The 50th Anniversary of IASS

Foreword

Dear Readers,

Congratulations to everybody who are studying, teaching, working in survey statistics, the members of IASS, one of the Associations of the International Statistical Institute, which celebrates its 50th anniversary!

This section of the newsletter consists of a collection of the congratulatory utterances and a collection of short articles depicting parts of the history of survey sampling. The section aims to overview various aspects of IASS activities from a historical perspective from different parts of the world.

The short articles tell the IASS story from its creation until current days, going through the development of survey sampling methods, achievements of young statisticians, publication of the scientific journals of the Association; history of survey statistics in some countries around the world coming to the urgent problems of today and taking a look at the future.

Some materials devoted to the jubilee of the IASS are postponed to the January 2024 issue of TSS. Historical topics of survey statistics will be continued. It may demonstrate why traditions of survey statistics are so different among the countries. They depend not only on the people and their work, but also on the economic and political situation in the country for science cannot develop during wars, repressions and famine. I invite you to share your stories on the history of the survey statistics. Please submit them before December 1, 2023.

IASS is an important international association that is very active on many fronts in this fast-paced changing world. Scientific production in survey statistics is huge. It is present in articles of scientific journals and books, implemented in software packages, presented at workshops and conferences, and applied in various fields of our life. Covid pandemic generated one more form of communication: virtual, through online meetings, webinars and conferences. This form successfully continues to exist in parallel to the traditional arrangements. It is impossible to overview everything that has been created and accomplished over 50 years by survey statisticians. The authors who contributed to this issue share their knowledge in a variety of fields covering multiple activities of the IASS. It is expected that the texts included here will evoke some thoughts, including willingness to attract young people to survey statistics.

We would like to thank the authors for their contributions and articles, for their kind attitude to the invitation of the TSS editors and for their sincere and careful work in preparation of the material. Thanks also go to the reviewers for their helpful inputs. Thank you to Jūratė Karasevičienė from Vilnius Gediminas Technical University for a jubilee emblem, to co-editor Eric Rancourt for cooperation and to Maciej Beręsewicz for putting the materials together. It was a pleasure to communicate with all of you during the preparation of this section, and I am thankful for this.

Have a pleasant reading.

Danutė Krapavickaitė

Editor of *The Survey Statistician*

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Present at the Creation?

Ivan P. Fellegi

Statistics Canada, IASS President 1985-1987

(IASS editors: Paper re-published from the IASS web site with permission from the author)

The ISI has, for decades now (probably since its beginnings), been searching to find ways to remain relevant. During its 37th Session held in London in 1969 a fundamentally important reappraisal of the mission and modalities of ISI was tabled; the committee which authored it had been chaired by M. G. Kendall ("Report of the Reappraisal Committee"). It contained wide-ranging recommendations which are well worth rereading even today. A segment of the report dealt with the possible creation of new sections within the Institute. It suggested that "if a strong feeling arises that it would be an advantage to create an international association in a new field, we suggest the Institute ought to take the lead and set up such a society as a section of the Institute".

I don't know whether the Reappraisal Committee was initiating a new discussion about sections of ISI or whether it was reacting to ideas already circulating then. As it happens, several of us had, in fact, been agitating for a new section, one devoted to survey methodology, a field that was, in most countries in the late 1960s, still quite an undeveloped field. A very influential advocate was P. C. Mahalanobis. As a "young Turk", indeed a very young one, I was also actively agitating in favour of such a development at every available opportunity, whispering in whatever influential ear was polite enough to let me do so.

It was during the ISI session in London in 1969 that the Bureau of the ISI (chaired at that time by W. G. Cochran) asked me to join them for a discussion about the possibility of forming a section of the ISI devoted to this new and aggressively evolving discipline. They listened to me making a brief pitch, but it was my sense that they already had their minds made up to give it a try – so I cannot claim that silver-tongued oratory, even less my impeccably argued case, convinced them. As is usual, when you talk too much, you end up being asked to do what you have been agitating for. So I was asked identify to chair a small committee whose first task would be to draft terms statutes for the putative new association.

