

APPLICATION OF MATHEMATICS AND STATISTICS IN ECONOMICS 2024

BOOK OF ABSTRACT



26th AMSE

**APPLICATIONS OF
MATHEMATICS AND STATISTICS
IN ECONOMICS**

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OF MATHEMATICS AND STATISTICS
IN ECONOMICS
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BOOK OF ABSTRACT

WROCLAW - PAWLOWICE, 28 AUGUST - 1 SEPTEMBER 2024

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SECTION OF THE CONFERENCE:

Papers are be thematically related to applications of mathematics and statistics in economics and should fall in one of the following sections:

- Macroeconomics, Public Economics and Methodological Issues of Economics
- Social Economics, Economic Sustainability and Demographic Economics
- Financial Markets, Risk Measurement and Insurance
- Microeconomic Issues
- Multidimensional Statistics in Economics

WELCOME

by
the Organizing Committee

It is a great pleasure for all of us from Wrocław University of Economics and Business to welcome all participants to the 26th AMSE Conference in Wrocław in Pawłowice.

The beginning of the conference dates back to 1998. The first conference was organized by Matej Bel University in Liptovský Trnovec in 3rd – 4th September, 1998. During the conference 23 papers were presented by scientists from many centres but mainly by the staff of Matej Bel University in Banská Bystrica in Slovakia and Prague University of Economics and Business in the Czech Republic. In 1999 a team from Wrocław University of Economics and Business joined the circle of participants and organizers. Since 2001, the conference has been organized periodically by the three centres mentioned.

The Matej Bel University has organized the following editions:

1998, Liptovský Trnovec
1999, Liptovský Trnovec
2000, Poprad
2003, Banská Bystrica
2007, Poprad
2010, Demänovská Dolina
2013, Gerlachov
2016, Banská Štiavnica
2019, Nižná
2023, Rajecké Teplice

Prague University of Economics and Business has hosted the following conferences:

2001, Zadov
2004, České Budejovice
2006, Trutnov
2009, Uherské Hradiště
2012, Liberec
2015, Jindřichův Hradec
2018, Kutná Hora
2022, Velké Losiny

Wrocław University of Economics and Business has held the following meetings:

2002, Kudowa Zdrój
2005, Wrocław
2008, Wisła
2011, Łądek Zdrój
2014, Jerzmanowice
2017, Szklarska Poręba
2021, online

In 2014-2018, papers presented on AMSE had been included in the Conference Proceedings Citation Index of the Web of Science database.

In 2024 AMSE conference is taking place in Wrocław for the twenty sixth time. We hope that this Conference will be as fruitful and interesting as all the nineteen previous enjoyable meetings of friends from the three countries.

We wish you a nice stay in Pawłowice in Wrocław!

Beata Zmyślona

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SUMMARIES OF PAPERS

GENDER-SPECIFIC OKUN'S LAW - DISAGGREGATION PERSPECTIVE

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Abstract

The presentation posits a disaggregation framework to study the gender-specificity of Okun's law. A bivariate system of gender-specific Okun equations is transformed into a single equation and a simple estimation framework is developed that is both econometrically correct and suited to generalizations towards a variety of stylized facts. The empirical part of the presentation demonstrates the framework in a case study for OECD countries, and explores as to whether it is male or female labour force that is more sensitive to fluctuations in overall economic activity.

