food preferences in Asia over the 10 evaluated years, ar_{max} indicators can be determined separately for each country studied, enabling the comparison of the consumption of 9 selected food product groups in the 3-year extreme periods, specifically 2001-2003 and 2011-2013. The ar_{max} as non-similarity indicators for the 17 surveyed Asian countries are shown in Table 3.

Table 3. Indices of the non-similarity of the structures' ar_{max} as a measure of the size of changes in food preferences in Asian countries in 2001-2013

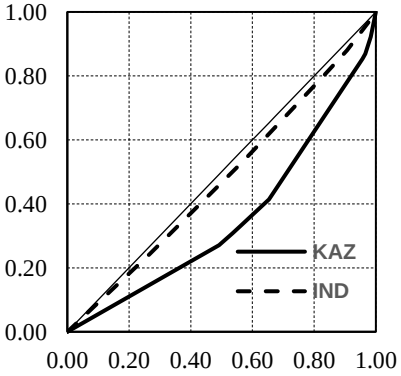
	Rank	Country	Code	ar_{max}
GR1	1	Kazakhstan	KAZ	0.293
	2	Uzbekistan	UZB	0.224
	3	Myanmar	MMR	0.202

	Rank	Country	Code	ar_{max}
	4	Tajikistan	TJK	0.193
	5	Viet Nam	VNM	0.151
GR2	6	Mongolia	MNG	0.132
GR2	7	Sri Lanka	LKA	0.096
GR2	8	Malaysia	MYS	0.093
GR3	9	Lao People's DR	LAO	0.088
GR3	10	China	CHN	0.077
GR3	11	Philippines	PHL	0.076
GR3	12	Japan	JPN	0.073
GR3	13	Indonesia	IDN	0.072
GR3	14	Thailand	THA	0.066
GR3	15	Cambodia	KHM	0.064
GR3	16	Pakistan	PAK	0.057
GR3	17	India	IND	0.050

Source: own calculations with the use of GradeStat software

In this case, the determined ar_{max} indices can be treated as synthetic indicators showing the size of changes in dietary preferences in the examined time period. It should be kept in mind that the largest possible non-similarity value (ar_{max}) for each country was calculated, which is related to the different ordering of product groups for each country. The ar_{max} indicators calculated for each country allow the creation of a ranking of countries with the largest changes in nutrition preferences. It can be noticed that the largest changes took place in Kazakhstan and the smallest in India. Figure 5 shows the broken curves L_{max} for both countries. To complement the figure, next to the broken lines for both ar_{max} measures are shown the orderings of the product groups and the coordinates of the points by which the polylines were determined ($x_j^{\wedge}$ - cumulative structures in the period 2001–2003; $y_j^{\wedge}$ - cumulative structures in the period 2011–2013).

Figure 5. Polylines L_max of the cumulated consumption structures of nine groups of food products for Kazakhstan and India



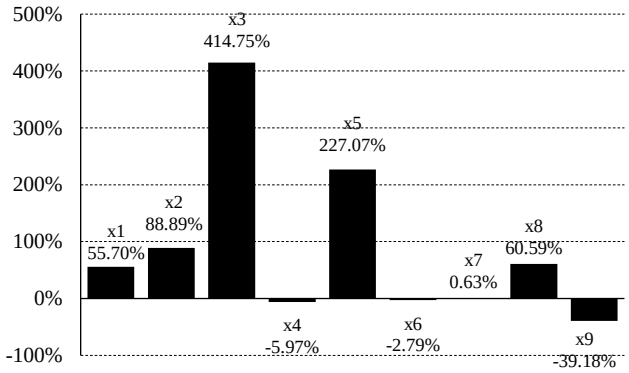
KAZ Polyline L_max			IND Polyline L_max		
Product	$x_j^{\wedge}$	$y_j^{\wedge}$	Product	$x_j^{\wedge}$	$y_j^{\wedge}$
x9	49.17%	27.04%	x4	0.19%	0.12%
x4	53.57%	30.78%	x9	26.70%	24.29%
x6	56.27%	33.16%	x6	56.78%	53.13%
x7	65.31%	41.39%	x2	58.85%	55.22%
x1	67.03%	43.81%	x8	82.58%	79.56%
x8	95.60%	85.30%	x7	90.70%	87.99%
x2	96.53%	86.89%	x3	98.80%	98.22%
x5	98.32%	92.18%	x1	99.55%	99.23%
x3	100.00%	100.00%	x5	100.00%	100.00%

Source: own preparation

Due to the fact that Kazakhstan and India occupy two extreme positions in the ranking created (respectively first and last in Table 3), it can be observed that the broken curve L_max created for India is practically coincident with the diagonal of the square. This represents evidence of a negligible degree of change in the Indian food preferences comparing the period 2011-2013 with the period 2001-2003. The reverse situation concerns the broken curve L_max for Kazakhstan. Its course clearly deviates from its diagonal shape, showing a clear change in the menu choices of Kazakhs in the studied period. Determining the ar_{max} indicators of the non-similarity and treating them as a synthetic variable, apart from creating a ranking, allows for the division of countries into groups in terms of the size of changes in food preferences. This study uses a simple division into three groups (see Table 3) based on the average deviation, in which the first group includes the largest, the second group a moderate and the third a negligible change in nutrition preferences.

Figure 6 shows the changes in preferences that occurred in the country that was the leader of the ranking - Kazakhstan.

Figure 6. Relative changes in the consumption of food products in Kazakhstan between 2011-2013 and 2001-2003



Source: own preparation

CONCLUSIONS

In spite of rapid economic growth, urbanization and globalization leading to a shift of Asian diets away from staples and towards livestock and dairy products, fruits, vegetables, fats and oils, there are many traditional reasons that slow this trend down and prevent quick changes. The countries where the changes in food preferences were the faintest are India, Pakistan and Cambodia – the least wealthy countries in the studied group. While the diversification of diets away from the traditional dominance of rice with rising incomes is expected and observed in Asia and current food consumption patterns are showing signs of convergence, there are

still countries where the food preferences are rather stable over the years. However, this situation may change in the future, because as a consequence Asian agriculture is following an irreversible path leading away from its traditional cereal crop production, especially rice. On the other side, Kazakhstan and Uzbekistan (formerly the Republic of USSR) changed their food nutrition patterns the most during the period of time analysed. The diet transition in those countries is characterized by increased consumption of fruit, poultry, fish and vegetables and relatively decreased consumption of pigmeat and rice. The rapid spread of global supermarket chains and fast-food restaurants is reinforcing those trends. Those changes can influence the global market and the world economy and can lead to reversed directions of imports and exports of goods in Asian countries and Europe. The methods of grade state analysis were very useful in emphasizing subtle changes in food product preferences that occurred over 10–13 years. Dividing countries into groups, the group with the most changes was identified as consisting of Kazakhstan, Uzbekistan, Myanmar, Tajikistan and Vietnam. In the second group, with moderate changes, appeared Mongolia, Sri Lanka and Malaysia. The fewest changes in food preferences occurred in Lao People's Democratic Republic, China, the Philippines, Japan, Indonesia, Thailand, Cambodia, Pakistan and India.

REFERENCES

Abdullah A. B., Ito S., Adhana K. (2006) Estimate of Rice Consumption in Asian Countries and the World Towards 2050. [in:] Proceedings for Workshop and Conference on Rice in the World at Stake. 2, 28-43.

Arnold B. C. (1987) Majorization and the Lorenz Order: A Brief Introduction, Lecture Notes in Statistics, 43. Springer-Verlag, Berlin.

Binderman Z., Koszela G., Szczesny W. (2014) Zmiany w strukturze gospodarstw rolnych w krajach Unii Europejskiej w latach 2003-2010 (aspekty metodyczne). Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie, Problemy Rolnictwa Światowego, 14(3), 15-26 (in Polish).

Borkowski B., Szczesny W. (2005) Metody wizualizacji danych wielowymiarowych jako narzędzie syntezy informacji. Roczniki Naukowe, Seria VII, 5, 11-15 (in Polish).

FAOSTAT. http://www.fao.org/statistics/en/.

Gastwirth J. L. (1971) A General Definition of the Lorenz Curve. Econometrica, 39(6), 1037-1039.

Gini C. (1914) Sulla Misura Della Concentrazione e Della Variabilità dei Caratteri, Atti del R. Istituto Veneto di Scienze Lettere ed Arti.

Glasser G. J. (1962) Variance Formulas for the Mean Difference and Coefficient of Concentration. Journal of the American Statistical Association, 57.

Koszela G. (2016) Wykorzystanie narzędzi gradacyjnej analizy danych do klasyfikacji podregionów pod względem struktury agrarnej. Wiadomości Statystyczne, 6, 10-30 (in Polish).

Kowalczyk T., Pleszczyńska E., Ruland F. (Eds.) (2004) Grade Models and Methods of Data Analysis. With Applications for the Analysis of Data Population. Studies in Fuzziness and Soft Computing, 151. Springer, Berlin - Heidelberg - New York.

Kuhnlein H. V., Receveur O. (1996) Dietary Change and Traditional Food Systems of Indigenous Peoples. Annual Review of Nutrition, 16(1), 417-442.

Lipoeto NI., Geok Lin K., Angeles-Agdeppa I. (2013) Food Consumption Patterns and Nutrition Transition in South-East Asia. Public Health Nutrition, 16(9), 1637-1643, doi: 10.1017/S1368980012004569.

Prabhu P. (2007) Westernization of Asian Diets and the Transformation of Food Systems: Implications for Research and Policy. Food Policy, 32(3), 281-298.

Reardon T., Timmer P. C., Barrett Ch. B., Berdegué J. (2003) The Rise of Supermarkets in Africa, Asia, and Latin America. American Journal of Agricultural Economics, 85(5), 1140-1146, https://doi.org/10.1111/j.0092-5853.2003.00520.x.

Reardon T., Timmer P., Minten B. (2010) Supermarket Revolution in Asia and Emerging Development Strategies to Include Small Farmers. Proceedings of the National Academy of Sciences, doi: 10.1073/pnas.1003160108.

Szczesny W. (2002) Grade Correspondence Analysis Applied to Contingency Tables and Questionnaire Data. Intelligent Data Analysis, 6(1), 17-51.

Zhou Y., Du S., Su C., Zhang B., Wang H., Popkin BM. (2015) The Food Retail Revolution in China and its Association with Diet and Health. Food Policy, 55, 92-100, https://doi.org/10.1016/j.foodpol.2015.07.001.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 430 – 439

Received: 26.06.2018
Accepted: 21.12.2018

IDENTIFICATION OF AN AGGREGATE PRODUCTION FUNCTION FOR POLISH ECONOMY

Nicholas Olenev https://orcid.org/0000-0002-1032-2455
Dorodnicyn Computing Centre, FRC CSC RAS
Peoples' Friendship University of Russia (RUDN University)
Moscow Institute of Physics and Technology
e-mail: nolenev@mail.ru

Abstract: This paper explores an aggregated production function, built on the distribution of production capacity with a limited age. Technologies are determined at the time of capacity creation. With increasing age, production capacity is decreasing, keeping the number of workplaces. The lowest labour input and the coefficient of capital intensity are reduced due to scientific and technological progress. The parameters of this production function were identified by parallel calculations according to the data of the Polish economy 1970-2017. The economic interpretation of the obtained results is given.

Keywords: aggregated production function, production capacity, parameter identificatin, parallel calculations, Polish economy

JEL classification: L11, M11, E23, C4

INTRODUCTION

The aggregation problem for productive opportunites of production units of an industry was first formulated in [Houthakker 1955]. The approach to derive propeties of the standard production function in macroeconomics from microfoundations is widespread. For example, if the distribution of ideas is Pareto, then the global production function is Cobb-Douglas, and technical change in the long run is labour-augmenting [Jones 2005].

