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SAE EDUCATION CHALLENGES TO ACADEMICS AND NSI[1]

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ABSTRACT

The aim of the paper is to present some experiences in teaching Small Area Estimation (SAE). SAE education experiences and challenges are analysed from the academic side and from the NSI side. An attempt was undertaken to discuss SAE issues in a wider perspective of teaching statistics. In particular, the topics refer to Polish conditions, but they are presented against the background of selected international experiences and practices. Information comes from a special inquiry - a survey conducted among employees of statistical offices and academics from universities involved in SAE research. A further issue is inclusion of SAE in the EMOS project (European Master in Official Statistics). The survey is extended with information collected by monitoring of trainings and projects organized by the leading centres dealing with SAE. The results obtained are related to a similar survey within Eurostat project: ESSnet on Small Area Estimation, which was conducted in 2010. The study includes interest in learning and the need to implement SAE methodology, a range of subjects taught as well as a range of applications, forms of training, type of courses, software used and teaching methods. In particular, it intends to answer how strong the interest in small area estimation is, what the demand for practical and theoretical knowledge in the field is and what the recommendations for universities and statistical institutes are.

Key words: Small Area Estimation, statistical education.

[1] The paper is based on presentation prepared for the international conference on Small Area Estimation SAE 2014, which was held in Poznan (September 2014). The author wishes to thank T. Klimanek, who was the co-author of the *Survey on teaching, use and/or development of SAE methods*, for his help and inspiration.

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1. Introduction

"Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write" (Samuel S. Wilks[3]). In the society of today, where every day we are inundated with a lot of information, the problem of statistical education is gaining greater and greater importance. The question of misunderstanding or misinterpretation of statistical data can be viewed in terms of the consequences. In addition to global issues, particular attention is paid to information at the local level, as it usually involves problems that are close to most of us.

The question of statistical education is extremely extensive and beyond the scope of this study. We restrict ourselves to one area of statistical research, which is Small Area Estimation (SAE). Conference on SAE held in Poznan in September 2014 was an occasion to raise a question on teaching SAE methods, its understanding, demand for specialists and problems connected with its applications. Justification for such limitation can be sought in the growing interest in this field of research and its importance. The history of modern survey sampling dates back to the mid of the 20th century when it grew considerably due to scientific developments, among others, in the work of Jerzy Neyman, Sir Ronald Fisher and Karl Pearson. Over time the range of topics investigated using survey methods has broadened enormously. We are witnessing an increasing demand for estimates at a lower level of geographic division than broad regions or countries. This is due to the growing importance of detailed information in policy-making, programs, allocation of government funds, in creating policy to ensure a balanced regional development. In response to this demand, in the mid-eighties of the last century, in May 1985 an international symposium was held in Ottawa. It was a joint initiative of Statistics Canada, The Laboratory for Research in Statistics and Probability of Carleton University and the Department of Mathematics and Statistics at the University of Montreal. This conference was certainly a very important event in the development of small area statistics. Many studies refer to it as a starting point towards the development of this field of statistical research. Small area estimation is particularly important for countries that undergo economic and social transition, in Central and Eastern European Countries, because of the decentralization process, development of free market economy, transfer of management to local authorities.

It should be stressed that the philosophy of small area statistics reflects holistic transformation of statistical research observed recently. First of all, it is the use of information from a variety of sources, including administrative registers (Wallgren and Wallgren 2007, 2014, Zhang 2012), estimation based not only on sample data, frequentist and model-depended approach (Ghosh and Rao 1994,

[3] This is a quote from the presidential address in 1951 of mathematical statistician Samuel S. Wilks to the American Statistical Association (JASA, Vol. 46, No. 253., pp. 1−18). Wilks was paraphrasing H. G. Wells from his book Mankind in the Making (full H.G. Wells quote is available at: http://osu.causeweb.org/cwis/SPT-FullRecord.php?P=FullRecord&ResourceId=1240).

Ghosh 2001, Rao 2003, Fuller 2009, Datta 2009, Burgard et al. 2014), model selection and checking (Datta at al. 2011, Pfefermann 2011), covariate selection, linear mixed models (Rao et al. 2014, Torabi 2015, Chambers et al. 2013), variance estimation (Maples, Bell and Huang 2009, Graf and Tillé 2014.), simulations, bootstrap (Burgard and Münnich 2014), calibration (Särndal 2007), benchmark (Hidiroglou and Smith 2005, Gosh at al. 2014), methods dealing with non-response (Särndal and Lundström. 2005, Longford 2005), data quality assessment (Wallgren and Wallgren, 2013) and many many others.

In particular, the aim of this paper was to present experiences and needs for teaching Small Area Estimation. Experiences in education and challenges were analysed, from the academic side and from the side of official statistics (National Statistical Institutes - NSIs). The study was aimed at answering the following questions:

- What is the experience in SAE methodology?
- How strong is the interest and demand for SAE methods, application, and teaching?
- What are the main problems in teaching SAE?
- What kind of risk should be considered when applying SAE?
- What are the most important sources of information on SAE developments?

The analysis allowed presenting differences in perception of particular SAE problems from the perspective of different institutions. When possible, changes observed in time were presented by referring to the results of the research conducted within Eurostat ESSnet project on SAE in 2010 (European Statistical System - ESS functions as a network). Answering formulated questions defined the structure of this paper. It starts with presenting the data and experiences of the surveyed institutions in SAE. The forms of activity in SAE, theoretical research and applications in the NSIs and at universities are compared. In the next section interest in teaching SAE is discussed by presenting needs for education and forms of teaching. The most important problems regarding teaching SAE are the subject of the third section. Risks and challenges in teaching SAE are discussed. It is followed by fourth section presenting an analysis of issues that attract special attention in a more general perspective of the European Statistical System, European Statistical Training Programme (ESTP) or European Master in Official Statistics (EMOS) project. Opinions on subjects that require special training as well as sources of information on SAE methodology are shown. Finally we summarize the results and draw some conclusions.