I suggested to the Bureau that the committee consist of J. P M. R. Desabie, Leslie Kish, M. N. Murthy, M. R. Sampford and S. Zarkovich and my recommendations were accepted. The drafting committee was in business. Our task was helped by an early draft of the statutes prepared by P. C. Mahalanobis although we did, in fact, draft the new statutes according to what we thought was needed. We worked by correspondence over a period of many months, and I must underline what a particularly valuable member Leslie Kish was: he never failed to respond to correspondence and he was full of good ideas – anyone surprised?

We submitted our work to the Bureau – not for approval of the statutes themselves, since we thought (and the Bureau agreed) that only the new association could adopt its own statutes – but to secure their blessing for the formation of a new Section of the ISI. They did, indeed, put forward our recommendations to the General Assembly of ISI during its 38th Session held in Washington in 1971 and this was unanimously accepted (Bulletin of the International Statistical Institute, 1971). We were asked to reconstitute ourselves as the new leadership of the formally yet to be created IASS: its Bureau, its Program Committee, its Nominating Committee and whatever else might be needed.

Had we been legalistic, we would have been facing an unsolvable problem. First of all, since there was no IASS, we lacked any legitimacy (we were unelected). Second, the Statutes clearly had to be approved by the members of the new Association, but since there was no Association until the Statutes were accepted (and until people enrolled in the new organisation), who would approve the draft statutes? We were aware of these legal niceties but not unduly worried about them. We received a number of time slots within the ISI program for sessions of the new IASS and we set about creating a program. Anders Christianson is quite right in remarking that the program in Vienna encompassed quite a broad range of topics. This was by conscious design: we wanted to establish a precedent for the broad scope of activities of the new organisation.

We also developed a list of people we wanted to nominate as the new (elected) leadership of the yet to be established IASS and we proceeded to sound out informally some leading lights of our profession.

During the first of "our" scientific meetings we set aside part of the available time for the first General Assembly of what became the IASS. Those present were asked to regard themselves as the founding members and they subsequently approved right then and there both the statutes and our proposed slate for the leadership of the new Association, under the presidency of Morris Hansen. The rest, as they say, is history; except that in this case the entire narrative is that: the early history of IASS.

Looking Back

Graham Kalton

IASS President 1991-1993

The 1973 ISI Congress in Vienna was the first Congress that I attended. It was a very enjoyable meeting, with many good sessions on survey sampling and survey methodology. I attended the first IASS General Assembly that took place at the Congress and that formally created the IASS as an organization affiliated with the ISI. The agenda for the General Assembly had been well prepared and the meeting went very smoothly. France's statistical office INSEE offered to run the IASS's secretariat and look after its finances, and that offer was gratefully accepted.

Although a number path-breaking texts on survey sampling had appeared in the 1950's and 1960's (e.g., by Hansen, Hurwitz, and Madow; Sukhatme; Murthy; Cochran; Yates; Deming; and Kish), the distinct discipline of survey statistics was not widely recognized and acknowledged by the broader statistical community 50 years ago. Looking back, I see the creation of the IASS as part of the more general emergence of the identity of survey statistics as a distinct discipline within the field of statistics. For example, around that time, the American Statistical Association's Social Statistics Section created a subsection of survey research methods in 1973 that became a separate Section on Survey Research Methods in 1977 and, in the UK, the Royal Statistical Society established a Social Statistics Section in 1976, encompassing survey methodology.

The IASS played a distinctive role in this emergence of survey statistics by establishing the field as an internationally recognized discipline. It provided—and still provides—a means for survey statisticians in different countries to share their expertise and experiences. More than that, particularly in the early days, the IASS sought to provide assistance to survey statisticians in countries that had very limited experience of sample surveys, running workshops and short courses offered at ISI Congresses with funds for statisticians from developing countries obtained from various sources. The IASS has contributed greatly to the enormous enhancements in the methods of survey research that have taken place around the world over the past fifty years, and its contributions will undoubtedly continue into the future.