Key words: *ender-specific Okun's law, disaggregation framework, OECD countries*

ALTERNATIVE METHODS FOR VISUALIZING CATEGORICAL DATA IN CLUSTER ANALYSIS

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Abstract

Visualization of categorical data presents two primary challenges: the unknown order of categories and the unknown distances between them. These issues are also evident when visualizing the outputs of cluster analysis of datasets with categorical variables. Consequently, traditional cluster scatterplots cannot be applied to these datasets. Our contribution introduces four novel visualization techniques for cluster analysis outputs on categorical datasets, aiming to achieve an analog to the cluster scatterplot. The methods, named HCADM, HCAKL, LBCADM, and LBCAKL, display the results of cluster analysis in a two-dimensional space and they are derived from a contingency table. Each axis of the graph represents one categorical variable from the dataset, with the categories of the variables depicted along the axes. These methods are designed to arrange clusters into the most compact regions possible in order to provide coherent visualization outcome. The HCADM and HCAKL methods utilize hierarchical clustering for the arrangement of variable categories. On the other hand, the LBCADM and LBCAKL methods use latent block clustering for the arrangement of variable values. While all four methods lead to similar arrangements, the LBCADM and LBCAKL methods rely on identifying clusters within the input data, which, unlike the HCADM and HCAKL methods, is not deterministic. The final arrangement of categories on the graph's axes ensures that adjacent categories are similar. This arrangement can be further refined by determining the distances between categories. To achieve this, the HCADM and LBCADM methods use direct methods such as occurrence frequency measure, inverse occurrence frequency measure, and Lin measure, while the HCAKL and LBCAKL methods employ the Kullback-Leibler distance, which accounts for the association between the visualized variables. The application of all four proposed visualization methods is demonstrated through illustrative examples. Based on experimental results, it is evident that the suitable choice of arrangement method and distance calculation significantly affects the clarity and interpretability of the graphs. It is impossible to definitively choose one method of distance determination and clustering that is suitable for identifying observation clusters in all cases. The selection of methods must always be approached individually and adapted to the specific situation. A critical step in graph creation is the identification of the category order. Hierarchical clustering and latent clustering methods are used to find the appropriate arrangement, with the former being simpler and, in some cases, more effective. We have also discovered that for categorical data, the Ward method has proven to be the least effective among the hierarchical clustering methods analyzed.

Key words: cluster analysis, data visualization, categorical data, ordering categories, distance of categories.

ENHANCING QUALITY OF LIFE FOR SENIORS: A COMPARATIVE STUDY OF POLAND, CZECHIA AND SLOVAKIA

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Abstract

Evaluating the quality of life for individuals aged 65 and older is essential for identifying their needs and ensuring their well-being. By examining various aspects, such as the feeling of neglect, financial situation, personal relationships, use of time, and sense of loneliness, we can better understand which areas require special attention. Equally important is considering seniors' participation in cultural and social life and their relationships with family and friends. Engagement in these areas positively impacts their well-being and sense of self-worth and contributes to greater social integration and improved quality of life. Therefore, a comprehensive assessment of older adults' quality of life should encompass both their material and health well-being and their social and cultural activity.

This study evaluates older adults' quality of life and prioritises their needs across Poland, Czechia, and Slovakia. Additionally, a comparison between these countries has been conducted, highlighting differences and similarities in assessing older adults' quality of life. Through this analysis, best practices have been identified, along with areas requiring greater attention from the social policies of each country.

The study utilises ranking methods that account for the total and distribution of ranks within the sample, interaction analysis among various needs, and ProFit analysis to assess the impact of selected factors on the quality of life evaluations in these countries. Additionally, a logit model is employed to identify the factors influencing improvements in quality of life.

The analysis is based on data from the European Union Statistics on Income and Living Conditions (EU-SILC) as part of the RPP 40/2024-EU-SILC project.

Key words: *Quality of Life, Older Adults, Socio-cultural Activity, Needs Assessment, EU-SILC*

CRITICAL PARAMETERS AND THEIR INFLUENCE ON LIMIT CYCLE PROPERTIES IN A FOUR-DIMENSIONAL MODEL OF THE KALECKIAN SYSTEM

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Abstract

A dynamical four-dimensional nonlinear model describing the development of four key economic variables (the rate of utilization, the wage share, the nominal interest rate, and the expected rate of inflation) is examined. We focus on the values of the critical parameters of the model that satisfy Liu's criteria to ensure the existence of limit cycles. The relationship between the parameter that measures the credibility of the monetary authority in shaping economic expectations and the other critical parameters is explored. The achieved results are illustrated by numerical simulations of the qualitative properties of arisen limit cycles.

Key words: Kaleckian economics, macroeconomic dynamic model, equilibrium, stability, limit cycles.