2. Experience in small area estimation of the surveyed institutions

Apart from assessing the progress in the development of Small Area Estimation methodology, this study addresses the issue of experiences and needs for teaching SAE. It was not an easy task, as knowledge in this area is not systematic. So in order to fulfil the aim of the study, to answer the formulated

questions on SAE education, a special inquiry was conducted. Two questionnaires were prepared, one for institutions and the other for individuals. This distinction was introduced as not all questions were relevant to both institutes and researchers at universities (e.g. concerning the forms of teaching activities). But there were only small differences between both versions. Usually there were just slight changes in formulating questions. The questionnaires were sent via e-mails, but some of them were collected during the SAE 2014 conference in Poznan. The structure of the questionnaire responded to the objective of the study. It consisted of 11 questions regarding: experience in SAE, interest in teaching and demand for SAE methodology, problems and challenges for teaching and practical application as well as sources of information on SAE.

To obtain information a mailing list of people and institutions involved in SAE research and projects was used. This was the list prepared to disseminate information on SAE 2014 conference organized in Poznan. The mailing list contained addresses of statistical institutes of the European countries, especially those participating in Eurostat Projects on SAE, but also from other countries that had been previously involved in cooperation on this subject (it was an updated database used in a survey conducted within ESSnet on SAE project in 2010). In addition, the mailing list included addresses of scientists and researchers whose field of study is indirect estimation, who published articles on this subject, participated in earlier conferences organized by EWORSAE Council (European Working Group on Small Area Estimation) or ISI satellite conferences (e.g. The First Asian ISI Satellite Meeting on Small Area Estimation in Bangkok, September 1-4, 2013).

As a result of the survey 60 responses were obtained: 19 from statistical institutes and 41 from university researchers. Almost a half of the responses in the survey came from Poland (5 of statistical institutes and 22 from academics). In this way, the study reflects also perception of the role of SAE, as well as the possibility of its practical applications, and the demand for education in this field in Poland. It should be underlined that Poland is a country experiencing economic transformation and developing regional self-government, so there is a possibility of making comparisons with the results obtained for other countries. Thus, while discussing selected issues, they are accompanied by a reference to the situation observed in Poland.

The study obtained information from statistical institutes of different countries around the world. It should be emphasized that these are the countries with different systems of official statistics and using different methodology in statistical surveys. Among the countries whose statistical institutes participated in the survey, one can specify: Albania, Austria, Canada, Hong Kong, Japan, Kosovo, Latvia, Lithuania, Moldova, Romania, Slovakia, Suriname, Ukraine, USA. A comment might be added on the participation of the Statistical Institute of the Russian Federation in the survey. In this case a response was received that Rosstat does not conduct research on small geographic areas and for this reason cannot fill in the attached questionnaire.

Analysing responses of individuals, it can be noted that among 41 scientists who responded to the survey, about a half were Poles (22 persons). The remaining 19 participants of the study were researchers from countries like Australia, Canada, Finland, Italy, Japan, Norway, Spain, UK and USA.

In any case, the study was of no sample survey character. Nevertheless, the results are not only interesting, but also can be helpful in assessing the needs as well as identifying areas of further research. Additionally, the answers obtained often satisfied the 'saturation' condition used as a criterion for the number of in-depth interviews in sociological research.

Assessing respondents experience in SAE, one should remember that the mailing list contained people and institutions that were earlier involved in some kind of research on this subject. Apart from unrepresentativeness of the sample, it is worth noting that participation in seminars and conferences was also one of the forms of experience, as outlined in the next question. Thus, it can be expected that in each case at least minimal experience would be indicated. Meanwhile, despite a significant increase in experience, 13% of respondents admitted a complete lack of experience, as compared to the survey conducted four years earlier.

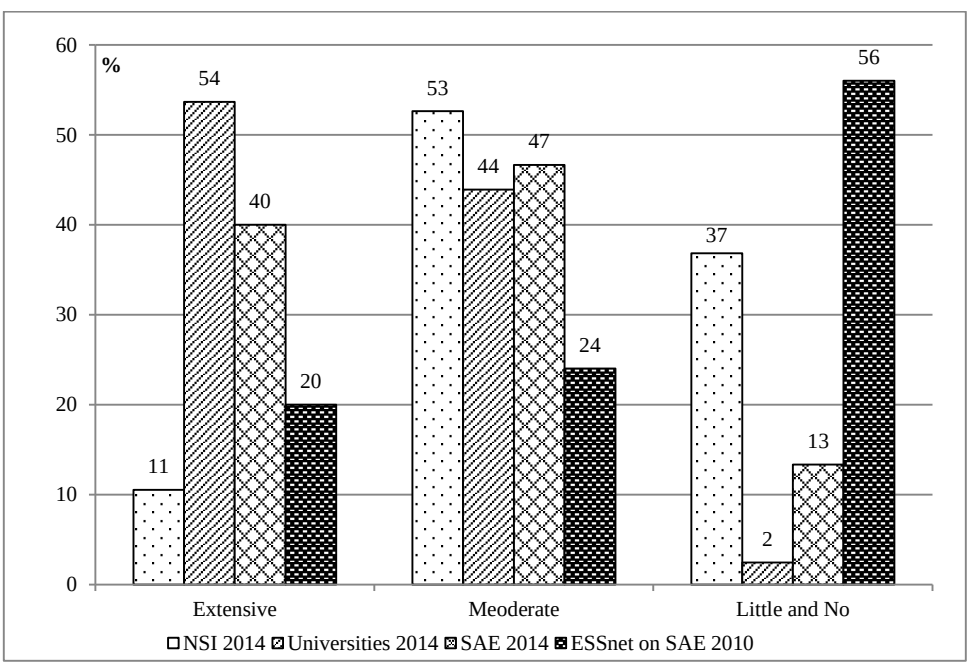

Figure 1. Experience in Small Area Estimation in surveyed institutions (%)

Source: Survey on teaching, use and/or development of SAE methods, July 2014, M. Szymkowiak, Report on the analysis of questionnaires used in WP 2, ESSnet on Small Area Estimation, 2010.