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Congratulations

My **very best wishes** to the members of the IASS on the occasion of its 50th anniversary. May the institution continue to grow, and be effective in promoting good survey methods all over the world.

With warm regards,

Nanjamma Chinnappa. India

IASS President 1997-1999

I have been a **member of IASS since its early days**. When I worked at the Government Social Survey in London in the early 70s, my boss Percy Gray – a brilliant survey statistician – attended the 1973 ISI meeting in Vienna where the first sessions organised by IASS were held.

Following that ISI meeting, there were several occasions when Percy told me how much he had enjoyed his discussions there with Jack Harewood, then the director of the Institute of Social and Economic Research (ISER) in Trinidad.

This highlights the advantages that a body like IASS can bring. Quite apart from any important papers presented at IASS sessions, these events provide a wonderful opportunity for networking with like-minded people with similar professional interests.

Peter Wingfield-Digby, UK

Former consultant of statistical surveys in Africa, Asia, the Pacific and the Caribbean

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Dear IASS member,

As a **long-standing member**, I wish you can enjoy being a member of the Association as much as I have over the years. Membership to the IASS and the ISI produced tremendous impact on both my professional and personal life. I could learn and get support from the best in the field, thanks to opportunities and connections established via the Association. May this be true also for you on this 50th anniversary of the IASS and beyond. And do not forget: if you enjoy being a member, tell your best friends about it and get them enrolled! It will make it even more enjoyable having your best friends also in the fold.

Pedro Silva, IASS President 2007-2009

Society for the Development of Scientific Research (SCIENCE), Brazil

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On the date to celebrate the **50th anniversary of the establishment of the IASS**, I offer my warmest congratulation to its leadership team, past and present, for their wonderful services to our profession, not only in providing a platform for networking amongst us, but also the opportunities offered to us to continuously improve our professional knowledge and capabilities as well.

My best wishes to IASS for its future endeavours.

Siu-Ming Tam, Ex-Chief Methodology

Australian Bureau of Statistics

Honorary Professorial Fellow, University of Wollongong, Australia

IASS is to be congratulated for its successful work during the 50 years since its creation. I am proud of having been a member for many years now.

I hope that that IASS will continue to play an important role also in the next 50 years to ensure the quality of survey statistics both in national governmental organisations and in the commercial field. I also hope that it will continue to be an association capable of handling the new challenges that is put forward by the advent of big data, machine learning and artificial intelligence. There is an increasing need for an organisation like IASS that works for correct and objective information also in the future and counteracts the increasing amount of fake news and information.

I also hope that IASS will continue to encourage and enthusiasm young students and statisticians for the field of high-quality surveys and statistics. There will always be a need for good and motivated statisticians also in the future.

Daniel Thorburn

Professor emeritus of official statistics

Stockholm University, Sweden

Dear IASS colleague members!

It is a **pleasure to celebrate with you the IASS 50th Jubilee**. Since its beginning, IASS has been promoting the development of survey statistics, providing opportunities for capacity building, bringing together people from different places, and fostering a welcoming network for survey statisticians. All of that because we have been working and learning together, enjoying a sense of belonging, as IASS matters for us. It is also time to pay tribute for those members who, before us, paved the way. Let us keep this collaborative environment for the long-lasting progress of IASS.

Congratulations to all and commemorative hugs.

Denise Silva

National School of Statistical Sciences (ENCE)

of the Brazilian Institute for Geography and Statistics (IBGE);

Society for the Development of Scientific Research (SCIENCE), Brazil

IASS President 2019-2021

I would like to convey my sincere **congratulations to the International Association of Survey Statisticians** on the 50th anniversary. I also express my gratitude to the founders of the Association, – distinguished survey statisticians I. Fellegi, late T. Dalenius, P. C. Mahalanobis, M. H. Hansen and L. Kish, – who all these years ago started extensive and fruitful discussions on survey statistics.