A review of the literature on vintage capital growth models that have been in the heart of growth theory in the 60s, the reasons for its collapse in the late 60s and the reasons for its revival in the 90s are presented in [Boucekkine et al. 2011].

https://doi.org/10.22630/MIBE.2018.19.4.41

Unlike these works the paper uses the consept of production capacity instead of capital. The increases in capital and in production capacity are related by the incremental capital-intensity ratio, which is assumed here to be variable over time.

The concept of production capacity was introduced in [Johansen 1968]. The production capacity is the maximal potential output a producing unit could produce in a given period of time, given technology, and fixed factors of production. The concept of capacity was used for construction of a production function represented by the distribution of production capacities by putty-clay technology [Johansen 1972]. This description of production functions arose from practical needs in the analysis of specific sectors of the economy. The mathematical study of production functions constructed by locally surnmable distributions of capacity among technologies is consided in [Shananin 1984].

The paper presents an evaluation of an original aggregate production function with limited age of production capacities [Olenev 2017] for recent Poland economy based on the vintage capacity model with putty-clay technology [Olenev et al. 1986]. Production capacity is determined as a maximum of possible output in a year. Gross domestic product (GDP) of Polish economy at constant 2010 prices measured in PLN is used here as the output. At a given capital intensity and a given depreciation rate one can evaluate age structure of production capacities by the past real investments. This two unknown parameters (the capital intensity, the depreciation rate) along with unknown parameters of a production function can be determined in an indirect way by comparison of pairs of time series for each macroeconomic index calculated by the model and taken from statistical data.

MODEL DESCRIPTION

Micro description of production capacity dynamics

Production capacity $\mathrm{m}(\mathrm{t},\mathrm{t})$ created in the year t is determined by gross fixed capital formation $\Phi(\mathrm{t})$ of this year t divided by a coefficient b of capital intensity.

$$\mathrm{m}(\mathrm{t},\mathrm{t}) = \Phi(\mathrm{t})/\mathrm{b}. \tag{1}$$

The value $\Phi(\mathrm{t})$ is the increases in total capital at time t. The value $\mathrm{m}(\mathrm{t},\mathrm{t})$ is incrice of the total production capacity at time t. The capital intensity b is the incremental capital-intensity ratio at time t which is used to move the description from the capital to the production capacity. The value of the capital intensity b depends on a present technological structure of Polish economy. Let's use here the form have used for economies of Greece [Olenev 2016] and Russia [Olenev 2017]:

$$\mathrm{b}(\mathrm{t}) = \mathrm{b}(0)\exp(-\beta \mathrm{t}). \tag{2}$$

Production capacity created in the year $\tau \leq \mathrm{t}$ decreases with increasing of its age $\mathrm{t} - \tau$ by specified rate $\mu > 0$.

$$m(\tau, t) = m(\tau, \tau)\exp(-\mu(t-\tau)). \tag{3}$$

It is supposed that a number r of workplaces in the firm remains constant through out the life period from its creation up to its dismantling. If a labour input of firm created in year τ at time $t \geq \tau$ is denoted by $\lambda(\tau, t)$ then the number of workplaces $r(\tau, t) = \lambda(\tau, t)m(\tau, t)$ and therefore the labour input increases (labour productivity decreases)

$$\lambda(\tau, t) = \lambda(\tau, \tau)\exp(\mu(t - \tau)). \quad (4)$$

Paper [Olenev et al. 1986] shows that if one switches the variables (τ, t) to the variables (λ, t) in the description of capacity dynamics, then the dynamics for a distribution density of production capacities $m(\lambda, t)$ satisfies a partial differential equation of the first order:

$$\frac{\partial m(\lambda,t)}{\partial t} = j(\lambda, t) - 2\mu m(\lambda, t) - \mu\lambda\frac{\partial m(\lambda,t)}{\partial \lambda}, \quad (5)$$

where $j(\lambda, t)$ is an investment in technology with labour intensity λ. The switch in variables is similar to the switch-over of the Lagrangian description to the Eulerian description for dynamics of each particle of the body in continuum mechanics [Mase et al. 2010]. The functions of $m(\tau, t)$ and $m(\lambda, t)$ have different economic meanings and are represented by completely different dependencies. The Lagrangian function $m(\tau, t)$ shows the dependence of capacity on time, and the Eulerian function of capacity density $m(\lambda, t)$ at each fixed t shows the dependence of capacity on labor intensity. They should not be confused and one can denotes them by different symbols. In the calculations we will use the Lagrangian notation.

Equation (5) completely determines the density $m(\lambda, t)$ if an initial condition $m(\lambda, 0) = n(\lambda)$ is specified. If as it is supposed in equation (1) all investments $J(t) = \frac{\Phi(t)}{b}$ come in a new technology with labour input $\nu(t)$ then $j(\lambda, t) = J(t)\delta(t - \nu(t))$ and we can find (see [Olenev et al. 1986]) by integrating (5) an equation for a total capacity of an industry or an economy

$$M(t) = \int m(\lambda, t)d\lambda. \quad (6)$$

The equation obtained here from microeconomic description is usually used in macroeconomic models:

$$\frac{dM(t)}{dt} = J(t) - \mu M(t). \quad (7)$$

If share of new capacities in total capacity of an economy $\sigma = J(t)/M(t)$ is constant then this microeconomic description allows to build an analytical expression for the production function of the economy, that is, the dependence of the output $Y(t)$ on the production factors: total capacity $M(t)$ and the total labour $L(t)$:

$$Y(t) = M(t)f(t, x), \quad (8)$$

where $x = L(t)/M(t)$. One only needs to define function of scientific and technical progress which in this model [Olenev et al. 1986] is reflected in a dynamics of the best and the lowest labour input $\nu(t) = \lambda(t, t)$.

$$\frac{1}{\nu(t)}\frac{d\nu(t)}{dt} = -\varepsilon\sigma(t), \tag{9}$$

where parameter $\varepsilon > 0$ is a rate of scientific and technical progress .

In general case when the share $\sigma(t)$ is not constant one can construct a production function numerically using relations (1)-(4),(9).

Aggregate production function with limited age A of production capacities

An analitical expression for aggregate production function was obtained in [Olenev 2017]. GDP, $Y(t)$, is determined by total capacity $M(t)$, labour $L(t)$, and production function (8).

The total capacity is determined from

$$\frac{dM(t)}{dt} = J(t) - \mu M(t) - \left(1 - \frac{dA(t)}{dt}\right) J(t - A(t)) e^{-\mu A(t)}, \tag{10}$$

where $A(t)$ is a maximal age of capacities [Olenev 2017].

If share of new capacities in total capacity is constant,

$$\sigma(t) = J(t)/M(t) = \sigma = \text{const}, \tag{11}$$

maximal age of capacities is fixed, $A(t) = A = const$, the total capacity and output increase exponentially,

$$M(t) = M_0 e^{\gamma t},\ Y(t) = Y_0 e^{\gamma t}, \tag{12}$$

then production function has the form [Olenev 2017, p.431, formula (14)]

$$f(t,x) = \frac{\sigma}{\gamma+\mu}\left\{1 - \left[1 - \frac{(\gamma-\varepsilon\sigma)}{\sigma}\frac{x}{\nu(t)}\right]^{(\gamma+\mu)/(\gamma-\varepsilon\sigma)}\right\} \tag{13}$$

where growth rate $\gamma = \gamma(\mu, \sigma, A)$ is determined from

$$\gamma + \mu = \sigma\left(1 - e^{-(\gamma+\mu)A}\right). \tag{14}$$

So let's begin numerical estimations of the model parameters by statistical data for Polish economy and on the base of microfoundations of the model. The use of the model microdescription in the process of identification makes it possible to estimate parameters even with varying $\sigma(t)$.

INDENTIFICATION OF PARAMETERS

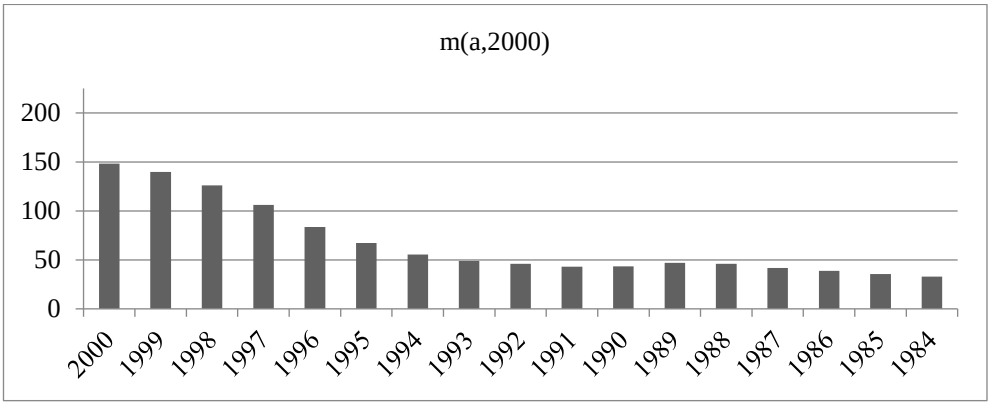
We use UN statistical data [National Accounts Main Aggregates Database] for GDP and gross fixed capital formation and official data of Polish statistical agency [Statistics Poland] for employments data. Recall that here GDP at constant 2010 prices in PLN is used as the output $Y(t)$ of Poland economy. The following obvious notation for τ, t is used here in the calculations and presentation of graphical results. If the current year $c \in [1970, 2017]$, then the model year $t = c - 1970$, the model year τ of capacity creation $\tau \le t$. So that $t \in [0, 47]$, $m(\tau, t) = m(a, c)$, where $a = \tau + 1970$ is the factual year of vintage capacity creation.

Let us evaluate the parameters b(0), β, μ, ν(0), ε, m(0) of the Poland economy 1970-2017 by the model described above from some natural conditions. One of the condition is that the production capacities are utilized an average on 70% approximately, implying an existence of a normal reserve of capacities on the level of approximately 30%.

Let use for estimation fitting of time series for labour L(t) and output Y(t). Since this model has only two macroeconomic indicators compared with statistical data, we can choose one of them equal to its statistical time series (we chose Y(t) in this algorithm), and adjust the other macro indicator (here L(t)) by selecting the desired parameters using the Theil inequality index T_L.