In 2010, the most of NSIs participating in the ESSnet survey admitted to have little experience when it comes to small area – 56% (see fig. 1). Four years later, the majority (64%) of the surveyed NSIs declared moderate (53%) or even extensive (11%) experience in SAE. Nevertheless, still 37% of them admitted to have little or no experience. There is no information to determine a similar trend among individual researchers at universities. Note, however, that among those surveyed, more than a half (54%) declared very extensive, with a further 44% of moderate experience in SAE. A result suggesting nearly 100% interest in the subject should not be surprising since the survey covered statisticians involved in this area of research and their opinion is the subject of analysis below.

It is interesting to compare forms of experience of the NSIs and universities (see tab.1). Statistical Institutes pointed primarily to practical applications as a basic form of activity in SAE (37%). However, among the academics scientific work and participation in seminars and conferences was the dominant form of experience (to the same extent, 51% of responses).

Table 1. Experience in Small Area Estimation by form of activity (%)

Form of experience in SAE	NSIs	Universities	Total
Theoretical (e.g. scientific research, literature studies)	16	39	32
Scientific research including:	16	51	40
Experimental research (e.g. simulations carried out on unreal data)	5	32	23
Development research (e.g. comparative analyses conducted on real data, assessing quality of the estimates, testing different estimators, models, etc.)	16	49	38
Practical applications (published estimates)	37	41	40
Scientific conferences, seminars and discussions	21	51	42
Teaching	16	27	23
Participation of NSI/your institution employees in lectures, seminars, courses	16	34	28
Joint projects (Eurostat etc.)	11	32	25
None	0	2	2

Notice: Percentage of the number of indications among a specified group of respondents. There was a possibility of choosing more than one issue and therefore the percentages do not sum to 100%.

Source: Survey on teaching, use and/or development of SAE methods, July 2014.

For statisticians from NSIs, the attendance in conferences and seminars was the second most common form of experience (21%). Other types of activity may be divided into two groups. The first is theoretical, scientific, and development research (16%). The second group is associated with teaching SAE: organizing and conducting courses, as well as participation in training and lectures (16%).

On the other hand, as for the experience indicated by academic teachers, development (49%) and theoretical (39%) research as well as practical applications (41%) should be emphasized, in addition to the already mentioned scientific work. Participation in lectures and joint research projects (e.g. Eurostat) could also be mentioned among important forms of SAE activities (34-32%). It is worth noting that teaching SAE (27%) was not the most common form of activity among academics.

Summarizing the results obtained for all the respondents, seminars and conferences (42%), as a forum for exchange of knowledge and experiences, are the most common form of activity as concerns SAE. In terms of frequency, the second and certainly no less important form is scientific research and practical applications (40%).

3. Interest in teaching and demand for sae methodology

The purpose of the study was, inter alia, a practical review feedback on the training needs of SAE. Among statisticians, there is a common belief in the need for education of SAE. This seems understandable among people who are engaged in this field of statistical research. The need for practical research is raised in almost in every study on this subject (see Platek et al.1987, Rao 2003). Clearly due to this belief the need for training seems to be understandable. However, it is also noted that statisticians and researchers who do not deal with indirect estimation often express their willingness to treat it as a cure-all for any shortcomings on the availability of data and estimation problems.

The results from the survey show that researchers who were themselves involved in SAE considered the need for NSI staff with methodological knowledge on indirect estimation as great (42%) and moderate (41%, see fig. 2). None of respondents participating in the survey considered education in this field as unnecessary. Comparing the opinions expressed in this regard by NSIs and Universities, we note that the frequency of indicating very big demand was twice as high for the official statistics (26%), compared to 13% among academics. This resulted in more often expressed moderate opinions on the educational needs among academics than official statisticians.

The results presented above seem to be very reasonable. They reflect strong demand for small domain estimates, articulated by official statistics and other recipients of their products. On the other hand, the results obtained for academics, confirm the importance of and the need for training, but keep a greater distance.

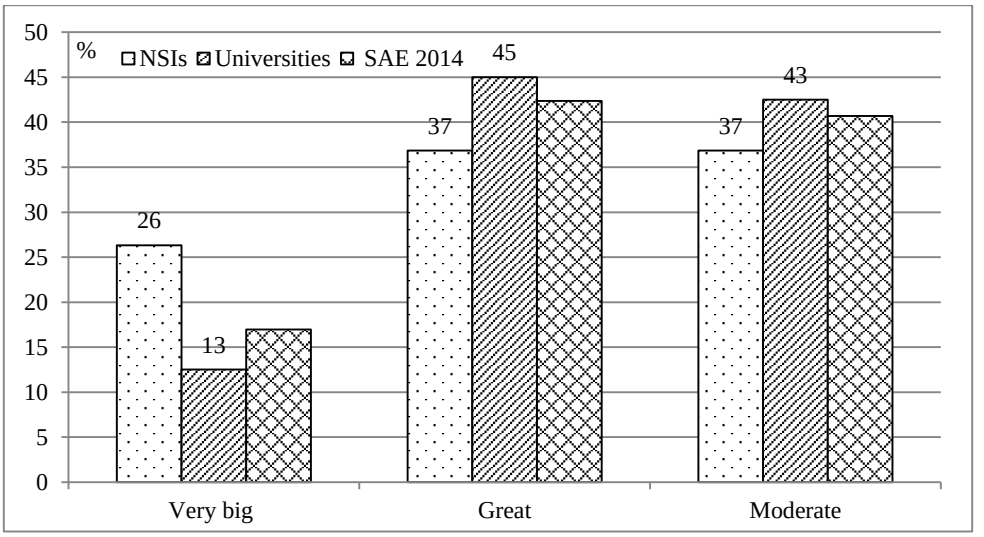

Figure 2. Need for education of NSI staff in SAE methodology in the opinion of NSI and Universities (%)