ACTIVE AGEING IN SLOVAK REGIONS

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Abstract

At the turn of the 21st century, all countries in the world are exposed to significant population changes, with demographic aging emerging as the most significant feature. This demographic shift, characterized by an increasing proportion of older people, is particularly pronounced in developed countries and has profound implications. As populations age, the social and health care costs associated with supporting an older demographic gradually rise, placing a significant strain on public systems. One proposed solution to alleviate some of this burden is the concept of active aging. Active aging extends beyond the physical activity of individuals to include their continued involvement in various spheres of life, including social, economic, spiritual, and cultural domains, as well as participation in civic activities. This holistic approach aims to keep older adults engaged and contributing to society, which can, in turn, enhance their quality of life and reduce the financial pressures on public services. To measure the level of older people's participation in the labour market, social activities, and family engagements in European countries, the Active Ageing Index (AAI) was developed. Slovakia is among the countries participating in this international comparison, which monitors various indicators of active aging. The AAI is a composite measure, derived from scores aggregated across four key domains: employment, participation in society, independent, healthy and secure living, and enabling environment. These domains are represented by 22 individual indicators sourced from major European household and individual surveys, providing a comprehensive picture of active aging. The assessment of the level of active ageing in EU countries was carried out at country level between 2010 and 2018, but no uniform methodology has been developed and results at regional level are not known. The paper deals with the assessment of the level of active ageing in the regions of the Slovak Republic. It describes the methodology used in terms of Slovak statistical data sources. It compares the success rate of regional policies at the level of individual active ageing domains. We have used the DEA method to compare the official UNECE methodology for setting weights used in the evaluation of countries and compared the results.

Key words: active ageing, AAI, composite index, regional level, DEA

The work of the authors has been supported by Scientific Grant Agency of the Ministry of Education, science, research and sport of the Slovak Republic and the Slovak Academy of Sciences no. 1/0124/24.

IMPACT OF THE COVID-19 PANDEMIC ON HEALTH CARE REVENUES IN THE CZECH REPUBLIC

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Abstract

There are multiple ways to pay for health care. The first option is to ask the patient to pay directly for the healthcare provided. The second option is to have the health care paid for by health insurance. In the case of the direct reimbursement system, which is used in less developed countries, the patient pays for the health services provided himself. A certain problem with this system is that the patient must have a significant amount of cash available to cover the health service if necessary. In developed countries, systems based on health risk sharing are predominantly used. This principle also works in the Czech Republic. An insured person who makes an upfront and relatively small payment for health care avoids unexpected high expenses in case he or she needs health services. Health insurance allows people to avoid direct health care costs that are relatively large. Public health insurance in the Czech Republic is one of the subsystems of social insurance and is an indispensable part of the Czech health system. The premiums collected are used to pay for health care for the insured, which is financed through health insurance companies. All persons with permanent residence in the Czech Republic must participate in public health insurance and foreigners who are employed in the Czech Republic must also participate. In the Czech Republic, the principle of solidarity is applied, i.e. premiums are paid according to income, but health services are provided according to the needs of the insured. The analysis uses data from the General Health Insurance Company, the largest health insurance company in the Czech Republic, which has the majority of insured persons. A mathematical and statistical method was used to analyse the impact of the Covid-19 pandemic. Using regression analysis, it was found that the greatest dependence between VZP income and the number of insured persons by region of the Czech Republic in 2016, 2020 (the year of the Covid-19 pandemic) and 2022 was for the category of entrepreneurs and a high quadratic dependence between the variables was proved using the adjusted index of determination. The category of insured employees had an exponential type of dependence in all years analysed. For all income categories analysed (for employees, for entrepreneurs and for total number of insured), the highest dependence between variables was shown in 2020, the year of the Covid-19 pandemic, and the lowest in 2016. All models can be considered statistically significant at the 5% significance level. It can be concluded that there is a high dependence between the VZP income and the number of insured persons by regions of the country, and the highest dependence was at the time of the Covid-19 pandemic, when the premium payments were adjusted.