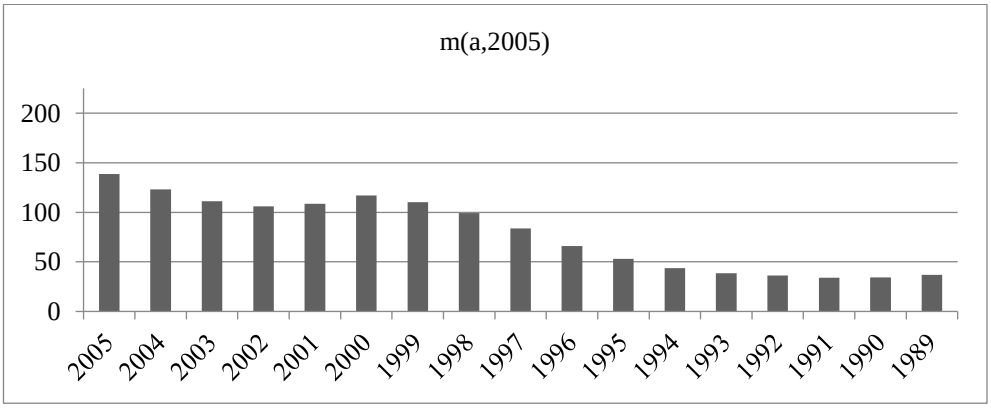
$$T_L = \sqrt{\frac{\sum_{t=t_0}^{t_n}(L(t)-L^{stat}(t))^2}{\sum_{t=t_0}^{t_n}(L(t))^2+(L^{stat}(t))^2}} \rightarrow \min.$$

Figure 1. Vintage production capacity in 2000 in constant prices of 2010, PLN billions



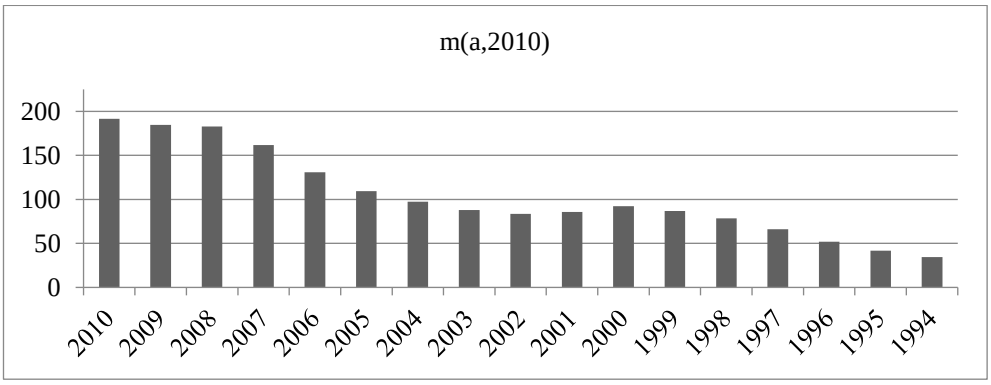
Source: own preparation

Figure 2. Vintage production capacity in 2005 in constant prices of 2010, PLN billions



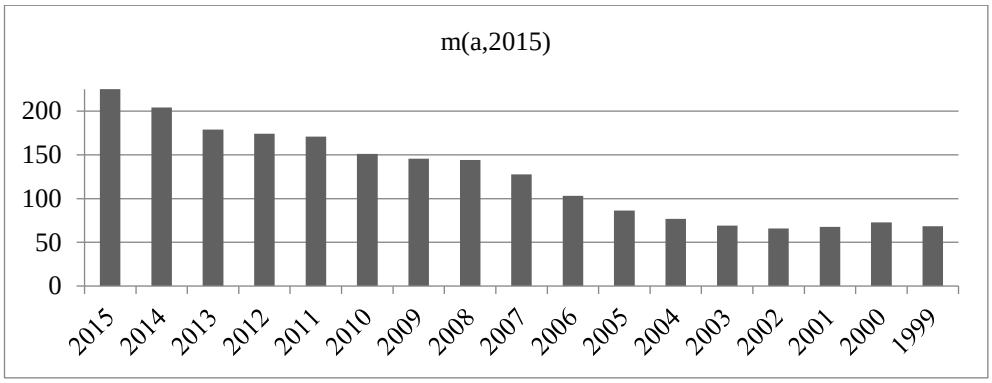
Source: own preparation

Figure 3. Vintage production capacity in 2010 in constant prices of 2010, PLN billions



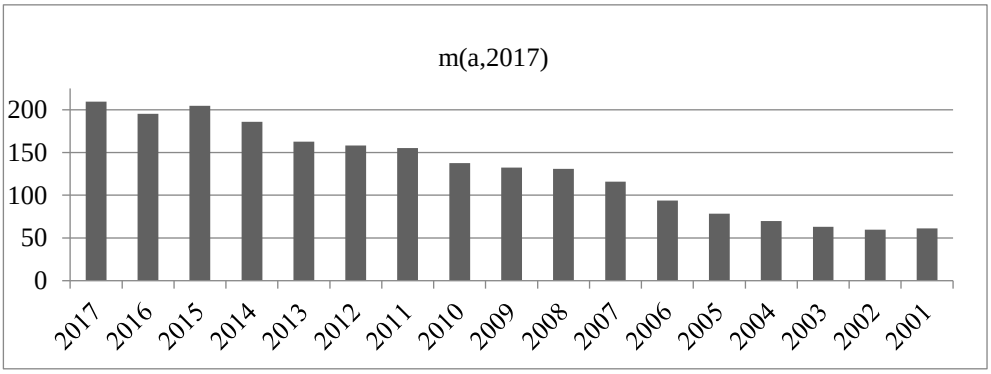
Source: own preparation

Figure 4. Vintage production capacity in 2015 in constant prices of 2010, PLN billions



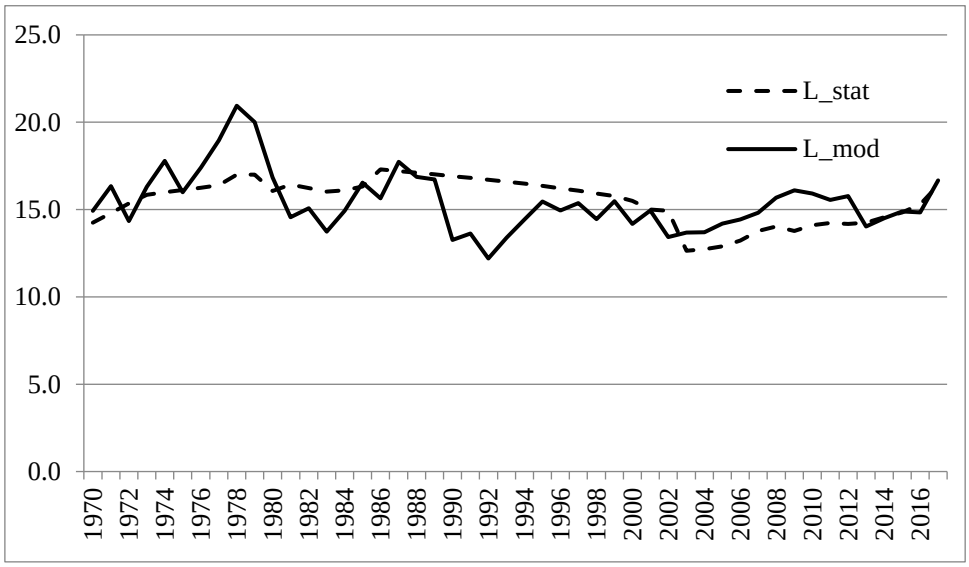
Source: own preparation

Figure 5. Vintage production capacity in 2017 in constant prices of 2010, PLN billions



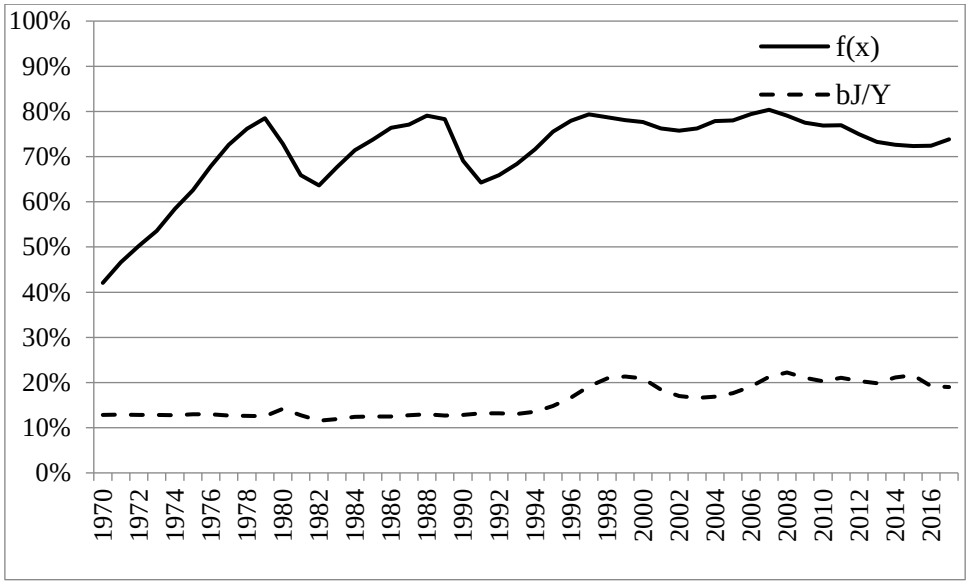
Source: own preparation

Figure 6. Identification of the model of Polish economy by fitting of the employment. Time series for employment: L_mod – estimation by vintage capacity model, L_stat – statistical data, millions people



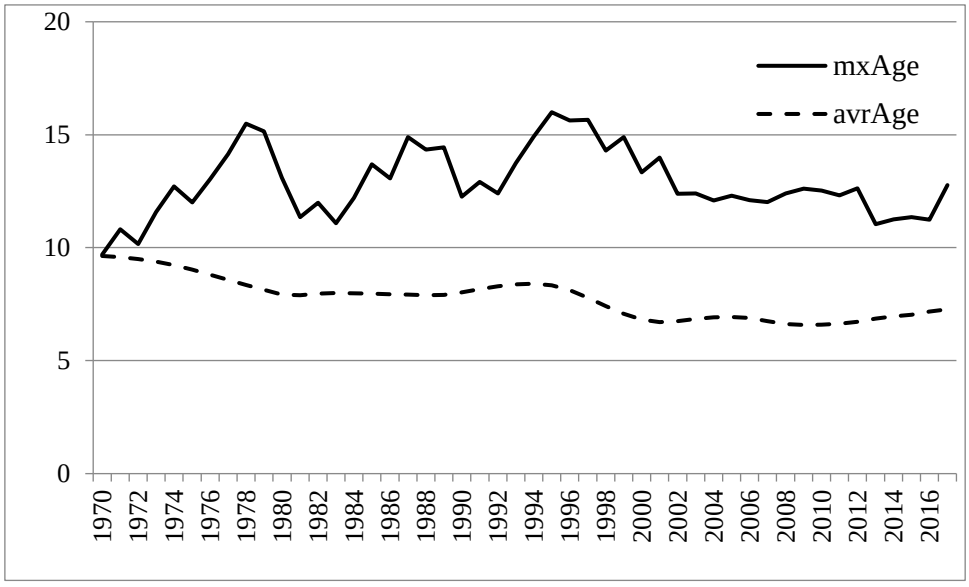
Source: own preparation

Figure 7.Time series for macroeconomic indices: f(x) – capacity utilization, bJ/Y – ratio of investment product to GDP



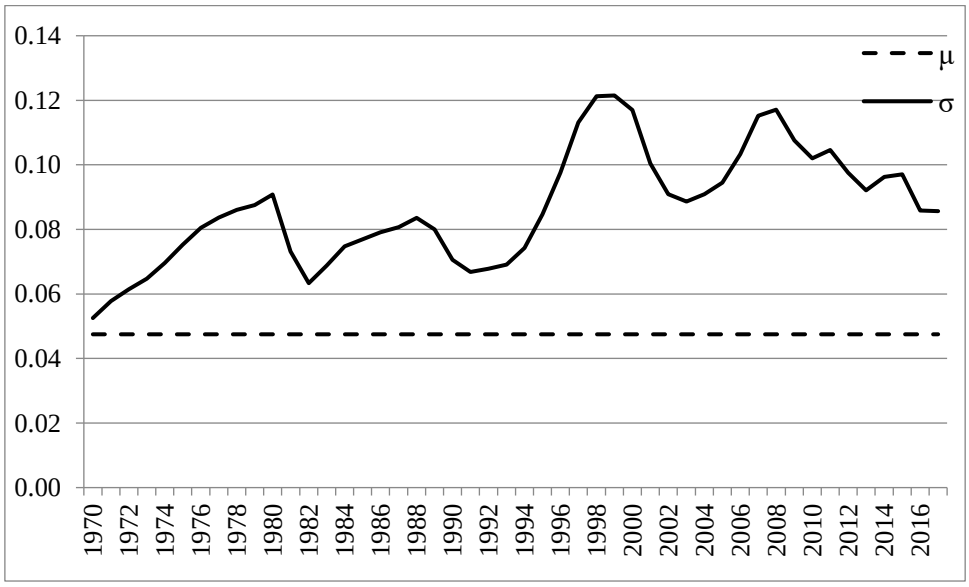
Source: own preparation

Figure 8. Time series for macroeconomic indices: mxAge – maximal age of capacities which are used in production of output, avrAge – average age of production capacities