Notice: Percentage of the number of indications among a specified group of respondents. There was a possibility of choosing more than one issue and therefore the percentages do not sum to 100%.

Source: Survey on teaching, use and/or development of SAE methods, July 2014.

The results of the study do not allow us to say with certainty what is the demand for experts in SAE. Analysing the opinions expressed in the survey, it should be noted that the majority (58%) of respondents from NSIs agreed with the statement that SAE is one of the most desirable area of study. Additionally, almost all NSIs stressed that they do not employ specialists in SAE.

Analysing the demand for statisticians, specialists in specific methods of research, a question about the most important issues that require increased knowledge of NSI's staff, was included in the questionnaire. It was addressed to both statisticians from universities and from statistical institutes, allowing a choice of several of the listed options. The results obtained fully meet the requirements of the era of Modern Information and Communication Technology (ICT). The majority of respondents (65%) indicated training in statistical software as the most important issue: 745% of statisticians working in NSIs and 61% from universities (fig. 3).

It is also worth noting that in the students' opinion (e.g. of those who study Computer Science and Econometrics at the Poznan University of Economics, see PKA, 2014), modules for teaching specialized software are of special interest. Therefore, in order to attract a specific field of study, an educational offer often found objects taking into account that demand (e.g. Practical Data Science with R, Data Mining with SAS Enterprise Miner, The statistical analysis of market research with IBM SPSS Visualization and reporting of statistical data R / SAS).

An increasingly common practice is also to offer students a choice of training modules that allow them to obtain additional certificates honoured in the labour market (e.g. SAS Global Certification program, SPSS certificate of Expert Technology, SAP certificate).

Table 2. Most important issues that require increased knowledge of NSI's staff in the opinion of NSIs and Universities

Methodological issue	**NSIs**	**Universities**	**Total**
Sampling	9	14	23
Calibration	8	8	16
Spatial analysis, e.g. GIS	13	19	32
Big Data	8	13	21
Software (SAS, R, SPSS, etc.)	14	25	39
The choice should be left to individuals to be compatible with their interests	5	10	15
There is no need for NSI staff to train in any area	0	0	0
Other, what?	0	2	2
Number of Respondents	**19**	**41**	**60**

Source: Survey on teaching, use and/or development of SAE methods, July 2014.

Coming back to the most important problems that need to broaden the scope of teaching, the second most common group, as in the opinion of the NSIs (68%) and academics (46%), are methods of spatial analysis (53% of all respondents, see fig.3 and tab. 2). These are very important issues that are becoming more and more popular, among other things, due to the development of Geographical Information Systems (GIS). But it is worth noting also a direct relationship of spatial analysis methods to SAE, which is also reflected by the most common use of indirect estimation. This is also visible in the most commonly used term for this area of research: Small Area Estimation instead of Small Domain Estimation.

Sampling is only third in the 'ranking' of the most desirable skills. The survey does not mention explicitly SAE as an important problem that requires a broader education. However, respondents had the opportunity of individual declarations. Only two out of 60 surveyed took advantage of this opportunity. Among these were indications of modelling, especially for large, complex data sets and statistical inference. None of the respondents pointed directly at SAE. Perhaps this is a result of a mature approach, indicating particular problems that are of great importance in improving the quality of indirect estimation, or simply SAE is considered as an integral part of the sampling methodology.

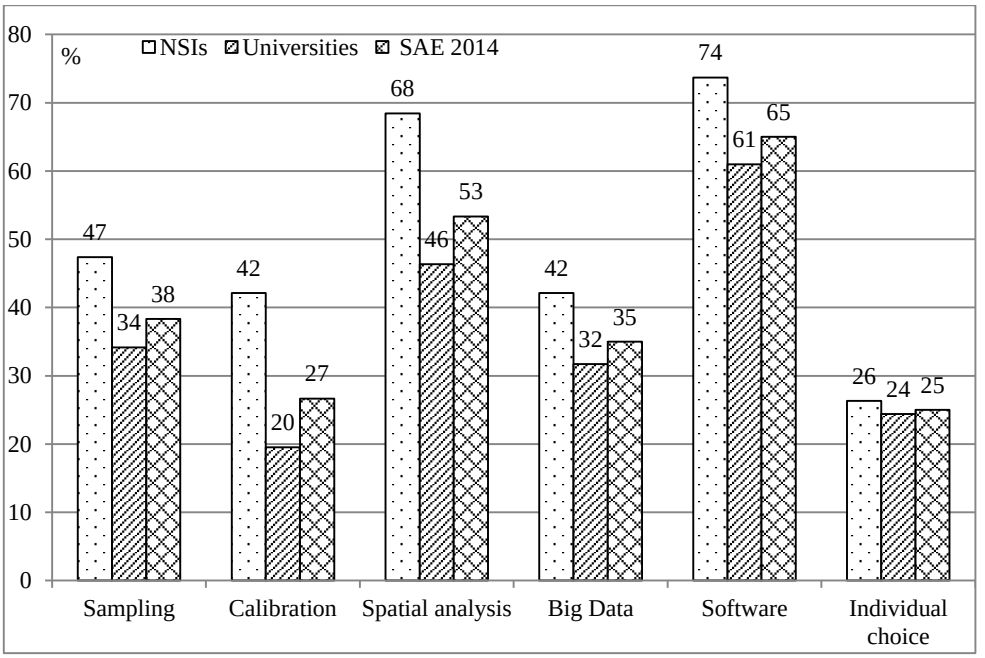

Figure 3. Most important issues that require increased knowledge of NSI's staff in the opinion of NSIs and Universities (%)