Key words: *Public health insurance, health financing, Covid-19*

THE POSSIBILITIES OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN THE MARKETING MANAGEMENT OF THE COMPANY

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Abstract

The main aim of the paper is to identify the possibilities of artificial intelligence application in the marketing activities of the company. A partial goal is to identify the extent of the current use of AI, as well as to provide examples of good practice in its commercial use. Paper contains the characteristics of the current level of development of artificial intelligence in the marketing sector as well as familiarization with the basic concept, functions and technologies of AI. The research focuses on two aspects. The first examines secondary sources and already conducted research from leading companies in the use of AI in marketing, and the second brings a unique insight into the way in which chosen digital marketing agency Visitero uses and applies AI, ascertained through an own questionnaire research. Significant trends in this area are identified from both analyses.

Key words: *Artificial Intelligence. Management. Marketing. Digital marketing.*

IS THERE ANY CONVERGENCE OF INFLATION PERCEPTIONS IN THE EU ?

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Abstract

Perceived inflation represents an interesting research topic over several decades, however, it gained momentum since the unexpected inflation increase in 2022. In the euro area, the topic is extremely relevant for the smooth and effective conduct of the single monetary policy. The goal of our paper is to identify the existence of convergence dynamic patterns in the consumer inflation perception within the European Union. For this purpose, we use EU Consumers' Quantitative Inflation Perception data for 2004-2023. In addition, we also apply convergence metrics to the ECB Consumer Expectations Survey data available since 2020.

Key words: *consumers, inflation, perceived inflation, convergence, European Union*

NUMBER OF JOBS DURING THE ACTIVE WORKING LIFE OF THE SILVER GENERATION

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Abstract

The silver generation is the term used to refer to the population of people aged 50 and over. Research on this growing group in the European Union is very topical, not only because of the approach taken by the EU authorities, who consider the ageing of the population not as a problem but as a challenge. The number of jobs held during a working life is an important feature of people's behaviour on the labour market. It is also increasing over time. The behaviour of the 50+ population (in our data, people born up to 1967 who turned 50 before 2017) is very different from that of members of generations X, Y or Z. We use Job Episode Panel data (generated on the basis of information included in the Survey of Health, Ageing and Retirement in Europe (SHARE) up to the 7th wave conducted in 2017), which describes the complete life history of respondents from the countries of the European Union and Switzerland from birth to 2017 or end of life. We are interested in the number of jobs at the age of 50 (complete count data) and also at the time of retirement and at the time of leaving the labour force. These data are right-censored count data for those who have not yet reached these moments until 2017, and final values may be higher than observed in the data. We use descriptive methods (tables and figures) to present the variable of interest. Means and variances are evaluated and increasing values are shown based on year of birth as well as dependence on gender, education and country (two groups with and without experience of the communist period) considering year of birth or aggregated year of birth resulting in reaching the age of 50 before or after the fall of an Iron Curtain in 1989. Intensity of changing a job after the age of 50 or even after retirement time is presented to distinguish between behaviour of retired and active respondents. Poisson regression model for count data is used to model the dependence and logistic regression to assess probability of changing job after the age of 50.

Key words: *Poisson regression, SHARE, censored count data*

INTEGRITY SUB-INDEX OF THE GLOBAL PENSION INDEX IN THE CONTEXT OF INDICATOR WEIGHTS

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Abstract

In recent years, the number of seniors has been increasing, the demographic profile of the population is changing, and pension systems are becoming unsustainable for many countries. A stable, efficient, and long-term sustainable pension system needs well-functioning pension plans in the private sector, as state pensions are not sufficient as the only source of pension income. That is why the integrity sub-index includes the quality of private pension plans, as well as the meaningful amount of costs associated with determining the amount of pensions and paying them out in the long term.

This contribution is devoted to the determination of weights for individual indicators of the sub-index of the integrity of pension systems from the point of view of several methods of determining weights in multi-criteria decision-making, which belong to the group of so-called subjective methods: Saaty's exact and approximate method, pairwise comparison method, and Best-Worst method. The contribution offers the determination of the value of the integrity sub-index of the Global Pension Index for Slovakia for the year 2023 based on the criteria of Mercer, which does not yet include Slovakia among the evaluated countries. The method that appears to be the most effective from the point of view of the relatively most accurate determination of the weights is determined.

Key words: *integrity, indicators, weights, Saaty's method, Best-Worst method*

The work of the authors has been supported by Scientific Grant Agency of the Ministry of Education, science, research and sport of the Slovak Republic and the Slovak Academy of Sciences no. 1/0124/24.