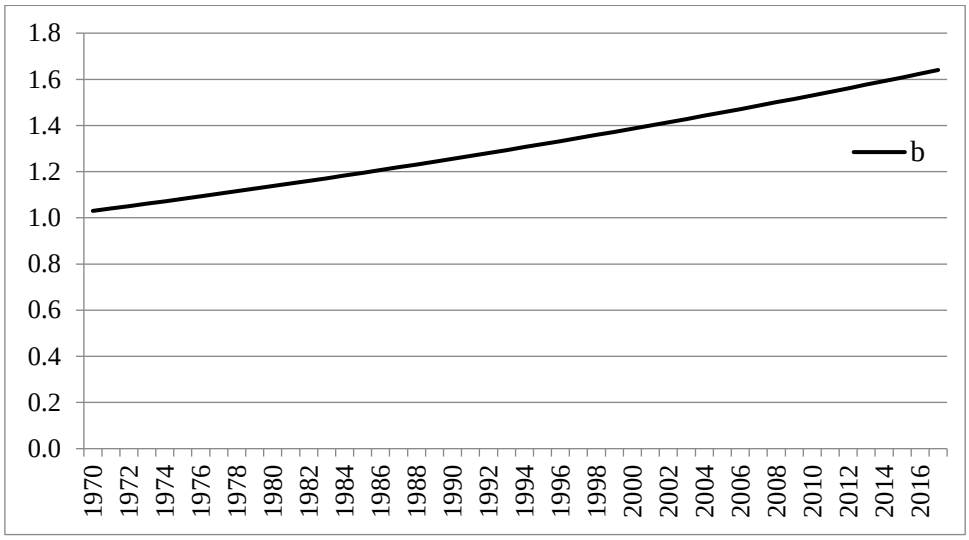
Source: own preparation

Figure 9. Time series for macroeconomic indices: σ(t) share of investments in total capacity, μ - rate of depreciation



Source: own preparation

Figure 10. Time series for macroeconomic indices: b(t) – capital intensity



Source: own preparation

RESULTS

Distribution of production capacity in 2000-2017 by age (vintage capacity) in constant prices of 2010, PLN billions are presented in the Figures 1-5. It is seen that in 2000-2017, the distribution structure of production capacity has improved. The share of new, more productive production capacity has increased. The quality of identification can be found in the Figure 6. Time series for some macroeconomic indices are presented in the Figures 7-10. It is interesting to note that the capital intensity in Poland is growing (see Figure 10) in contrast to Greece [Olenev 2016] and Russia [Olenev 2017]. The share of new capacities in total capacity has two periods: oscillations near 0.08 in 1970-1996, and oscillations near 0.10 in 1997-2017. So, this is an attempt of Polish economy to move to a faster growth rate.

SUMMARY

In the paper we present an estimation of an original aggregate production function for Polish economy obtained by the micro model identification on the base of official statistical data. The values of parameters are the next: the limit age for capacities of the Polish economy $A = 17$ years. the capital intensity coefficient $\mathrm{b}(0) = 1.03$ years in 1970, $\beta = -0.00995$, $\mu = 0.0475$, the best labour input in 1970 was $\nu(0) = 0.0205$ in millions employed peoples necessary to produce one billion PLN in constant prices of 2010, $\varepsilon = 0.290$, $\mathrm{m}(\tau, 0) = \mathrm{m}(0,0)\mathrm{e}^{0.010\tau}$, where $\tau \leq 0$; $\mathrm{t} = 0$ corresponds to the year 1970. All parameters of the model are found by a complete search usung hight performance computations.

Note that the parameter $\beta < 0$ for the Polish economy in contrast to the Greek and Russian economies. This means that the technological structure of the Polish economy becomes more complicated, and production becames more capital-intensive. The model of economy, techniques of its identification and especially its application for Polish economy require further research. For examp;e, the identification set method [Kamenev, Olenev 2015] can allow to study the forecast stability of the model.

The author expresses his sincere appreciation to the unknown reviewers for the productive comments. Mistakes remain my own.

REFERENCES

Boucekkine R., De la Croix D., Licandro O. (2011) Vintage Capital Growth Theory: Three Breakthroughs. Economic Growth and Development, 87-116.

Houthakker H. S. (1955) The Pareto Distribution and the Cobb-Douglas Production Function in Activity Analysis. Review of Economic Studies, 23(1), 27-31.

Johansen L. (1968) Production Functions and the Concept of Capacity. Recherches recentes sur la Fonction de Production. Collection Economie Mathematique et Econometrie, 2, 49-72.

Johansen L. (1972) Production Functions: an Integration of Micro and Macro, Short run and Long Run Aspects. Contributions to Economic Analysis, 75, Amsterdam, London, North-Holland.

Jones C. I. (2005) The Shape of Production Function and the Direction of Technical Change. Quarterly Journal of Economics, 120(2), 517-549.

Kamenev G. K., Olenev N. N. (2015) Study of the Russian Economy's Identification and Forecast Stability using a Ramsey Type Model. Mathematical Models and Computer Simulations, 7(2), 179-189.

Mase G. Th., Smelser R. E., Mase G. E. (2010) Continuum Mechanics for Engineers. (Third Ed.) CRC Press, Taylor&Francis Group.

National Accounts Main Aggregates Database. https://unstats.un.org/unsd/snaama/dnl List.asp.

Olenev N. (2016) Economy of Greece: an Evaluation of Real Sector. Bulletin of Political Economy, 10(1), 25-37.

Olenev N. N. (2017) Parameter Identification of an Endogenous Production Function. CEUR-WS, 1987, 428-435.

Olenev N. N., Petrov A. A., Pospelov I. G. (1986) Model of Change Processes of Production Capacity and Production Function of Industry. [in:] Mathematical Modelling: Processes in Complex Economic and Ecologic Systems, 1, 46-60. (in Russian).

Shananin A. A. (1984) Investigation of a Class of Production Functions Arising in the Macro Description of Economic Systems. USSR Computational Mathematics and Mathematical Physics, 24(6), 127-134.

Statistics Poland. http://stat.gov.pl/en/.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 440 – 451

Received: 14.09.2018
Accepted: 21.12.2018

SELF-REPORTED HEALTH STATUS: A MICROECONOMETRIC ANALYSIS FOR TURKEY

Gülşah Sedefoğlu https://orcid.org/0000-0002-7012-184X
PhD Student, Social Science Institute, Istanbul University, Turkey
e-mail: gulsahsedefoglu@gmail.com
Mehmet Ali Soytaş https://orcid.org/0000-0001-5839-6069
Faculty of Business
Özyeğin University, Turkey
e-mail: mehmet.soytas@ozyegin.edu.tr

Abstract: In this paper, we examine the effects of the demographic, health and socio-economic indicators on self-reported health status (SRH) in Turkey for the year of 2012. Independent variables taken into account in the study are formed under these three titles. The Health Survey data have been collected by Turkish Statistical Office (TURKSTAT). We first used ordered logit model as a microeconometric approach but, however, generalized ordered logit model is applied after the rejection of the parallel regression assumption. Results show that people who have a chronic disease and an accident in their life are less likely to report good health. An increase in body mass index, getting older, being a female cause a negative effect on reporting good health. Increasing income level, living in urban area, being employed have a positive effect on reporting good health. In the education category, people are more likely to report fair health but the effect decreases when the education level increases.

Keywords: self-reported health, ordered logit, generalized ordered logit

JEL classification: I10, I12, C25

INTRODUCTION

Self-reported health (SRH) is one of the remarkable topics employed frequently because of its power of measuring health inequalities in a country or within countries [Clarke, Ryan 2006]. In many of the studies, SRH is widely used to get information about individual health status in a population [Vaillant, Wolff

https://doi.org/10.22630/MIBE.2018.19.4.42

2012] by asking the question "What is the status of your health?" or "How is your health status in general?". Although doubts about measuring of self-reported health have a great attention in the literature, it has been reappraised thanks to time and economic advantages of the collected self-reported health data [Subramanian et al. 2010]. Besides, people's perspective of their health, measured with a Likert scale as very bad, bad, fair, good and very good health, reflects the mortality rates which is not captured in objective measures. Reporting very bad and bad or fair health can be a signal of high mortality rates; reporting good and very good health can be a symbol of low mortality rates [McCallum et al. 1994]. Literature on health is divided into different groups which analyze the relationship between SRH and biological, socio-economic, gender effects, and other many effects as well. For instance: Winkleby et al. [1992], Fernandez et al. [1999], Bloom, Canning [2000], Schulz et al. [2000], Shibuya et al. [2002], Tubeuf et al. [2008], Hosseinpoor et al. [2012], Oncel [2015], Tansel and Karaoğlan [2016], Boerma et al. [2016], Deaton and Paxson [2017], Sedefoglu and Soytas [2017]. However, in the national literature, in Turkey, not many studies have considered the linkage of SRH and demographic, socio-economic and health in the same paper. In this paper, we look at the demographic, socio-economic and health effects on SRH to highlight the importance of the three factors and to extend the literature through that way. Evaluation of demographic, socio-economic and health effects on SRH for a developing country as Turkey has a crucial importance on planning process of policies. Furthermore, ordered logit or probit models are mostly employed in both national and international literature because of the measurement method of dependent variable to find out the relationship between SRH and the factors thought that they are going to have an effect on SRH. However, the parallel regression hypothesis has to be valid to expound the parameters. The generalized logit model is run if Wald test results give the information of not valid parallel regression assumption.

The rest of the paper is organized as follows: The second section gives information about the applied method and empirical data. The third section summarizes the econometric results. Lastly, summary information is given in the fourth section.

APPLIED METHOD AND EMPIRICAL DATA

A number of models are available in microeconometric theory for such data like health, poverty, income inequality, or etc. and those models, such as binary logit models, ordered and multinomial logit models, are discussed in relation to type of the dependent variable. When dependent variable consists of two values as 1 and 0, models are known as binary logit and probit models; when dependent variable occurs with more than two ordered values, the estimation of the parameters can be made through ordered logit or probit models. The probability of an event is the common characteristics of the mentioned models and they cannot be

measured with the way that used in classical regression due to the reason of differences of measurement way of attitudes, behaviors, characteristics or decisions [Liao 1994].

In this paper, ordered logit model is preferred as an empirical approach. In a basic form, ordered logit model fixed into our research is specified as follows:

$$SRH_i = DV_i\beta + HV_i\gamma + SEV_i\alpha + e_i$$

where the variable of SRH_i is a dependent variable formed by a response of the question "What is the status of your health?" and it ranges from 1 to 5 where the numbers mean very bad, bad, fair, good and very good, respectively. DV_i represents the demographic variables; HV_i indicates the health variables; SEV_i displays the socio-economic variables; β, α and γ are the parameters; e_i is the error term of the model. In the ordered logit model, it is important to take parallel regression assumption into account to interpret the coefficients correctly. The fundamental problem in the ordered logit model is that the assumption is mostly violated [Williams 2006]. A Wald test provided by Brant (1990) is helpful to test the parallel regression assumption separately for each variable [Long 2001]. Rejection of the assumption makes it necessary to refer alternative models. In that case, generalized ordered logit model is one of the alternative models to ordered logit model because of the violation of parallel regression hypothesis.

In Table 1, definition of independent variables is presented. Age, gender, marital status and living area are described under the demographic variables. Education groups, income groups and employment status are specified under the socio-economic variables and the variable of accident, body mass index (bmi), chronic, insurance are defined as health variables.