Over the years, the Association has had an essential role in promoting the development of the theory and practice of sample surveys. I am extremely grateful for all the publications written by the members of the Association in the Survey Statistician newsletter and beyond that help me and my fellow young statisticians to better understand the sampling methodology. The latter works inspire me as a PhD student, and guide toward further development of the sampling theory and its applications in the rapidly changing environment.

On this celebratory occasion, I wish the Association continued success for many years ahead.

Ieva Burakauskaitė

PhD Student of Mathematics at Vilnius University, Lithuania

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Some Memorable Recollections of IASS First Meeting

J. N. K. Rao

Carleton University, Canada, jrao34@rogers.com

Abstract

International Association of Survey Statisticians (IASS) evolved during the biannual meeting of International Statistical Institute held in Vienna, Austria, 1973. Invited and contributed paper sessions were organized prior to the start of the ISI meeting, devoted to survey sampling theory and methods. I give a brief account of my participation as organizer of an invited paper session and as a speaker in another invited paper session. The first IASS meeting attracted several distinguished survey statisticians.

Keywords: International Association of Survey Statisticians, International Statistical Institute, survey sampling.

1 Introduction

IASS evolved during the biannual meeting of ISI held in Vienna, Austria, 1973. Several invited paper sessions and contributed paper sessions were organized and presented prior to the start of the ISI meetings. A variety of topics were covered during the meetings followed by stimulating discussions.

2 Two invited paper sessions

I organized an invited paper session entitled “Analytic uses of and inferences from sample surveys”. Four leading survey statisticians presented papers in this session. The first IASS Newsletter (now called Survey Statistician) lists the following presentations: (1) J. Sedransk (USA): “Design and analysis of analytical sample surveys. (2) G. Nathan (Israel): “Tests of independence in contingency tables from complex surveys. (3) W. Fuller (USA): Regression analysis for sample surveys. (4) K. R. W. Brewer and R. W. Mellor (Australia): “The effect of sample structure on analytical surveys. H. O. Hartley (USA) and T. M. F. Smith (UK) acted as invited discussants. Fuller’s paper appeared in Sankhya C (Fuller 1975), and it received a lot of attention as judged from subsequent citations.

I participated as invited speaker in another session entitled “Foundations of survey sampling” organized by C. E. Särndal (Canada). The IASS Newsletter lists the following presentations: (1) W. A. Ericson (USA): “A Bayesian approach to two-stage sampling”. (2) V. P. Godambe and M. E. Thompson (Canada): “Philosophy of sample survey practice”. (3) J. N. K. Rao (Canada): “On the foundations of survey sampling”. M. R. Sampford (UK), G. A. Barnard (UK) and R. M. Royall (USA) acted as invited discussants

I might also mention another session entitled “Sampling from imperfect and multiple frames”, organized by A. Sunter (Canada). One of the speakers in that session was H. O. Hartley (USA). W. A. Fuller (USA) acted as invited discussant. Hartley’s paper on unified theory of multiple frame

surveys appeared in Sankhya C (Hartley 1974) and this paper is also highly cited. Sankhya C started in 1974 and I was invited to serve as co-editor. I invited both Fuller and Hartley to submit their papers and both graciously agreed to my invitation. Sankhya C was devoted to survey sampling theory and methods. Unfortunately, it was discontinued after 1978.

All in all, the first IASS meeting was highly successful. The second IASS meeting was held in Warsaw, Poland in 1975 prior to the start of ISI meeting. Subsequently, IASS became a part of ISI and IASS sessions were organized as part of ISI program.