REGIONAL PRICE LEVELS IN THE CZECH REPUBLIC – 2020 EDITION

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Regional price levels represent topic that is currently under spotlight; however, regional price levels, which would allow appropriate intraregional comparison, are not officially published. The researcher team of the Prague University of Economics and Business has been dealing with this topic for a decade. The latest estimates for the reference year 2020 have been recently calculated, nevertheless, the results are preliminary and subject to further validation and accuracy improvement.

Obviously, the results may be affected by the covid19 pandemic, even though temporary changes in economy are excluded. At the same time, the results are the latest estimates of regional price levels in the Czech Republic reflecting long-term development in Czech economy and its NUTS 3 regions. On one hand, regional differences are being eliminated as e-commerce is becoming more and more popular. This trend accelerated in 2020 as a response to several lockdowns. On the other hand, real estate and rental markets may be considered more dissimilar. Impact on various product groups will be further analysed.

Key words: *regional price levels, disposable income, EKS*

EVALUATING SUSTAINABILITY PENSION SUB-INDEX WITH BEST-WORST METHOD AND FUZZY BEST-WORST METHOD

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Abstract

Annually since 2009, the Mercer CFA Institute publishes the Global Pension Index, evaluating the pension systems of approximately 47 countries. This assessment includes both developed and less developed countries. However, notable absences include countries such as Russia, Ukraine, Luxembourg, and almost all African countries. Additionally, neither Slovakia nor the Czech Republic is included in the overall pension index. Therefore, our aim is to establish the overall pension index for these countries as well. Another reason for our contribution is that Mercer sets weights for individual indicators without explaining the rationale behind these weights. This lack of transparency can question the validity and reliability of index scores. Our study addresses this gap by providing a detailed explanation and justification for the weights assigned to the indicators within the sustainability sub-index using several multi-criteria decision-making methods such as Saaty's Analytical Hierarchy Process, pairwise comparison, Best-Worst Method, and Fuzzy Best-Worst Method. The Fuzzy Best-Worst Method, in particular, uses triangular fuzzy numbers to handle uncertainty and vagueness in the decision-making process. The Global Pension Index evaluates three main factors: adequacy, sustainability, and integrity of pension systems. The adequacy sub-index assesses retirement income levels and the extent to which pension systems provide sufficient financial support to retirees, considering factors such as minimum pension, net replacement rates, and savings levels. The integrity sub-index evaluates the regulatory framework and governance of pension systems, focussing on transparency, accountability, and protection against fraud or mismanagement. This includes the effectiveness of regulatory oversight and the quality of communication with members. The sustainability sub-index focusses on the future and uses various indicators that affect the likelihood that the current system will provide future benefits. It includes the economic importance of the private pension system, its financing level, the expected retirement duration now and in the future, the participation rate of the elderly in the labour market, current public pension expenditure, government debt, and real economic growth. Key indicators influencing this sub-index are the coverage of private pension plans, demographic factors, and the level of pension assets as a share of GDP. Each index value represents a score between 0 and 100, with higher scores indicating better performance. Our findings indicate that using different weighting methods can significantly impact the sustainability sub-index scores, highlighting the importance of the chosen methodology. Including Slovakia in our analysis provides new information on the sustainability of the country's pension system, providing a comprehensive understanding of its strengths and weaknesses compared to other European nations. This research contributes to the continuous improvement of the global pension index by improving the transparency and justification of the weighting process. It assists policymakers, researchers, and stakeholders in making informed decisions about pension system improvements and reforms. Furthermore, our study emphasizes the need for ongoing

monitoring and adaptation of pension systems to ensure their resilience in the face of evolving challenges. By fostering dialogue and knowledge sharing, we aim to create a collaborative environment conducive to the development of sustainable pension systems worldwide. In conclusion, our research underscores the critical role of robust, transparent, and justified methodologies in evaluating the sustainability of pension systems. By exploring potential synergies between different indicators and methodologies and highlighting the importance of technological advancements and data analytics, we aim to refine the assessment framework for the sustainability of the pension system sustainability. Our findings also stress the importance of interdisciplinary collaboration and cross-sectoral partnerships in driving meaningful reforms and innovations in pension governance, ultimately contributing to more resilient and sustainable pension systems globally.