Table 1. Definition of independent variables[1]

Variables	Description
Demographic Variables (DV)	
Age	If the individual's age group is: age15_24 then 1, others 0 age25_34 then 1, others 0 age35_44 then 1, others 0 age45_54 then 1, others 0 age55_64 then 1, others 0 age65_74 then 1, others 0 age75 then 1, others 0
Gender	Female 1, others 0
Marital Status	If the individual is married 1, others 0
Living Area	If the individual is living in urban 1, others 0

[1] For the sake of brevity, the table of descriptive statistics is not given in the main paper but the detailed table of descriptive statistics can be obtained from the authors upon request.

Variables	Description
Socio-economic Variables (SEV)	
Education	If the individual's education level is; illiterate 1, others 0 incomplete 1, others 0 primary 1, others 0 secondary 1, others 0 high school 1, others 0 tertiary 1, others 0
Income[2]	If the individual is; very poor 1, others 0 poor 1, others 0 medium 1, others 0 rich 1, others 0 very rich 1, others 0
Employment	If the individual is employed 1, others 0
Health Variables (HV)	
Accident	If the individual has an accident including all accident types 1, others 0
Body Mass Index (bmi)	Number
Chronic	If the individual has a chronic health problem 1, others 0
Insurance	If the individual is paying all health expenses 1, others 0

Source: own elaboration

In Table 2, health reporting scores are represented. According to results, 56.73% of the people respond the question as good while 0.76% of the people respond the question as very bad. The second highest rate after the response of good is obtained in the response of fair with 23.16 and the third one is seen in very good with 13.10%. The response of bad is the fourth one with 6.26% in five categories.

Table 2. Health reporting scores

Health Status	Very good	Good	Fair	Bad	Very bad	Total
Frequency	3364	14562	5944	1606	194	25670
Percentage (%)	13.10	56.73	23.16	6.26	0.76	100

Source: own calculations

[2] Income categories were created by 20% quantiles based on the individuals' income levels in the dataset.

RESULTS

In order to see the effects of the demographic, health and socio-economic indicators on self-reported health status in Turkey, ordered logit model is estimated the results are reported in Table 3. Concerning the results of the ordered logit model, health variables accident, bmi, chronic and insurance; demographic variables age, female urban; socio-economic variables education, employment and income are effective on self-reported health status at a statistically significant level.

Table 3. Ordered logit model results

N= 25670 LR chi2(24) = 10535.76 Prob > chi2 = 0.0000 Log likelihood = -23918.326			
Variables	Coefficients and Standard Errors	Variables	Coefficients and Standard Errors
accident	-0.2655*** (0.0529)	urban	-0.1218*** (0.0313)
bmi	-0.0167*** (0.0028)	illiterate	-1.0703*** (0.0665)
chronic	-1.6406*** (0.0320)	incomplete	-0.6853*** (0.0701)
insurance	0.1132* (0.0642)	primary	-0.5186*** (0.0481)
age25_34	-0.5438*** (0.0522)	secondary	-0.2314*** (0.0526)
age35_44	-0.8841*** (0.0579)	high school	-0.18737*** (0.0486)
age45_54	-1.2454*** (0.0597)	poor	0.2406*** (0.0563)
age55_64	-1.6299*** (0.0632)	medium	0.3085*** (0.0506)
age65_74	-1.9688*** (0.0694)	rich	0.3508*** (0.0520)
age75	-2.4975*** (0.0798)	veryrich	0.53838*** (0.0522)
female	-0.2276*** (0.0296)	employed	0.1365*** (0.0327)
married	-0.0344 (0.0354)	Cut 3	-3.4836 (0.1134)
Cut 1	-8.1998 (0.1784)	Cut 4	0.26046 (0.1100)
Cut 2	-5.7481 (0.1644)		

Note: Coefficients signed as *, **, and *** are statistically significant at the level of 10%, 5% and 1%, respectively.

Source: own calculations

In ordered logit model, parallel regression assumption must be tested. To test the validity of the assumption, Walt test suggested by Brant (1990) is applied and test results are reported in Table 4. In the test results, significant chi-square values mean that the parallel regression assumption is not valid. In Table 4, the parallel regression hypothesis is rejected for all model and for 16 of the 23 variables. Since the assumption is rejected in ordered logit model, generalized ordered logit model is estimated.

Table 4. Walt test results

Independent variables	Chi2	Prob	d.f.
All	408.33	0.000***	69
accident	26.16	0.000***	3
bmi	3.80	0.283	3
chronic	100.07	0.000***	3
insurance	3.12	0.373	3
age25_34	14.89	0.002**	3
age35_44	21.13	0.000***	3
age45_54	28.72	0.000***	3
age55_64	22.44	0.000***	3
age65_74	14.99	0.002**	3
age75	20.47	0.000***	3
female	50.26	0.000***	3
married	47.66	0.000***	3
urban	19.40	0.000***	3
illiterate	4.92	0.177	3
incomplete	13.40	0.004**	3
primary	14.13	0.003**	3
secondary	6.04	0.110	3
highschool	5.98	0.113	3
poor	0.72	0.868	3
medium	3.15	0.369	3
rich	4.62	0.202	3
veryrich	8.49	0.037**	3
employed	46.88	0.000***	3

Note: Coefficients signed as *, **, and *** are statistically significant at the level of 10%, 5% and 1%, respectively.

Source: own calculations

Generalized ordered logit model estimation results are showed in Table 5. Coefficients of the generalized ordered logit model cannot be interpreted directly. Thus, marginal effects are computed in order to interpret the coefficients. Values of the marginal effects are represented in Table 6.

Table 5. Generalized ordered logit model results

N= 25670 LR chi2(96) = 10899.79 Prob > chi2 = 0.0000 Log likelihood = -23736.312				
	Coefficients and Standard Errors			
Variables	mleg1	mleg2	mleg3	mleg4
accident	-0.14983 (0.2723)	-0.4620*** (0.0948)	-0.4023*** (0.0654)	0.0390 (0.0812)
bmi	-0.0039 (0.0136)	-0.0154*** (0.0052)	-0.0188*** (0.0035)	-0.0101** (0.0051)
chronic	-1.6595*** (0.2521)	-1.9332*** (0.0922)	-1.8034*** (0.0376)	-1.2441*** (0.0505)
insurance	0.16865 (0.3709)	0.2915** (0.1332)	0.1184 (0.0852)	0.0838 (0.0905)
age25_34	-0.3404 (0.4494)	-0.2140 (0.1788)	-0.6450*** (0.0821)	-0.3767*** (0.0671)
age35_44	-0.3362 (0.4532)	-0.6060*** (0.1721)	-1.0361*** (0.0842)	-0.6706*** (0.0815)
age45_54	-0.6532 (0.4329)	-0.9793*** (0.1674)	-1.4214*** (0.0838)	-0.9442*** (0.0906)
age55_64	-1.3211*** (0.4007)	-1.3260*** (0.1665)	-1.7650*** (0.0860)	-1.2853*** (0.1120)
age65_74	-1.1729*** (0.4012)	-1.4868*** (0.1674)	-2.0760*** (0.0931)	-1.9966*** (0.1953)
age75	-1.3901*** (0.3993)	-1.9354*** (0.1695)	-2.6251*** (0.1109)	-2.7835*** (0.3862)
female	0.5208*** (0.1650)	0.1226* (0.0627)	-0.2476*** (0.0390)	-0.2600*** (0.0447)
married	0.3681** (0.1738)	0.1666** (0.0671)	0.0720 (0.0465)	-0.3015*** (0.0555)
urban	-0.1140 (0.1648)	-0.0935 (0.0607)	-0.01717 (0.0396)	-0.2741*** (0.0489)
illiterate	-2.2848*** (0.6183)	-1.2634*** (0.1520)	-1.1121*** (0.0858)	-1.1838*** (0.1729)
incomplete	-2.0664*** (0.6330)	-0.9211*** (0.1609)	-0.8101*** (0.0905)	-0.4650*** (0.1158)
primary	-1.4542** (0.6050)	-0.6667*** (0.1397)	-0.6544*** (0.0648)	-0.3635*** (0.0718)
secondary	-0.9267 (0.6590)	-0.1795 (0.1672)	-0.3645*** (0.0751)	-0.1853** (0.0708)
highschool	-0.9042 (0.6522)	-0.2009 (0.1578)	-0.3094*** (0.0692)	-0.1284** (0.0655)
poor	0.3838 (0.2603)	0.2829** (0.0937)	0.2240*** (0.0698)	0.17045* (0.0989)

Variables	Coefficients and Standard Errors			
	mleg1	mleg2	mleg3	mleg4
medium	0.1614 (0.2215)	0.3875*** (0.0857)	0.2998*** (0.0628)	0.2132** (0.0883)
rich	0.2894 (0.2474)	0.4896*** (0.0930)	0.3170*** (0.0649)	0.2580** (0.0886)
veryrich	0.3413 (0.2638)	0.7337*** (0.0986)	0.52925*** (0.0658)	0.4154*** (0.0874)
employed	0.8921*** (0.2615)	0.5275*** (0.0788)	0.1992*** (0.0419)	-0.0238 (0.0491)
constant	7.4046*** (0.8576)	5.0302*** (0.2652)	3.7604*** (0.1494)	-0.2245 (0.1769)

Note: Coefficients signed as *, **, and *** are statistically significant at the level of 10%, 5% and 1%, respectively.

Source: own calculations

According to Table 6, estimated coefficients can be summarized as follows:

Accident: The variable of accident is found statistically significant at the level of 1% for the category of bad, fair and good. Significant results show that if the individual has an accident, they are more likely to report bad and fair health compared to having not an accident.

Bmi: The category of fair and good health at the level of 1%, the category of bad at the 5% and the category of very good at the level of 10% are found statistically significant. It means that increase of 1% in body mass index causes an increase (%) in the likelihood of bad and fair health.

Chronic: All health category is found statistically significant at the level of 1%. Thus, people who have a chronic disease, when we compare with the people who have not a chronic disease, are more likely to report very bad, bad and fair health and they are less likely to report good and very good health.

Insurance: The variable of insurance is statistically significant at the level of 10% only for the category of bad health. Therefore people who pay all health expenses are less likely to report bad health.

Age: In age groups, all health categories are found statistically significant at the level of 1% except for the category of very bad and for the variable of age25_34 in the category of bad. Compared to the reference category of age15_24, people are more likely to report bad and fair health when they are getting age and they are less likely to report good and very good health with increasing age.

Female: The variable is found statistically significant for the category of fair and very good health at the level of 1% and for the category of very bad and good at the level of 5%. Females, compared to men, are more likely to report fair health while they are less likely to report good and very good health.

Married: The married variable is statistically significant for the category of very bad and bad at the level of 10% and for the category of good and very good at the

level of 1%. Married people are more likely to report good health although they are less likely to report very good, bad and very bad health in comparison with unmarried people.

Urban: The urban variable is statistically significant at the level of 5% for the good health and at the level of 1% for the very good health. People who live in urban area, compared to rural area, are more likely to report good health while they are less likely to report very good health.

Education: In education groups, all variables are statistically significant at the level of 1% for fair, good and very good health except the variable of highschool. The variable of illiterate is statistically significant at 10% for very bad health and at 5% for bad health. The variable of incomplete is statistically significant at 10% for bad health. The variable of primary is statistically significant at 10% for very bad health and at 5% for bad health. Compared to the reference category of tertiary, people who are in the illiterate, incomplete, primary, secondary and high school education level, they are more likely to report bad and fair health. Even the signs of the coefficients are positive on reporting of bad and fair health, people are more likely to be optimistic about their health when the education level increases.

Income: In income groups, the variable of poor is statistically significant at the level of 10% for very bad and good health and at the level of 5% for bad and fair health. The variable of medium and rich are statistically significant at the level of 1% for the bad and fair health and at the level of 5% for the good and very good health. The variable of very rich is statistically significant at the level of 1% for all health categories except for the very bad health. Based on the reference category of very poor, significant variables in income groups report that individuals are more likely to report good and very good health with rising income level.

Employed: The variable of employed is statistically significant for the category of very bad, bad and good health at the level of 1% and for the category of fair at the level of 5%. Significant coefficients report that employed people, compared to unemployed people, are less likely to report very bad, bad and fair health.

