

Summary of the publications

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1 Psychometric methods for test assesment

1. D. Dimitrov, Dimitar Atanasov. 2020. *Latent D-Scoring Modeling: Estimation of Item and Person Parameters*. Educational and Psychological Measurement. WoS.

This study presents a latent (item response theory-like) framework of a recently developed classical approach to test scoring, equating, and item analysis, referred to as D-scoring method. Specifically, (a) person and item parameters are estimated under an item response function model on the D-scale (from 0 to 1) using marginal maximum-likelihood estimation and (b) analytic expressions are provided for item information function, test information function, and standard error of estimation for D-scores obtained under the proposed latent treatment of the D-scoring method. The results from a simulation study reveal very good recovery of item and person parameters via the marginal maximum-likelihood estimation method. Discussion and recommendations for practice are provided.

2. D. Dimitrov, Dimitar Atanasov. 2021. *Testing for Differential Item Functioning Under the D-Scoring Method*. Educational and Psychological Measurement. WoS.

This study offers an approach to testing for differential item functioning (DIF) in a recently developed measurement framework, referred to as D-scoring method (DSM). Under the proposed approach, called P-Z method of testing for DIF, the item response functions of two groups (reference and focal) are compared by transforming their probabilities of correct item response, estimated under the DSM, into Z- scale normal deviates. Using the liner relationship between such Z-deviates, the testing for DIF is reduced to testing two basic statistical hypotheses about equal variances and equal means of the Z-deviates for the reference and focal groups. The results from a simulation study support the efficiency (low Type error and high power) of the proposed P-Z method. Furthermore, it is shown that the P-Z method is directly applicable in testing for differential test functioning. Recommendations for practical use and future research, including possible applications of the P-Z method in IRT context, are also provided.

3. Dimiter M. Dimitrov , Dimitar V. Atanasov, Yong Luo (2020) *Person- Fit Assessment under the D-scoring Method*, Measurement: Interdisciplinary Research and Perspectives, 18:3, 111-123, WoS.

This study examines and compares four person-fit statistics (PFSs) in the framework of the D-scoring method (DSM): (a) van der Flier's U3 statistic; (b) Ud statistic, as a modification of U3 under the DSM; (c) Zd statistic, as a modification of the Z3 (l_z) statistic under the DSM; and (d) the nonparametric statistic HT. The data were obtained via DSM-based simulations under a 2x3x3x3x3 design by five conditions: type response behavior (guessing and cheating), sample size, test length, percent misfitting items, and percent misfitting persons. The U_d and Z_d statistics outperformed U3 and HT and demonstrated excellent performance on detecting person misfit. Recommendations for the practice are provided.

4. Dimiter M. Dimitrov & Dimitar V. Atanasov. (2021), *An Approach to Test Equating under the Latent D-scoring Method*. Measurement: Interdisciplinary Research and Perspectives. 19:3. 153-162.

This study offers an approach to test equating under the latent D-scoring method (DSM-L) using the nonequivalent groups with anchor tests (NEAT) design. The accuracy of the test equating was examined via a simulation study under a 3×3 design by two conditions: group ability at three levels and test difficulty at three levels. The results for bias (systematic error) and root mean square error (RMSE; total error) indicated very high accuracy in the recovery of true equated D-scores across all simulation conditions, providing strong support of the proposed approach to test equating under the DSM-L.

2 Branching Stochastic processes and their applications

1. Nikolay M.Yanev, Vessela K.Stoimenova, Dimitar V.Atanasov. 2020. *STOCHASTIC MODELLING AND ESTIMATION OF COVID-19 POPULATION DYNAMICS*. Comptes rendus de l'Acadé'mie bulgare des Sciences, Vol 73, No4, pp.451-460. WoS.

The aim of the paper is to describe a model of the development of the COVID-19 contamination of the population of a country or a region. For this purpose a special branching process with two types of individuals is considered. This model intends to use only the observed daily statistics to estimate the main parameter of the contamination and to give a prediction of the mean value of the non-observed population of the contaminated individuals. This is a serious advantage in comparison with other more complicated models where the observed official statistics are not sufficient. In this way the specific development of the COVID-19 epidemics is considered for different countries.

2. Nikolay M.Yanev, Vessela K.Stoimenova, Dimitar V.Atanasov. 2020. *BRANCHING STOCHASTIC PROCESSES WITH IMMIGRATION AS MODELS OF COVID-19 PANDEMIC DEVELOPMENT*. Comptes rendus de l'Acadé'mie bulgare des Sciences, Vol 73, No11, pp.1489-1498. WoS.