Notice: Percentage of the number of indications among a specified group of respondents. There was a possibility of choosing more than one issue and therefore the percentages do not sum to 100%.

Source: Survey on teaching, use and/or development of SAE methods, July 2014.

The above considerations should be complemented by another comment. The survey results indicated a much greater demand for skills in calibration reported by NSI staff (42% of responses) compared to 20% of such opinion among academics. It is understood that the demand for the ability to calibrate is much more appreciated by statistical institutes than among academics. One might be surprised by 10 percentage points difference in the number of indications of the importance of education in the area of Big Data. It was observed that 42% of responses on the significance of this issue was among statisticians from NSIs compared to 32% among academics. Big Data still raises lively discussion, many doubts and controversies.

4. Experience in teaching SAE, problems and challenges

Information on SAE education was obtained from surveyed statisticians who worked at universities. Academics were asked if their universities were teaching SAE. It turned out that SAE teaching experience was not large. Among surveyed respondents about 44% declared teaching SAE at their universities. But SAE

education was rather not a part of regular lectures. Regular SAE courses are taught only at few universities, these are University of Southampton, Pisa, Trier, Helsinki, and University of Maryland and University of Michigan (Lehtonen 2014). Often basic information about SAE methodology was presented during other modules and lectures. In most cases these were seminars during master or post-doctoral studies.

Trainings and workshops organized in connection with scientific conferences were another often practiced forms of education in SAE. A similar form was taken by SAE dissemination among the employees of the institutions concerned. Trainings and workshops organized for special needs of other institutions, such as statistical offices were also listed among other forms of SAE education.

Trainings were one of the most common forms of education in SAE. They were organized both by universities, as well as NSIs. There were at least a few centres offering trainings and courses on SAE. The following list is not complete, but one could mention here University in Southampton with a 10 year long tradition of Southampton Statistical Sciences Research Institute, Universities in Helsinki, Pisa, Trier, Pompeu Fabra University in Barcelona, Statistics Finland and Istat (Italian National Institute for Statistics). Particularly noteworthy is the European Statistical Training Programme (ESTP) offered by European Statistical System (ESS). ESS is the partnership between Eurostat (with a leading role) and NSIs that are responsible for the development, production and dissemination of statistics. The purpose of the ESTP is to provide the opportunity to participate in international training courses at postgraduate level and other learning opportunities.

Another important ESS initiative was the establishment of the European Master in Official Statistics (EMOS) project. EMOS is an infrastructure project aimed at developing a programme for training and education in official statistics within existing master programmes at European universities. Increasing demand for quality information is widely recognized implying a strong investment in training of statistics. Programs like EMOS can be a part of the answer to these needs (Sorvillo, 2014). EMOS is planned to provide certified training in methodologies, statistical surveys, statistical production, analysis and statistical law and should be offered by a network of NSIs and Universities. Among others, *Survey methodology* and *Small Area Estimation* are in the list of elective courses.

Statistical software used in SAE was already discussed, but it still certain focus. ICT and software used in indirect estimation, modelling, simulations, bootstrap, etc. is of significant importance to the development of SAE. Therefore, compatibility of software used in NSIs and at universities for educational purposes might be desirable.

In the SAE2014 survey, 13 out of 19 NSIs expected knowledge of special statistical software, pointing SAS as the most preferable. However, the most popular software used in SAE, both in teaching and scientific research, was R. It was indicated almost twice as often as SAS (51% of respondents versus 28%, see fig.4). SAS software was used mostly in the NSIs, but becomes less popular

among academics. Other software, like Bugs, WinBugs or SAS were rarely indicated. There were also institutions, like, e.g. Statistics Canada, which declared to develop their own, very flexible software for SAE.