Table 6. Marginal effects of the generalized ordered logit model

Variables	Very bad	Bad	Fair	Good	Very good
accident	0.00040	0.0145***	0.0614***	-0.0794***	0.0030
	(0.00079)	(0.0036)	(0.0129)	(0.0139)	(0.0063)
bmi	0.000009	0.0004**	0.0028***	-0.0024***	-0.0007*
	(0.00003)	(0.00013)	(0.0006)	(0.0006)	(0.00039)
chronic	0.00475***	0.0539***	0.2524***	-0.2141***	-0.0970***
	(0.0008)	(0.0027)	(0.0057)	(0.0068)	(0.0041)
insurance	-0.00046	-0.0083*	-0.0123	0.0150	0.00614
	(0.0011)	(0.0044)	(0.0148)	(0.0161)	(0.0064)
age25_34	0.00096	0.0050	0.1170***	-0.0970***	-0.0260***
	(0.0014)	(0.0050)	(0.0158)	(0.0168)	(0.0042)

Variables	Very bad	Bad	Fair	Good	Very good
age35_44	0.00095	0.01839**	0.1880***	-0.1640***	-0.0433***
	(0.0014)	(0.00612)	(0.0173)	(0.0184)	(0.0045)
age45_54	0.00209	0.03413***	0.2622***	-0.2421***	-0.0562***
	(0.0017)	(0.00779)	(0.0181)	(0.0191)	(0.0043)
age55_64	0.00595**	0.0535***	0.3276***	-0.3204***	-0.0667***
	(0.0029)	(0.0106)	(0.0193)	(0.0196)	(0.0040)
age65_74	0.00521*	0.0709***	0.3894***	-0.3857***	-0.0798***
	(0.0028)	(0.0133)	(0.0206)	(0.0200)	(0.0036)
age75	0.00723*	0.12043***	0.4477***	0.4904***	-0.0849***
	(0.0037)	(0.0198)	(0.0236)	(0.0188)	(0.0033)
female	-0.00135**	-0.00191	0.0458***	-0.0227**	-0.0198***
	(0.0004)	(0.0016)	(0.0064)	(0.0071)	(0.0034)
married	-0.0010*	-0.00356*	-0.0080	0.0365***	-0.0239***
	(0.0005)	(0.00182)	(0.0078)	(0.0088)	(0.0046)
urban	0.00028	0.00215	0.00053	0.0190**	-0.0220***
	(0.0004)	(0.0014)	(0.0065)	(0.0075)	(0.0041)
illiterate	0.01834*	0.03930**	0.1783***	-0.1752***	-0.0607***
	(0.0107)	(0.0133)	(0.0203)	(0.0207)	(0.0055)
incomplete	0.01531	0.02145*	0.1294***	-0.1366***	-0.0296***
	(0.0098)	(0.0117)	(0.0203)	(0.0211)	(0.0061)
primary	0.00498*	0.01457**	0.0995***	-0.0921***	-0.0264***
	(0.0026)	(0.0047)	(0.0118)	(0.0127)	(0.0050)
secondary	0.00324	0.00179	0.0620***	-0.0536***	-0.0133***
	(0.003)	(0.0051)	(0.0139)	(0.0148)	(0.0048)
highschool	0.00316	0.00252	0.0508***	-0.0471***	-0.0094**
	(0.0029)	(0.0049)	(0.0127)	(0.0135)	(0.0046)
poor	-0.00085*	-0.00596**	-0.0301**	0.0233*	0.0136
	(0.0005)	(0.0019)	(0.0105)	(0.0128)	(0.0083)
medium	-0.00395	-0.0090***	-0.0403***	0.0328**	0.0169**
	(0.0005)	(0.0018)	(0.0095)	(0.0118)	(0.0073)
Rich	-0.00068	-0.01088***	-0.0407***	0.0315**	0.0207**
	(0.00055)	(0.0068)	(0.0097)	(0.0321)	(0.0075)
veryrich	-0.00824	-0.01679***	-0.0694***	0.0535***	0.0335***
	(0.00062)	(0.0021)	(0.0984)	(0.0118)	(0.0075)
employed	-0.00212***	-0.01127***	-0.0206**	0.0359***	-0.0017
	(0.0006)	(0.0018)	(0.0067)	(0.0075)	(0.0037)

Notes: Coefficients signed as *, **, and *** are statistically significant at the level of 10%, 5% and 1%, respectively. Basic categories for the age, income and education groups are age15_24, tertiary and very poor.

Source: own calculations

SUMMARY

In this study, we aim to discuss self-reported health in Turkey based on the demographic, health and socio-economic variables with an empirical evidence of microeconometrics. Generalized ordered logit model is implemented after ordered logit model is operated with Wald test. As a result of the study, we can conclude that self-reported health status is not only effected by biological factors, is effected by demographic, socio-economic and health factors at different levels. Generalized ordered logit model results remark that rising level of body mass index, having chronic disease and accident play an efficient role to report fair health instead of good health. In view of gender differences, females are less likely to report good and very good health compared to male. Living in the urban area makes people think about their health as good. Employed people are also more likely to report good health. In income groups, significant variables indicate that people are more likely to report good and very good health when they are getting richer. In education categories, enhancing education level decreases the likelihood of reporting fair health and thus it boosts the likelihood of reporting good health. In view of the foregoing results, as a conclusion remark, we can point out that taking the demographic, socio-economic and health factors into account to put forth the importance of those factors in SRH is helpful to people who work on improving process of policies.

REFERENCES

Bloom D., Canning D. (2000) The Health and Wealth of Nations. Science, 217, 1207-1209.

Boerma T., Hosseinpoor A. R., Verdes E., Chatterji S. (2016) A Global Assessment of the Gender Gap in Self-Reported Health with Survey Data from 59 Countries. BMC Public Health, 16, 2-9.

Clarke P. M., Ryan C. (2006) Self-Reported Health: Reliability and Consequences for Health in Equality Measurement. Health Econ., 15, 645-652.

Deaton A. S., Paxson C. H. (2017) Aging and Inequality in Income and Health. The American Economic Review, 88, 248-253.

Fernandez E., Schiaffino A., Rajmil L., Badia X., Segura A. (1999) Gender Inequalities in Health and Health Care Services Use in Catalonia (Spain). Journal of Epidemiology and Community Health, 53(4), 218-222.

Hosseinpoor A. R., Williams J. S., Amin A., Carvalho I. A., Beard J., Boerma T., Kowal P., Naidoo N., Chatterji S. (2012) Social Determinants of Self-Reported Health in Women and Men: Understanding the Role of Gender in Population Health. PLoS One, 7(4), 1-9, https://www.ncbi.nlm.nih.gov/pubmed/22514667.

Karaoğlan D., Tansel A. (2016) The Causality Effect of Education on Health Behaviours: Evidence from Turkey. Turkish Economic Association Discussion Paper, 2, 1-25.

Long J. S., Freese J. (2001) Regression Models for Categorical Dependent Variables Using Stata. United States of America: Stata Corporation.

Liao T. F. (1994) Interpreting Probability Models Logit, Probit, and other Generalized Linear Models. California: SAGE Publications.

McCallum J., Wang D. (1994) Self-Rated Health and Survival: A 7-Year Follow-Up Study of Australian Elderly. American Journal of Public Health, 84, 1100-1105.

Oncel B. D. (2015) Shattered Health for Women: How Gender Roles Affect Health Socio-Economic Status Nexus Over Life Cycle? Topics in Middle Eastern and African Economies, 17, 2, 122-155.

Sedefoglu G., Soytas M. A. (2017) Examining Health Status of Females in Urban and Rural Areas in Turkey: A Bayesian Approach. Current Debates in Economics & Econometrics, Volume 2, IJOPEC Publication.

Schulz A., Israel B., Williams D., Parker E., Becker A., James S. (2000) Social Inequalities, Stressors and Self-Reported Health Status Among African American and White Women in the Detroit Metropolitan Area. Social Science & Medicine, 51, 1639-1653.

Subramanian S. V., Hujits T., Avendano M. (2010) Self-Reported Health Assessments in the 2002 World Health Survey: How do they Correlate with Education? Bulletin of the World Health Organization, 88, 131-138.

Shibuya K., Hashimoto H., Yano E. (2002) Individual Income, Income Distribution, and Self-Rated Health in Japan: Cross Sectional Analysis of Nationally Representative Sample. BMJ, 324, 16-19.

Tubeuf S., Jusot F., Devaux M., Sermet C. (2008) Social Heterogeneity in Self-Reported Health Status and Measurement of Inequalities in Health. IRDES Working Paper. http://www.irdes.fr/EspaceAnglais/Publications/WorkingPapers/DT12SocialHeterogeSelfReportHealthStatus.pdf.

Vaillant N., Wolff F. C. (2012) On the Reliability of Self-Reported Health: Evidence from Albanian Data. Journal of Epidemiology and Global Health, 2, 83-98.

Winkleby M. A., Jatulis D. E., Frank E., Fortmann S. P. (1992) Socioeconomic Status and Health: How Education, Income, and Occupation Contribute to Risk Factors for Cardiovascular Disease. American Journal of Public Health, 82, 816-822.

Williams R. (2006) Generalized Ordered Logit/Partial Proportional Odds Models for Ordinal Dependent Variables. The Stata Journal, 6, 58-82.

QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 4, 2018, pp. 452 – 461

Received: 16.10.2018
Accepted: 21.12.2018

CONJOINT ANALYSIS AS A STATISTICAL TOOL FOR STUDYING CONSUMER BEHAVIOUR. CHARACTERISTICS, TYPES AND EXAMPLES OF USE

Agnieszka Tekień https://orcid.org/0000-0001-6811-060X
Krystyna Gutkowska https://orcid.org/0000-0002-0873-8478
Sylwia Żakowska-Biemans https://orcid.org/0000-0001-8225-6533
Faculty of Human Nutrition and Consumer Sciences
Warsaw University of Life Sciences – SGGW, Poland
e-mail: agnieszka_tekien@sggw.pl; krystyna_gutkowska@sggw.pl;
sylwia_zakowska_biemans@sggw.pl

Abstract: Conjoint analysis is a statistical method popular in marketing research. It allows to analyze the combined effect of many product attributes in order to look into consumer's willingness to purchase. An important advantage of this method is the ability to examine respondents' preferences without usage of the questionnaire with declarative answers. The article presents the most important types of conjoint analysis, their characteristics and examples of application. It also looks for new development paths for conjoint analysis and consumer sciences.

Keywords: conjoint analysis, consumer research, consumer study, conjoint choice-based, consumer behaviour

JEL classification: D12, D90, C19

INTRODUCTION

The beginning of conjoint methods dates back in the 1960s. The conjoint analysis as a method has developed from the 'conjoint' measurement in mathematical psychology.
Standard methods of consumer research (for example: survey questionnaire) are useful and have many advantages such as simplicity of the design and application as well as relatively low costs. However, they also have undeniable defects, such as lack of opportunity to interact with consumer and possibility of deepening the topic

https://doi.org/10.22630/MIBE.2018.19.4.43

if needed. Sometimes the reality is oversimplified in survey questionnaire, even if the question is most accurately formulated - i.e. by narrowing the list of possible answers, among which the respondent chooses. The great problem of such research is its declarative nature, which also means that there could be no strong connection with decisions made in reality, which are often under the influence of impulses or not fully conscious. The consumer research area is constantly inspired by constantly changing reality, including consumer behaviour, attitudes and openness (or lack of it) in the conduct of the study. Due to the dominance of electronic devices, the classic paper interviews conducted by a trained interviewer are often displaced by (cheaper and faster) online surveys. The need to get to know consumers raises natural questions about quality of the results of standarized questionnaires, face-to-face and computer-assisted interviewing methods, such as: whether the consumer standing in front of the store's shelf will pick what he previously declared in the questionnaire? Which product characteristics affects the intention to purchase the most and which one the least? Why does the consumer choose producer A instead of B? Why consumers declare that they buy something and then choose a completely different product in a real store?