A special class of two-type branching stochastic processes with immigration is proposed to describe the Covid-19 pandemic development. The model is constructed to use only the observed daily statistics and to estimate the main parameter of the infection. In this way a forecasting of

the mean value of the non-observed population of the infected individuals is available. This is an advantage in comparison with other more complicated models where the officially reported data are not sufficient for estimation of the model parameters. The development of the Covid-19 pandemics is considered for all countries as it is presented in the specially created site <http://ir-statistics.net/covid-19> where the obtained results are updated daily.

3. D. Atanasov, Vessela Stoimenova & Nikolay M. Yanev (2021). *Statistical modelling of COVID-19 pandemic development applying branching processes*. Journal of Applied Statistics. WoS.

In this paper, a statistical model for COVID-19 infection dynamics is described, using only the observed daily statistics of infected individuals. For this purpose, two special classes of branching processes without or with an immigration component are considered. These models are intended to estimate the main parameter of the infection and to give a prediction of the mean value of the non-observed population of the infected individuals. This is a serious advantage in comparison with other more complicated models where the officially reported data are not sufficient for estimation of the model parameters. The model is applied for different regions in the world and the corresponding parameters of the infection dynamics are estimated.

4. Dimitar Atanasov, Vessela Stoimenova and Nikolay M. Yanev. (2021). *Branching Process Modelling of COVID-19 Pandemic Including Immunity and Vaccination*. Stochastics and Quality Control. SCOPUS.

We propose modeling COVID-19 infection dynamics using a class of two-type branching processes. These models require only observations on daily statistics to estimate the average number of secondary infections caused by a host and to predict the mean number of the non-observed infected individuals. The development of the epidemic process depends on the reproduction rate as well as on additional facets as immigration, adaptive immunity, and vaccination. Usually, in the existing deterministic and stochastic models, the officially reported and publicly available data are not sufficient for estimating model parameters. An important advantage of the proposed model, in addition to its simplicity, is the possibility of direct computation of its parameters estimates from the daily available data. We illustrate the proposed model and the corresponding data analysis with data from Bulgaria, however they are not limited to Bulgaria and can be applied to other countries subject to data availability.

3 Application of statistical methods

1. Penka Yordanova Hristova, Dimitar Vladislavov Atanasov *Българска Адаптация на Скалите за Емоциите „Надежда“, „Отегчение“ и „Безпомощност“ от Въпросника за емоции, свързани с ученето и училището (Част I): НОБ Скала за Емоции в Часовете*. Psychological Thought, 2021, Vol. 14(1), 226-251. SCOPUS.

The Bulgarian adaptation of the “hope”, “boredom” and “hopelessness” scales of the Achievement emotions questionnaire (AEQ) was accomplished within a representative sample of 800 students. The Confirmatory and Exploratory analyses revealed that the 3 factor model with the three discrete emotions (hope, boredom, and hopelessness), standing for each of the individual factors, had an adequate fit. The reliability of the adapted scales is good ($.80 < \text{McDonald's } \omega < .90$). The validity of the instrument assessed with the between-scale correlations of the adapted scale (positive correlation between the same emotional valence and negative correlation between the different emotional valence scales) and the correlations between the adapted scales and the subject grade, GPA, and state exam grades of 7th graders are theoretically and empirically consistent. The same results for the reliability, validity, and internal structure of the adapted scale were confirmed in a subsequent study with an independent sample of 255 respondents.

2. Atanasov, Dimitar and Manev, Krassimir and Stoimenova, Vesela and Voynova, Ralica, THE TEST TASKS FROM THE STATE MATRICULATION EXAMINATION FOR THE INFORMATICS PROFILE DURING THE ACADEMIC YEAR 2021-2022. MATHEMATICS AND INFORMATICS. 2023. 66. 1. DOI 10.53656/math2023-1-5-the. ISSN: 1310-2230. WoS.

In the academic year 2021/2022, the first class of Informatics Specialization in Secondary school Informatics graduated and the first State Matriculation Examinations were held for the graduates of the specialization. This article makes some quantitative and qualitative evaluations of the results of this part of the exam, containing multiple-choice and open-ended questions. The obtained results would be useful for improving the test part of the exam in preparing the topics for subsequent exams.