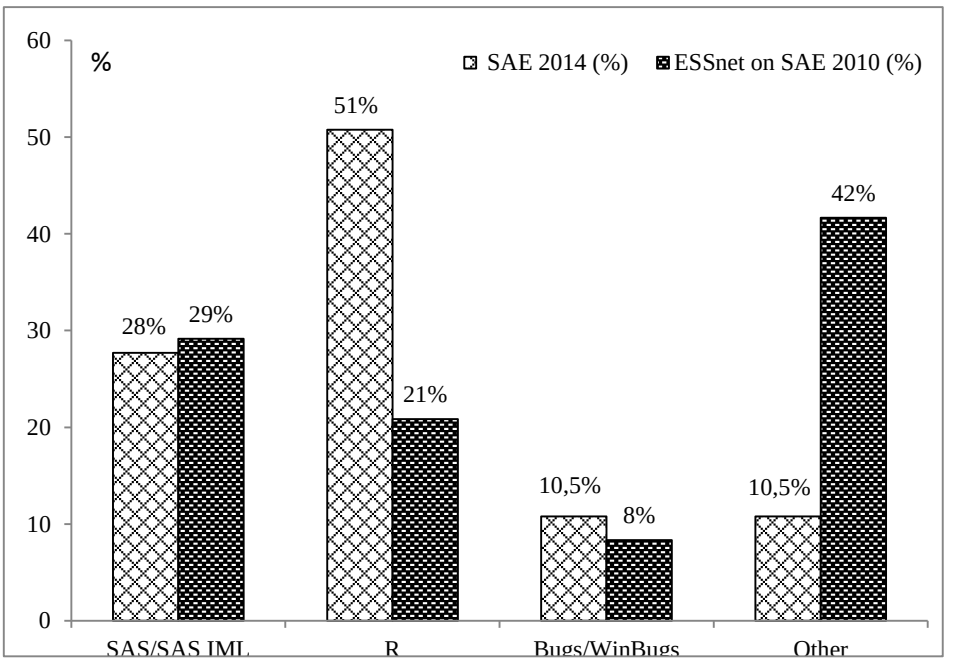

Figure 4. Software used in Small Area Estimation (%)

Source: Survey on teaching, use and/or development of SAE methods, July 2014, M. Szymkowiak, Report on the analysis of questionnaires used in WP 2, ESSnet on Small Area Estimation, 2010.

Comparing trends observed in time, once again a huge increase in popularity of R should be stressed. A good illustration would be the fact that in 2014 80% of all responses were indicating R, while in 2010 it was 21%. In this sense, the implementation of SAS is also gaining popularity, as in 2010 its score was 29% of responses in comparison to 44% in 2014. The increasing use of R and SAS program was associated with a clear reduction of interest in other software.

In the discussion so far the need for teaching of statistics was underlined, in particular small area statistics. But the results obtained show relatively little interest, with a very small number of universities, where SAE teaching programs were implemented. Recognizing these difficulties, a request to identify problems and challenges in teaching SAE was formulated. Subsequently a question about problems and risk in applying SAE was asked.

At first, the problems in teaching SAE will be discussed. The question on problems was of an open form. Answers collected here were divided into four groups. The first group contained statements indicating a lack of adequate

preparation of students. The second one consisted of indications showing low awareness of not only the demand for specialists in SAE, but of ignorance of the existence of such a field of statistical research in general. In the third group demands on improving the attractiveness of classes of small area statistics were placed. The last group included suggestions to use the uniqueness of SAE for the dissemination of knowledge. It seemed to be worth listing to some of the opinions expressed in the survey, as it was thought of as a tool to share different views on the problem and how to cope with it.

1. Inadequate preparation among students
   - Students are not sufficiently prepared
   - Made it more understandable for students
   - Lack of sufficient knowledge of mathematical statistics
   - Problem with understanding basic methods in survey sampling, not only SAE
   - Some potential students may not be very familiar with statistical modelling or Bayesian inference
   - Lack of knowledge of statistical software
2. Low awareness of SAE as the field of statistical research
   - Low awareness of the need for knowledge and the development of SAE methods
   - Little popularity of the field
   - Small number of experts
   - Lack of textbooks in Polish
   - Use basic sampling course to generate interest of students in SAE
   - Reluctance of students to quantitative subjects
   - Recognition of the purpose of SAE
3. The attractiveness of classes
   - Careful preparation of teaching materials which allows full interaction between participants and the lecturer
   - Case studies based on actual research and applications
   - Incorporation of recent deliverables in teaching
   - More extensive use of multivariate data analysis in SAE, especially in the selection of auxiliary variables
   - Teaching students to build appropriate statistical models for use in SAE
   - Linking SAE and GIS
4. Unique challenges
   - Process approach to teach small area statistics - use of different methods and data sources
   - Understanding the capabilities and limitations of SAE
   - Teaching students to realise the difference between practical and theoretical approaches to SAE

– Make people understand the differences between the different approaches for inference (design-based, model-assisted, model-based).

The question about problems with teaching SAE somehow forces the question of problems and risks associated with the use of SAE methods. If they were commonly known and used in the majority of research and analysis, it can be assumed that they would be more familiar. Knowledge of these methods would identify the demand for specialists and experts in the field. So, it is worth to consider problems and risks arising from the use of SAE methodology. In addition, SAE methods require highly advanced knowledge, it is rather impossible to teach them at primary level. They are difficult and, as pointed above, student's knowledge is often insufficient to pass a basic course in survey sampling.

The respondents participating in the survey emphasized mainly bias of indirect estimators (62% of respondents, see tab. 3) and model-based approach (50%) as primary risks of practical application of SAE methods. More often the bias problem was pointed by academics than statisticians from the NSIs. Statisticians in official statistics institutions most frequently emphasized difficulty in variance estimation (53%), what in comparison to opinion of academics and all respondents was in fourth place. This relationship may seem a bit surprising, as NSIs put great emphasis on quality of the estimates (including not only accuracy but also unbiasedness).

Table 3. Problems and risks of applying SAE in official statistics (%)

Problems and risks	**NSIs**	**Universities**	**Total**
Small sample size	42	39	40
Bias of indirect estimators	47	68	62
Model dependent approach	42	54	50
Difficulty in estimating the variance	53	32	38
There are no risks	5	2	3
Other	11	2	5

Notice: Percentage of the number of indications among a specified group of respondents. There was a possibility of choosing more than one issue and therefore the percentages do not sum to 100%.

Source: Survey on teaching, use and/or development of SAE methods, July 2014.

Among statisticians from universities, a small sample size (39%) and the difficulty in estimating variance (32%) were mentioned as less important.

The frequency distribution indicating importance of such problems as sample size, bias, model dependent approach and variance estimation, was more uniform among statisticians from NSIs. 11% of responses from NSIs indicated “Other” issues, not specified in the study of problems in application of SAE. These results

clearly show the difference between NSIs and universities. This is probably associated with the difference of the statutory tasks of both institutions: providing estimates and education, while the development of science is the common denominator.