Key words: *pension system, sustainability, weights, fuzzy best-worst method*

The work of the authors has been supported by Scientific Grant Agency of the Ministry of Education, science, research and sport of the Slovak Republic and the Slovak Academy of Sciences no. 1/0124/24.

FERTILITY RATES IN THE CZECH REPUBLIC: PAST DEVELOPMENT AND POSSIBILITIES OF PROJECTIONS TO THE FUTURE

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Abstract

Three main demographic processes contribute to the changes in populations: births, deaths and migration. The number of live births is a positive item in the population balance, number of deaths negative and migration can be both depending on whether in the immigration exceeds emigration or vice versa. The processes are expressed by demographic indicators such as the fertility rates, mortality rates and net migration. We focus on age-specific fertility rates (f_x) which is the number of children per woman in specific age calculated as the ratio of the number of live births to women at age x (or in a given five- or ten-year age group) to the average state of women at age x (age group). Regarding the age – Czech statistical office observes fertility rates of women from 15 years to 45 years (but the first category includes also younger mothers, and the last category includes also older mothers).

The aim the presentation is to present the current development of the total fertility rates in the Czech Republic and introduce the Lee-Carter model and its adjustments for modelling and the projections of the age-specific fertility rates.

The development of total fertility rates has been changing since 1950 as it depended on many social-economic factors – tangible and more importantly intangible. Fertility rates were the highest in 1950 and started to decrease since that. Increase in the 1970s was related to the economic incentives provided by the communist regime. Uncertain situation after the change of the regime in 1990s caused the decrease in fertility rates which started to grow slowly after that, but never reached original height. In 2021, there was a rare upward swing, which is very unlikely to happen again. Exactly opposite situation happened year after – the 2023 generation was the least numerous in the last 22-year-period, so low fertility rates are expected. While the highest age-specific fertility rates were at the age of 20 in the past, it switched to 30 years in recent years and the distribution of the age-specific fertility rates is closer to normal distribution while originally it was skewed to the left.

Modelling of the age-specific fertility rates by stochastic Lee-Carter model has advantage that previous development of the indicator is taken into account, while older data have lower weight than newer data. However, the main drawback is that fertility rates are influenced also by economic and social variables that are not included in the model. Hence, the projected fertility rates can be than lower or higher than expert guess – for example expected fertility rates in pessimistic, middle or optimistic variant of the Czech Statistical Office in its population projection.

There are several adjustments of the time-invariant parameters a_x and b_x and time variant index k_t of the model that aim on improving of the performance and fit of the model. We present some of them and discuss the impact on the projected age-specific fertility rates.

Key words: *demographic processes, demographic projections, fertility rates, stochastic modelling*

HOW EARLY LOAN REPAYMENT CAN MODIFY THE RESULTS OF SURVIVAL ANALYSIS IN P2P LENDING

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Abstract

This contribution studies online peer-to-peer (P2P) lending and the occurrence of loan default using survival analysis. It focuses on the issue of early repayment of loans, which has not been sufficiently studied in the context of P2P data. This study shows that the consideration of prepayment loans can substantially affect the results for loan defaults in certain aspects. It will also be shown that different approaches to loan prepayment have different effects on identifying the determinants of loan default and on predicting the incidence of default. Moreover, the contribution confirms the expectation that the size of the analysed data set also plays a role in this issue. By analysing loans made by the P2P platform Lending Club with a duration of 60 months, which are generally riskier, the study also complements existing studies. These studies did not consider early repayment of the loan and they either focused only on loans with a duration of 36 months or combined both types of loans. It will also highlight certain specificities of P2P data that need to be kept in mind when evaluating the results obtained.