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Survey Sampling During the Last 50 Years

Ton de Waal[1] and Sander Scholtus[2]

[1] Statistics Netherlands & Tilburg University, t.dewaal@cbs.nl
[2] Statistics Netherlands, s.scholtus@cbs.nl

Abstract

In this short paper we sketch how survey sampling changed during the last 50 years. We describe the development and use of model-assisted survey sampling and model-assisted estimators, such as the generalized regression estimator. We also discuss the development of complex survey designs, in particular mixed-mode survey designs and adaptive survey designs. These latter two kinds of survey designs were mainly developed to increase response rates and decrease survey costs. A third topic that we discuss is the estimation of sampling variance. The increased computing power of computers has made it possible to estimate sampling variance of an estimator by means of replication methods, such as the bootstrap. Finally, we briefly discuss current and future developments in survey sampling, such as the increased interest in using nonprobability samples.

Keywords: model-assisted sampling, mixed-mode survey designs, adaptive survey designs, variance estimation, nonprobability samples.

1 Introduction

When the editor of The Survey Statistician asked us to write this short paper on survey sampling during the last 50 years we were both honoured and intimidated. We are users of sampling theory rather than developers of new sampling theory, and many others could far better describe the ins and outs of sampling theory. We accepted the invitation anyway when we realized that most survey statisticians are actually like us: users, rather than developers, of sampling theory. Another reason for us to accept the invitation to write this short paper is that we work in official statistics. Official statistics has always been and still is a driving force behind the application of survey sampling theory in practice and the development of innovative survey sampling methods.

Sampling theory focuses on how to select a set of units, such as persons, enterprises, households, or dwellings, from a larger (finite) population of interest, and, after data collection, on how to conduct research, analyse the observed data and infer unknown properties of the population of interest.

Although we will focus here on the last 50 years, of course the history of survey sampling goes back a lot further. The seminal paper by Neyman (1934) is generally considered as the starting point of modern sampling theory. In that paper Neyman showed the benefits of using stratified simple random sampling (SRS) compared to the then popular representative approach, which essentially consisted of constructing a sample that was a miniature version of the population. Another seminal paper was Horvitz and Thompson (1952) in which they derived their well-known estimator for population totals that can be used when units are drawn with different inclusion probabilities. With hindsight, their insight may seem surprisingly simple: give each unit a weight inversely proportional to its inclusion

probability, but the apparent simplicity is probably due to the fact that the Horvitz-Thompson (HT) estimator is so often used nowadays, for instance as an essential element of a more complicated estimation process. Historically, the importance of this result – as well as the analogous result by Hansen and Hurwitz (1943) for with-replacement samples – is that it showed that unbiased estimation is possible when units are included in a sample with different probabilities, as long as these inclusion probabilities are known (and non-zero). This supported the development of other probability sampling methods than stratified SRS.

Nowadays, many different sampling methods are used, such as SRS, stratified sampling, cluster sampling, and probability proportional to size (PPS) sampling in order to obtain valid and accurate population parameter estimates in an efficient way. Sampling theory plays an important role in many different fields, such as official statistics, marketing research, epidemiology, environmental studies, and political and social sciences.

Section 2 of this paper discusses how sampling theory changed during the last 50 years. Section 3 ends with the present and some concluding remarks.

2 How sampling theory changed during the last 50 years

As we all know the computing power has increased immensely over the last 50 years. What was impossible to do 50 years ago is often quite easy – and quick – to do nowadays. These advancements in computer technology facilitated the implementation of more complex sampling designs in common practice, and improved the accuracy of estimates as well as the measurement of the accuracy. They have also inspired survey statisticians to come up with more evolved and much more complex sampling approaches than would have been possible 50 years ago.