In the process of seeking answers to these questions, a conjoint analysis method was established to widen our knowledge about the consumer. To get to know consumers without specific 'filter' which is the traditional survey task with direct questions to the respondent.

Similar articles presenting the history of the conjoint analysis and its types, as well as methods of implementation, are already in the literature [Agarwal, Green 1991; Green, Krieger, Wind 2001; Louviere, Flynn, Carson 2010] but the aim of this article, in addition to the approximation of the theory, is a review of the previous studies using conjoint analysis and an attempt to discuss the future of the method also in the context of possible development paths.

HISTORY OF CONJOINT IN THE WORLD

Issues mentioned in the introduction, questioning the full usefulness of declassified data, have led scientists into the area of science previously not used in business and consumer sciences - into the areas of mathematical psychology.

The first study that gave foundations to this method was conducted by Luce and Tukey [Luce, Tukey 1964]. Kruskal and Young also contributed their scientific work [Kruskal 1965; Young 1969] and Carrol in 1969 with his paper 'Categorical conjoint measurement' presented at the Annual Meeting of the Association of Mathematical Psychology in Michigan.

The rapid development and extensive popularization of conjoint analysis was influenced by several factors. First and foremost, consumer market development has played a significant role with its need to analyze consumer preferences. The rapid development of computer software and its computing capabilities have made new types of analysis possible to be converted in a short time. Moreover, conjoint

analysis allows data collection to be intuitive for the respondent and easy to recalculate and analyze for the researcher so that the method could be easily used worldwide.

In addition, conjoint analysis responds to a very important issue that decision makers faces: why consumer may declare that he/she will buy product X when in store he/she will put into basket product Y? What are hidden reasons? And, what points-out Green [Green et al. 2001]: 'how to trade off the possibility that option X is better than option Y on attribute A while Y is better than X on attribute B?'.

Green defines that conjoint analysis uses 4 types of data collection procedures but concerning strong development of discrete conjoint techniques, it is worth to notice that data are collected in five ways:

- Full profile techniques: complete set of full-profile prop cards. Respondent has to rate each card from 0 to 100 likelihood-of-purchase scale.
- Compositional techniques: self-explicated preference-data collection (e.g. CASEMAP [Srinivasan 1988]). In this type of collecting data each respondent in first step rates the desirability of each set of attribute level (scale 0 to 100) and then rates the attributes on importance scale.
- Hybrid techniques: self-explicated evaluation task. Respondent fulfills a task where is obliged to evaluate a subgroup of full-profile cards [Green, Goldberg, Montemayor 1981]. Then, complex data is a result from utility function.
- Adaptive conjoint analysis: another version of hybrid technique [Johnson 1987]. The process of data collection is two-step. Firstly, respondent carry out a self-explication task and then evaluates a set of partial-profile descriptions. Whole process is strongly supported by computer, partial-profile descriptions are dependent on respondents earlier paired comparisons.
- Choice-based conjoint: part-worth model to respondent's evaluative choices. Research designers evaluate part-worth functions at discrete levels for each from the considered attributes. Repeating after [Green et al. 2001], when designing a study, we set P attributes and J stilmuli.

When considering a respondent, we assume that y_{jp} is the desirability of the *pth* attribute for the *jth* stimulus and that y_{jp} is inherently continuous. Then, the vector model for respondent's preference for the *jth* stimulus is s_j:

$$s_j = \sum_{p=1}^{p} w_p y_{jp} \tag{1}$$

where w_p means respondent's weight for each of the P attributes.

When we consider, the ideal-point model, preference s_j is inversably related to the weighted squared distance d_j^2 of the location y_{jp} of the *jth* stimulus from the individual's ideal point x_p, where d_j^2 is defined as

$$d_j^2 = \sum_{p=1}^{p} w_p \left(y_{jp} - x_p\right)^2 . \tag{2}$$

In the part-worth model

$$s_j = \sum_{p=1}^{p} f_p\left(y_{jp}\right) \quad (3)$$

where y_{jp} is the category level and f_p is a function denoting the part-worth corresponding to level y_{jp}. In practice, $f_p(y_{jp})$ is estimated for a selected set of discrete levels of y_{jp}.

But before conjoint analysis became such an elaborate tool, we have to go back to the 1970s. As mentioned above, the dynamic development of digitization and computer techniques has opened new paths to researchers. A new look at behavioral sciences, the development of psychometry and mathematical psychology has also resulted in marketing research development. What is worth to mention is that cluster analysis methods let the researchers use it in market segmentation [Green, Frank, Robinson 1967]. Previously, analysts used a priori market segmentation where prior to the start of the study, consumer segments are defined and then assigned to those segments, and their behavior is analyzed in this segment.

In the new approach (a posteriori) it turned out that it is worth 'let data speak for themselves' and after analyzing the data decide what are the similarities in attitudes, behaviors, choices or needs. In this version of segmentation, researchers may divide respondents basing on the purpose of the study, such as benefits sought, brand preferences, psychographics or other.

Beginings of conjoint measurement were focused on axiomatic approaches to fundamental measurement [Luce, Tukey 1964]. Subsequently, first conjoint algorithm - Monanova - was designed [Kruskal 1965] and programmed by Joseph Kruskal and Frank Carmone. It used ranked response data in order to obtain ordered metric-scale data from random-order response data and a set of factorially designed stimuli.

Later, in the 80s, new programs were introduced [Johnson 1987] - adaptive conjoint analysis used graded paired comparisons as one set of inputs in the model. This was also the time when first PC-based programs where created (e.g. [Herman 1988] full-profile with stimuli based on orthogonal designs). New possibilities of computer software development had a huge impact on popularizing this method, as well as gave new opportunities to scientists to look for better theoretical solutions and options.

CONJOINT ANALYSIS IN POLAND

Among Polish scientists who worked on the development of this analysis, certainly should be mentioned works of Marek Walesiak, Andrzej Bąk and Józef Dziechciarz [Dziechciarz-Duda, Król 2014; Dziechciarz, Walesiak 1995; Dziechciarz, Walesiak 1999].

Conjoint analysis in Poland had been develeped both in the scientific field [Dziechciarz, Walesiak 1995; Dziechciarz, Walesiak 1999; Szymańska, Dziedzic

2005; Walesiak 1997] and applied fields of business and commercial marketing research.

The development of conjoint analysis in Poland implies the implementation of the method both in scientific and business research but also a great deal of research has been devoted to the development of methodology [Dziechciarz, Walesiak 1995; Walesiak 1997], data analysis methods [Szymańska, Dziedzic 2005; Walesiak 1997] as well as the application of the method [Dziechciarz, Walesiak 1999; Walesiak, Bąk 1977]. Especially interesting is the development of statistical packages: SPSS [Walesiak, Bąk 1977] and R software (http://keii.ue.wroc.pl/conjoint/conjoint-manual.pdf). Defining new areas of exploration and applying them into real research projects makes it easier and more effective to use this analysis of consumer behavior.

An interesting addition to the conjoint analysis itself is applying hedonic regression in the first step of the analysis. If a wider approach and use existing data or market offerings (hedonic regression) is added to consumer issues by usage of conjoint analysis, it can lead to more reliable research results.

The theory of hedonic models assumes that there is a relationship between the price of good and its attributes, which is described by a certain function h (called hedonic function). The general form of the hedonic function h can be determined by the general regression model:

$$C = h(\boldsymbol{W}, \boldsymbol{\alpha}, \delta) \tag{4}$$

where:

C - product price,

W - product characteristics vector,

α - parameters vector,

δ - random component of the model.

With historical statistic market data available the probable price of a product can be determined within a certain range of attributes, as well as some 'valuation' of each attribute.

Such approach can have a profound effect on determining appropriate profiles in conjoint analysis and thus can significantly improve the quality of analysis. Consequently - also increase the reliability of the results of the analysis of consumer preferences.

This method was used in research in Poland as well as in other countries [Chen, Rothschild 2010; Costanigro, McCluskey, Mittelhammer 2007; Dziechciarz-Duda, Król 2014].

HOW TO USE IT?

Conjoint analysis is used worldwide nowadays. It is commonly used both in scientific research and business analysis. Looking at the latest researches with

conjoint usage, it can be noticed that the range of usage is very broad: from business and consumer preferences research [Meyerding 2016], across medicine and patient preferences [Hofheinz et al. 2016], housing market [Rofè, Pashtan, Hornik 2017] and even hotels and restaurants [Lee 2016].

To better understand what aspects of consumer behavior can be measured with conjoint a short example was prepared - a pork raw meat research. If trying to get the knowledge what is important for pork meat consumers, the first step is to define list of product's attributes (as in Table 1: meat, portioning, packaging, weight) and levels (each attribute has its levels, e.g. 'Packaging': Vacuum, MAP, bulk - see Table 1).

Table 1. Adaptive conjoint - scheme of the attributes and levels

Meat	Portioning	Packaging	Weight
Pork raw meat without additives	in one piece	Vacuum	250 g
Pork raw meat with additives, e.g. beta-glucan, Omega-3 acids	Minced	MAP	500 g
	sliced meat (for chops)	bulk	750 g
	meat on the stew (in pieces)		1000 g

Source: own study

The research and sample results (Table 2) were prepared for adaptive conjoint analysis.

The respondents were presented with different possible variants of the offer described by its features and asked to rank them in order from the most preferred to least preferred variant. The advantage of this technique is that we do not ask the respondent what is important to him in isolation from the environment, but the respondent simply judges how much he would be interested in the offer. The higher attribute's significance means that this is the attribute to which consumers pay higher attention. Levels must be considered as less and more preferred within the given attribute (Table 2).

Table 2. Adaptive conjoint - sample results (attribute's significance & level's utility)

Attribute	Significance	Attribute level	Utility
Meat	29	Pork raw meat without additives	28.2
		Pork raw meat with additives, e.g. beta-glucan, fiber, Omega-3 acids	6.2
Portioning	24	in one piece	16.3
		Minced	14.2
		sliced meat (for chops)	18.9
		meat on the stew (in pieces)	10.2

Attribute	Significance	Attribute level	Utility
Packaging	20	Vacuum	9.2
		MAP	9.5
		Bulk	14.5
Weight	27	250 g	14.9
		500 g	19.1
		750 g	12.3
		1000 g	16.2

Source: own study

In this sample data, it can be conducted that the most important attributes are 'meat' (29%) and 'weight' (27%). When looking at levels, it can be stated that 'pork raw meat without additives' (utility: 28.2) is preferred over 'pork raw meat with additives' (utility: 6,2). In 'weight' attribute option '500g' (u. 19.1) is preferable. In 'portioning' the most often selected was 'sliced meat' (u. 18.9) and in 'packaging' was 'bulk' (u. 14.5).
These results allow researchers to get a closer look at consumer preferences.

CONJOINT ANALYSIS - DAYS TO COME?

Having in mind the determinants that have contributed to the development of conjoint analysis, future prospects are still an open topic. Considering how much has already been done and how broadly the method is being used, one could ask is there any more space for development? Or rather the method will remain in its present form?
Thinking over about conjoint capabilities, it may be helpful to separate topics into: methodology development, application possibilities and consumer behavioral aspects.
Conjoint analysis is already widely used but there are still areas which have not yet been developed. The main methodology areas that can be predicted to be development directions are:

- virtual/more realistic visualizations of products or attributes and levels,
- dynamic simulations that consider real time action-reaction sequences,
- new research that shows conjoint's credibility and its opportunities.

Analysing potential application possibilities, following further option is likely to be realized:

- narrowed groups of respondents such as municipalities, suppliers, employees, teachers, etc.