Key words: *survival analysis; competing risks; default modelling; early repayment of loan; peer-to-peer lending*

COMMEMORATION OF THE 50TH ANNIVERSARY OF THE DEATH OF PROF. JAROSLAV HÁJEK AND HIS TEACHING ACTIVITIES AT THE UNIVERSITY OF ECONOMICS

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Abstract

This year we commemorate the 50th anniversary of the untimely death of the world-renowned Czech mathematician and mathematical statistician, Prof. Ing. RTDr. Jaroslav Hajek, DrSc. (1926-1974). He studied statistics and insurance engineering at the University of Special Sciences (1945-1949), where he graduated as a Doctor of Technical Sciences (1950). During his scientific training at the Mathematical Institute of the Academy of Sciences, he was an external lecturer at the then Faculty of Statistics of the University of Economics. His entire career was connected with the Mathematical Institute and the Faculty of Mathematics and Physics of Charles University, where he was the head of the Department of Mathematical Statistics from 1964 to 1974. He was invited as a visiting professor to the world's leading universities and was elected a member of the International Statistical Institute and other prestigious scientific societies. In the last years of his life, Prof. Hájek struggled with a serious illness, to which he finally succumbed at the age of 48. His professional interests included the theory of sampling from finite populations, nonparametric statistics and random process theory, among others. His bibliography includes more than 50 articles, monographs and textbooks, some of which have become an integral part of statistical theory. Hájek-Šidák's central limit theorem is world-famous and is often the first association of statisticians when Czechoslovakia or the Czech Republic is mentioned. Our paper is organised in two parts. In the first, we discuss Professor Hajek's biography in general. In the second, we comment on the contents of the teaching text prepared for our University for a course on sampling Theory of Sample Surveys (1955) and Hajek's estimator of the population total under the scheme of proportional inclusion probabilities. In finite population (equal and unequal inclusion probabilities or complex samples) sampling, Jaroslav Hajek's contributions to the general asymptotics are fundamental; for this reason, we touch briefly on the problem.

Key words: *prof. Hájek legacy, nonparametrics, sample surveys, history of statistics*

BENCHMARKING OF THE EUROPEAN BANKING SECTORS' EFFICIENCY: APPLICATION OF THE NETWORK DEA

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Abstract

The global financial crisis, sovereign debt crisis, COVID-19, and the invasion in Ukraine highlighted the need to optimise the production processes in banking sectors in Europe. Data development analysis (DEA) is a method used to evaluate the efficiency of production units and to benchmark them. It is an important part of analysing and managing the production processes. The contribution attempts to measure and compare technical efficiency scores of 26 European banking systems in 2020 by using Network-DEA (N-DEA), specifically the two-stage slacked-based model (SBM) by Kaoru Tone and Miki Tsutsui (2009). The methodology of N-DEA allows us to assess the efficiency scores of two sub-processes: the deposit collection process and the intermediation process that reflects the use of deposits for earning assets (loans and purchased bonds).

Therefore, by N-DEA the deposit collection efficiency, the intermediation process efficiency and its overall technical efficiency can be gained. Most banking systems in Europe reveal a large inefficiency in collection of deposits and higher efficiency in intermediation of the deposits into earning assets. The results of our analysis can be interesting for the regulatory institutions of banking sectors at national and European level as well as for the management of individual investigated banking systems. The research reported in this contribution is supported by the grant scheme VEGA 1/0442/22 New DEA models applicable for regulatory purposes in financial and network industries.

Key words: *Performance measurement, Optimization, Regulation, Banking, Network Data envelopment analyses.*

THE GENDER'S EFFECT ON THE CASH FLOWS OF A REVERSE ANNUITY CONTRACT WITH A CRITICAL ILLNESS INSURANCE OPTION

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Abstract

The phenomenon of an ageing population is causing a very large increase in the proportion of pensioners in most European countries. Pensioners are among the groups most at risk of poverty. In Poland, due to the different retirement ages, pensioners are exposed to living in extreme material conditions in retirement. The economic status of married couples is among the factors that most determine their financial situation.

The paper is addresses issues related to the financial protection of pensioners through the usage of various financial and insurance contracts. We consider the model describing the cash flows associated with critical illness insurance combined with a reverse annuity contract. Examples analyse the effect of gender on the premiums and benefits paid under this contract.

Calculations are estimated on the basis of data set concerning the histories of treatment in case of lung cancer for inhabitants of Lower Silesia region.

Key words: *reverse annuity contract, health insurance benefits, effect of gender*

NOTES