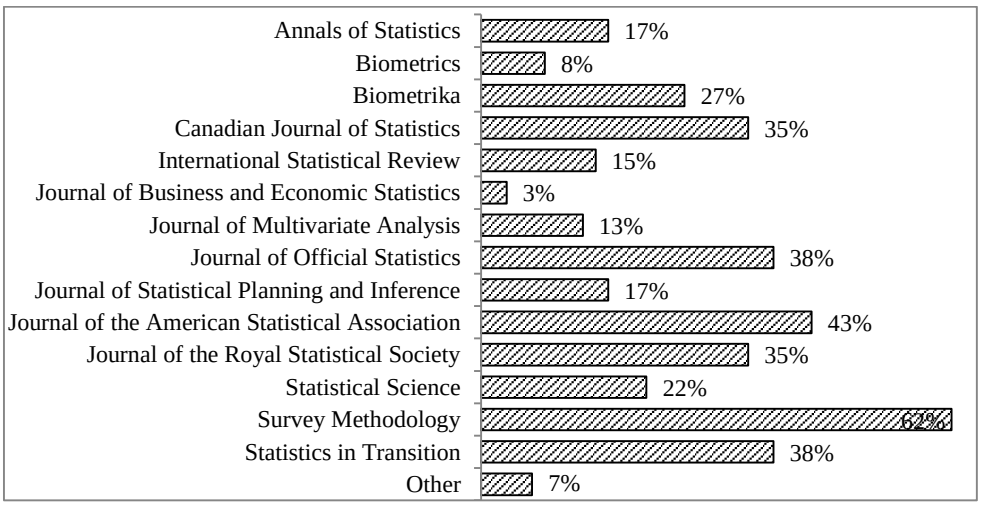

Figure 5. Main sources of information on SAE methodology and applications (%)
Source: Survey on teaching, use and/or development of SAE methods, July 2014.

Development of SAE methodology needs deepening and dissemination of knowledge and information about proposals of new methods, results of the research conducted and simulation. Statistical literature is very extensive. As regards SAE the most specialized scientific journals are: Survey Methodology (62%), Journal of the American Statistical Association (43%), Journal of Official Statistics (38%), Statistics in Transition (38%), Canadian Journal of Statistics (35%), Journal of the Royal Statistical Society (35%), Biometrika (27%) (see Fig. 5).

SAE is a relatively new area of statistical research. People dealing with these topics mostly know each other (if not personally, then through papers and via Internet). R. Lehtonen (2014) defines this as SAE "ecosystem". Its important part includes conferences and seminars organised by international organisations like International Statistical Institute or International Association of Survey Statisticians. Important contributions were made by conferences in Jyväskylä, Pisa, Elche, Trier, organized within the framework of the European platform called EWORSAE, that is European Working Group on Small Area Estimation which was founded in 2007 in Pisa.

Other components of SAE "ecosystem" mentioned by R. Lehtonen are those of U.S. SAIPE Program: Small Area Income and Poverty Estimates (Kalton and Citro 2001). On the European side there are European Union Framework Programmes for Research and Technological Development (FP) research projects

conducted by Universities and NSIs. Several projects could be mentioned here: EURAREA, AMELI, SAMPLE. Their output is huge, not only through the development of knowledge, but also its dissemination and the introduction of specific forms of cooperation between the different centres. European Statistical System initiated also another program aimed at development of a framework for the production of small area estimates for ESS social survey. Essential elements of SAE "ecosystem" are of course books (Rao, 2003, Longford 2005, Fuller 2009), manuals, scientific and working papers, presentations and research reports.

5. Conclusion

The results of the *survey on teaching, use and development of SAE methods*, other available information from previous studies and the Internet allow for concluding that there is a growing awareness of SAE methodology. More than a half of the surveyed NSIs declared to have moderate experience in SAE.

However, this experience in SAE was mainly participation in seminars and conferences, but also scientific research was often mentioned. Therefore, great needs for education of NSI staff in SAE methodology was expressed by over 60% of NSIs. But it was not SAE methodology that was indicated as the field that requires increased knowledge of NSI staff. In view of the survey, the most important issues that need to broaden the scope of teaching were statistical software (SAS, R, SPSS, etc.) and methods of spatial analysis (GIS). As regards the software used in Small Area Estimation, R was the most popular in scientific research and SAS was the software most often used in the NSIs.

Referring to the main problems and challenges in teaching SAE, many opinions were expressed on poor preparation of students for advanced topics. Low awareness of SAE as the field of statistical research was also underlined. Suggestions could be found to use basic sampling course to generate interest of students in SAE. It was proposed to increase attractiveness of classes by introducing case studies based on actual research, practical implementation and incorporation of recent deliverables in the teaching process. Among unique challenges of SAE applications, the importance of understanding the capabilities and limitations was recognized as essential.

Problems in teaching are not independent form problems of SAE application. An analysis in this field pointed out first of all to bias of indirect estimators. However, for statisticians from NSIs, the main problem was difficulty in variance estimation. But they also stressed many other problems unspecified directly in the study. The main source of information on SAE methodology and applications is undoubtedly *Survey Methodology*. Among other scientific journals one should emphasize the importance of *Statistics in Transition*, particularly as a journal with a large audience among statisticians in Central and Eastern Europe.

Being aware of the limitations of the analysed survey, it is our hope that the results presented will help to bring together opinions of scientists from

universities and practitioners working in National Statistical Offices and other institutions. And allow to confront and compare they own ideas and experiences with those expressed by colleagues representing the academic community, official statistics, research centres as well as other institutions involved in developing and applying small area estimation methods.