Considering further consumer behavioral aspects, the method can explored by:

- time limits - simulation of the situation where consumer have limited time (e.g. in a hurry to work or train) and is in need to make a decision. How much time dimension affects consumer decisions?
- financial limits, e.g. 'buy 4-5 things and your budget for shopping is X'. What would the consumer choose when facing with limited budget? How consumer reacts when the shopping list consist also several other products? Does he/she choose the same products or maybe products attributes get new part-worth utilities?
- increased choice: choosing not only among similar products but among all products from the whole category shelf (e.g. buy yoghurt from whole dairy shelf). It is quite easy to choose one out of three products but what happens when (similarly to shopping situation) respondent have to find desired product among others also from other categories? Is he still so vigilant? Is the selection still focused on the same attributes?
- noise: simulation of the situation e.g. when parent with a baby is doing shopping or when in store floors are being washed or goods are serviced. How much noise affects the decision-making process? Do parents choose differently?
- technology/VR: when forcing to make decisions located in virtual reality in simulated point of sale.

Presumably these are the main development paths for conjoint analysis. Huge work in the development of this method has already been done, but there is still much to do. It can be said that conjoint is surely mature but not outdated. As long as the behavior of consumers will be important to researchers, conjoint methods will continue to be developed and applied.

SUMMARY

As discussed above, conjoint analysis has been an effective and widely used method for consumer research and understanding for many years, especially when interested in learning about consumer behavior in a simulated decision-making situation. Currently, the use of the method is very broad, both in business and in scientific research. At the same time quite extensive theory and various ways of constructing the study and analysis of the obtained data allow to choose preferred method for a particular research problem.

However, the question is interesting: what next? Has the conjoint analysis theory had been completed already? Or can it be further extended? Is there a gap in the current state of knowledge? Do the researchers notice any shortcomings? Does the method effectively evaluate consumers' decisions? Could there be elements that are not covered/described/explained enough by the analysis?

Such element that is not considered in conjoint analysis, can be time constraint (during respondent decision making process). As a matter of fact, the respondent during survey is not in a hurry, he/she has the comfort of responding at his/her own

pace. But what if he/she acted under the pressure of time? It is completely different to choose products in the store when we have the convenience of time in the store, and otherwise, when we know that if we do not buy the necessary products within minutes, we miss our train or plane. There is an open question about how time pressure can be incorporated into a conjoint test and how much the theory and methods of analysis will change.

Surely it can be assumed that conjoint analysis still has interesting development prospects ahead, which will probably have a positive impact on its ability to analyze consumer behavior. Forthcoming years can bring new ways of analyzing consumers and their decisions and conjoint analysis have the opportunity to take part in widening this knowledge.

REFERENCES

Agarwal M. K., Green P. E. (1991) Adaptive Conjoint Analysis versus Selfexplicated Models: Some Empirical Results. International Journal of Research in Marketing, 8(2), 141-146.

Chen Ch. F., Rothschild R. (2010) An Application of Hedonic Pricing Analysis to the Case of Hotel Rooms in Taipei. Tourism Economics, 16(3), 685-94.

Costanigro M., McCluskey J. J., Mittelhammer R. C. (2007) Segmenting the Wine Market Based on Price: Hedonic Regression When Different Prices Mean Different Products. Journal of Agricultural Economics, 58(3), 454-66.

Duncan L. R., Tukey J. W. (1964) Simultaneous Conjoint Measurement: A New Type of Fundamental Measurement. Journal of Mathematical Psychology, 1, 1-27.

Dziechciarz-Duda M., Król A. (2014) Regresja hedoniczna i conjoint analysis w badaniu cen rynkowych i preferencji konsumentów. Metody Ilościowe w Badaniach Marketingowych, Zeszyty Naukowe, Studia Ekonomiczne, 195(14), 33-43.

Dziechciarz J., Walesiak M. (1995) Pomiar łączonego oddziaływania zmiennych (conjoint measurment) w badaniach marketingowych. Przestrzenno-czasowe modelowanie i prognozowanie zjawisk gospodarczych, 149-158.

Dziechciarz J., Walesiak M., Bąk A. (1999) An Application of Conjoint Analysis for Preference Measurement. Argumenta Oeconomica, 1(7).

Green P. E., Frank R. E. Robinson P. J. (1967) Cluster Analysis in Test Market Selection. Management Science, 13(8), 387-400.

Green P. E., Goldberg S. M., Montemayor M. (1981) A Hybrid Utility Estimation Model for Conjoint Analysis. Journal of Marketing, 45, 33-41.

Green P. E., Krieger A. M., Wind Y. (2001) Thirty Years of Conjoint Analysis: Reflections and Prospects. Interfaces, 31(3–Supplement), 56-73.

Herman S. (1988) Software of the Full-Profile Conjoint Analysis. [in:] Metegrano M. (Ed.) Proceedings of the Sowtooth Conference on Perceptual Mapping, Conjoint Analysis and Computer Interviewing. Ketchum, Idaho.

Hofheinz R. et al. (2016) Patient Preferences for Palliative Treatment of Locally Advanced or Metastatic Gastric Cancer and Adenocarcinoma of the Gastroesophageal Junction: A Choice-Based Conjoint Analysis Study from Germany. BMC Cancer, 16(1), 937.

Johnson R. M. (1987) Adaptive Conjoint Analysis. [in:] Proceedings of the Sawtooth Software Conference on Perceptual Mapping, Conjoint Analysis and Computer Interviewing. 253-264

Kruskal J. B. (1965) Analysis of Factorial Experiments by Estimating Monotone Transformations of the Data. Journal of the Royal Statistical Society, 27(2), 251-263.

Lee S. H. (2016) How Hotel Managers Decide to Discount Room Rates: A Conjoint Analysis. International Journal of Hospitality Management, 52, 68-77.

Louviere J. J., Flynn T. N., Carson R. T. (2010) Discrete Choice Experiments Are Not Conjoint Analysis. Journal of Choice Modelling, 3(3), 57-72.

Meyerding S. (2016) Consumer Preferences for Food Labels on Tomatoes in Germany - A Comparison of a Quasi-Experiment and Two Stated Preference Approaches. Appetite, 103, 105-112.

Rofe Y., Pashtan T., Hornik J. (2017) Is There a Market for Sustainable Urbanism? A Conjoint Analysis of Potential Homebuyers in Israel. Sustainable Cities and Society, 30, 162-70.

Srinivasan V. (1988) A Conjunctive-Compensatory Approach to the Self-Explication of Multiattributed Preferences. Decision Sciences, 19(2), 295-305.

Szymańska A., Dziedzic D. (2005) Conjoint analysis jako metoda analizy preferencji konsumentów. Zeszyty Naukowe AE w Krakowie, 680 (in Polish).

Walesiak M. (1997) Conjoint Measurement. Prace Naukowe Akademii Ekonomicznej we Wrocławiu, 744, 473-504 (in Polish).

Walesiak M., Bąk A. (1977) Realizacja badań marketingowych metodą Conjoint Analysis z wykorzystaniem Pakietu Statystycznego SPSS for Windows. (in Polish).

Young F. (1969) Polynomial Conjoint Analysis of Similarities: Definitions for a Special Algorithm. Research paper, 76, Psychometric Laboratory, University of North Carolina.

IOŚ-PIB
INSTYTUT OCHRONY ŚRODOWISKA
PAŃSTWOWY INSTYTUT BADAWCZY

XIX INTERNATIONAL SCIENTIFIC CONFERENCE QUANTITATIVE METHODS IN ECONOMIC RESEARCH

Speech given during the conference by PhD Krystian Szczepański, Director of the Institute of Environmental Protection – National Research Institute

Ladies and gentelmen,

In this conference we will discuss about economy, and many of you are considering why Institute of Environmental Protection cooperate this conference. The reasons are many but most important issues is that environmental protection has very strong correlations with economy. I mean less impact more savings eg. improving energy efficence is less used fuel for heating our house and for production of our goods. Further, less emissions mean less dangerous substances for the environment and our health what have direct impact of cost of health care.

Institute of Environmental Protection - National Research Institute is responsible for running the National Database of GHG and other substances - an IT tool that since 2010 collects data on the amount of gases and dust emitted to air by plants operating in Poland. Entities with activities leading to the emissions to the air report data to the National Database every year. Currently, there are around 30,000 entities registered in the National Database. Reported data covers very wide range of information. The entity characterizes the technological structure, determines the amount of fuels or raw materials consumed in a year, provides information on emission permits, and first of all determines the emissions of particular pollutants emitted into the air and indicates the methodology for determining emission. Data provided by entities are verified initially at the implementation stage (automatic verification formulas) as well as after the deadline for reports (end of February).

The data collected in the National Database can be used for multidimensional comparative analysis. The data is used, for example, for the development and updating of: air protection programs, low-emission economy plans, inventory of emission sources in voivodeships, and works related to the annual assessment of air quality (including model analyzes).

Instytut Ochrony Środowiska – Państwowy Instytut Badawczy
Institute of Environmental Protection – National Research Institute
00-548 Warszawa
ul. Krucza 5/11D
tel.: 22 37 50 525 (sekretariat)
fax: 22 37 50 501
sekretariat@ios.gov.pl
www.ios.gov.pl

IOŚ-PIB

In addition, the Institute carries out analyzes of information collected in the National Database, eg by preparing a report for the European Commission on large combustion plants (LCPs), supporting the Ministry of the Environment on current issues, or preparing a report for the Minister of the Environment every year.

This only one example how we can use quantitative methods in environmental protection area and they are necessary for good to manage it.

Thank you for your participation and I wish you a good conference and interesting topics for discussion.

PhD Krystian Szczepański
Director of the Institute
of Environmental Protection
-National Research Institute

Warsaw, 18.06.2018

Instytut Ochrony Środowiska – Państwowy Instytut Badawczy
Institute of Environmental Protection – National Research Institute
00-548 Warszawa
ul. Krucza 5/11D
tel.: 22 37 50 525 (sekretariat)
fax: 22 37 50 501
sekretariat@ios.gov.pl
www.ios.gov.pl

REVIEWERS COOPERATING WITH THE JOURNAL IN 2018

WARSAW UNIVERSITY OF LIFE SCIENCES – SGGW:

Bolesław Borkowski
Mariola Chrzanowska
Hanna Dudek
Konrad Furmańczyk
Krzysztof Gajowniczek
Michał Gostkowski
Urszula Grzybowska
Sebastian Jarzębowski
Stanisław Jaworski
Andrzej Karpio
Marek Andrzej Kociński
Grzegorz Koszela
Monika Krawiec
Joanna Landmesser
Aleksandra Matuszewska-Janica
Luiza Ochnio
Marian Podstawka
Alexander N. Prokopenya
Wiesław Szczesny
Ludwik Wicki
Dorota Żebrowska-Suchodolska

OTHER UNIVERSITIES (POLAND):

Iwona Bąk (West Pomeranian University of Technology)
Beata Bieszk-Stolorz (University of Szczecin)
Mariusz Borawski (West Pomeranian University of Technology)
Ryszard Budziński (University of Szczecin)
Szczepan Figiel (University of Warmia and Mazury in Olsztyn)
Tomasz Górecki (Adam Mickiewicz University)
Justyna Kujawska (Gdansk University of Technology)
Karol Kukuła (University of Agriculture in Cracow)
Tadeusz Kwater (University of Rzeszow)
Arkadiusz Manikowski (University of Warsaw)
Iwona Markowicz (University of Szczecin)
Aldona Migała-Warchoł (Rzeszow University of Technology)
Kesra Nermend (University of Szczecin)
Joanna Olbryś (Bialystok University of Technology)
Arkadiusz Orzechowski (Warsaw School of Economics - SGH)
Dorota Pekasiewicz (University of Lodz)
Artur Prędki (Cracow University of Economics)
Andrzej Wiatrak (University of Warsaw)
Dorota Witkowska (University of Lodz)