REFERENCES

MAPLES, J. J., BELL, W. R., HUANG, E. T., (2009). Small Area Variance Modelling with Application to County Poverty Estimates from the American Community Survey Statistical Research Division, U.S. Census Bureau, Washington, DC.

BURGARD, J. P., MÜNNICH, R., (2014). SAE teaching using simulations, presentation during International Conference on Small Area Estimation SAE Poznan 2014.

BURGARD, J. P., MÜNNICH, R., ZIMMERMANN, T., (2014). The Impact of Sampling Designs on Small Area Estimates for Business Data, Journal of Official Statistics, Volume 30, Issue 4.

CHAMBERS, R., CHANDRA H., SALVATI, N., TZAVIDIS, N., (2013). Outlier robust small area estimation. Journal of the Royal Statistical Society: Series B (Statistical Methodology), Volume 76, Issue 1, pages 47–69, January 2014.

CHANCE, B., (2002). Components of Statistical Thinking and Implications for Instruction and Assessment. Journal of Statistics Education Volume 10, Number 3 (2002).

DATTA, G. S., (2009). Model-based approach to small area estimation, in: Handbook of Statistics: Sample Surveys: Inference and Analysis, Volume 29B, Eds.: D. Pfeffermann and C.R. Rao, The Netherlands: North-Holland, pp. 251−288.

DATTA, G. S., HALL, P., MANDAL, A., (2011). Model selection by testing for the presence of small-area effects, and applications to area-level data. Journal of the American Statistical Association, 106, 361−374.

FULLER, W. A., (2009). Sampling Statistics, Hoboken, New Jersey: John Wiley & Sons.

GHOSH, M., (2001). Model-Dependent Small Area Estimation – Theory and Practice, in: Lectures Notes on Estimation for Population Domains and Small Areas, eds. R. Lehtonen, K. Djerf, „Reviews" no. 5, Statistics Finland, University of Jyväskylä.

GHOSH, M., RAO, J. N. K., (1994). Small Area Estimation: An Appraisal, „Statistical Science", Vol. 9, No. 1.

GHOSH, M., KUBOKAWA, T., KAWAKUBO, Y., (2014). Benchmarked Empirical Bayes Estimators for Multiplicative Area Level Models. presentation during International Conference on Small Area Estimation SAE Poznan 2014.

GRAF, E. TILLÉ, Y., (2014). Variance Estimation Using Linearization for Poverty and Social Exclusion Indicators. Survey Methodology. June 2014, Vol. 40, No. 1.

HIDIROGLOU, M. A., SMITH, P., (2005). Benchmarking through calibration of weights for microdata. Working Papers and Studies, European Communities, Eurostat, Luxembourg.

KALTON, G., CITRO, C. F., (2001). Small-Area Estimates of School-Age Children in Poverty. Division of Behavioral and Social Sciences and Education, Commission on Behavioral and Social Sciences and Education, Committee on National Statistics.

LEHTONEN, R., (2014). Experiences and challenges in teaching Small Area Estimation, presentation during International Conference on Small Area Estimation SAE Poznan 2014.

LONGFORD, N. T., (2005). Missing Data and Small-Area Estimation, Springer.

PFEFFERMANN, D., (2011). Modelling of complex survey data: why is it a problem? How should we approach it? Survey Methodology, 37, (2), 115−136.

PFEFFERMANN, D., (2013). New important developments in small area estimation. Statistical Science, 28, (1), 40−68.

PLATEK, R., RAO, J. N. K., SÄRNDAL, C. E., SINGH, M. P., (1987). Small Area Statistics. An International Symposium. John Wiley & Sons. Ltd.

PKA 2014. The report on the program assessment held on 17-18 May 2014 for the field of study: computer science and econometrics conducted within the area of social sciences (first- and second-degree) at the Faculty of Informatics and Electronic Economy, Poznan University of Economics, State Accreditation Commission),

http://ue.poznan.pl/data/upload/articles/20141031/ce25bb287995611010/011-4-raport-pka-2014.pdf.

RAO, J. N. K., (2003). Small Area Estimation, John Wiley & Sons. Ltd.

RAO, J. N. K., SINHA, S. K., DUMITRESCU, L., (2014). Robust small area estimation under semi-parametric mixed models. Canadian Journal of Statistics, 42(1), 126–141.

SÄRNDAL, C-E. LUNDSTRÖM S., (2005). Estimation in Surveys with Nonresponse, John Wiley & Sons, Ltd.

SÄRNDAL, C-E., (2007). The Calibration Approach in Survey Theory and Practice, Survey Methodology, Vol. 33, No. 2, 99–119.

SORVILLO, M. P., (2014). EMOS as a new tool for training professionals in official statistics: NSIs' point of view, Paper available on EMOS website: http://www.crosportal.eu/sites/default/files//NTTS2013fullPaper_241%20Sorvillo.pdf.

SZYMKOWIAK, M., (2010). ESSnet on Small Area Estimation. Report on the analysis of questionnaires used in WP 2, October 2010.

TORABI, M., SHOKOOHI, F., (2015). Non-parametric generalized linear mixed models in small area estimation. Canadian Journal of Statistics Volume 43, Issue 1, pages 82–96, March 2015.

WALLGREN, A., WALLGREN, B., (2007, 2014). Register-based Statistics. Statistical Methods for Administrative Data. John Wiley & Sons. Ltd.

WALLGREN, A., WALLGREN, B., (2013). Quality Assessment in Systems with Registers and Sample Surveys. http://www.statistics.gov.hk/wsc/IPS078-P2-S.pdf.

ZHANG, L.-C., (2012). Topics of statistical theory for register-based statistics and data integration. Statistica Neerlandica, Vol. 66, No. 1. p. 41–63.