2.1 Model-assisted survey sampling

Model-assisted survey sampling aims to combine the best of both worlds: the design-based world and the model-based world. The term 'model-assisted' is used for estimation methods that employ a model for the target variable but yield consistent estimators from a design-based point of view, even when an incorrect model is assumed (Särndal, Swensson and Wretman, 1992). The models used in model-assisted survey sampling generally rely on the availability of additional information on auxiliary variables that are related to the target variable to be measured. Such additional information often consists of population totals or population means that are known from other data sources than the survey at hand. These population totals or means can then be used improve estimates for the target variable. Regression models are often used in this context. 50 Years ago, computing power was just reaching a point where it became practical to estimate parameters of regression models during regular statistical production (Rao and Fuller, 2017) and a lot of work on model-assisted estimation was done over the next two decades.

A very important and nowadays widely used estimator is the generalized regression estimator (GREG). This is a model-assisted estimator designed to improve the accuracy of estimates when auxiliary information is available at unit level. It utilizes the relationship between the target variable and the auxiliary variables, while calibrating the sampling weights to known totals of the auxiliary variables. The GREG estimator (Cassel, Särndal, and Wretman, 1976, Särndal, Swensson and Wretman, 1992, Lohr, 1999) can be expressed as a sum of the HT estimator and a weighted difference between known totals and their HT estimators. The ratio estimator is a special case of GREG assisted by a particular model with only one covariate (Deville and Särndal, 1992). Also non-linear GREG estimators have been developed (see, e.g., Lehtonen and Veijanen, 1998). In an influential paper, Deville and Särndal (1992) introduced the family of calibration estimators, which contains many existing estimators such as GREG and procedures based on raking as special cases.

Originally, the main motivation of the theoretical work on model-assisted estimation was variance reduction. Over the past decades, GREG and other calibration estimators have been adopted widely in practice: sometimes to reduce variance, but probably more often to try to mitigate possible bias

due to selective non-response or undercoverage; see, e.g., Bethlehem (1988). Here, a slight increase in variance due to calibration is actually often anticipated in practice (Kish, 1992). In the presence of non-response, calibration estimators should be considered as model-based rather than model-assisted, since the choice of model can be crucial for bias reduction.

2.2 Complex survey designs, especially mixed-mode and adaptive survey designs

In the early years of survey sampling, a sampling design (i.e., the procedure used to select the sample) was typically used in a relatively simple survey design (i.e. the more general procedure of how to collect data). In most cases, surveys were collected by one mode only, for instance by personal interviewing, paper questionnaires, or by telephone interviewing, and only one sample had to be drawn. Nowadays mixed-mode survey designs and adaptive survey designs are often used.

Response rates have been steadily declining during the last 50 years, whereas survey costs have been steadily increasing. This has triggered the development of mixed-mode survey designs and adaptive survey designs.

Mixed-mode surveys combine different modes of data collection, such as in-person interviewing, telephone interviewing, paper questionnaires, and web questionnaires. Mixed-mode surveys aim to increase response rates, improve the representativeness of the sample, and reduce survey costs. For these reasons, mixed-mode surveys have become more common in practice in recent years. A drawback of mixed-mode surveys is that each data collection mode can introduce its own mode effect, for instance due to the fact that different groups of persons respond differently to different modes. When using mixed-mode designs, it can be hard to disentangle real changes in the population from mode effects (Schouten et al., 2021).

Adaptive survey designs are closely related to mixed-mode surveys and their aims are the same as those of mixed-mode surveys, but they take the idea a step further. Instead of deciding beforehand which data collection mode will be used for each unit selected into the survey sample, the data collection mode may be adjusted during data collection based on the data already observed. For instance, when elderly people are underrepresented in the data observed so far, one may switch to more in-person interviewing and more paper questionnaires and fewer web questionnaires than were originally planned, since elderly people are generally more likely to respond to in-person interviewing and paper questionnaires than to web questionnaires (Schouten et al., 2021).

In both mixed-mode surveys and adaptive survey designs, several sampling designs have to be used (at least one for each mode). The various sampling designs have to be aligned with each other in order to obtain accurate estimates, preferably at low costs. This obviously complicates the construction of these sampling designs.

2.3 Variance estimation

The area in survey sampling theory that probably changed the most during the last 50 years is the estimation of sampling variance. When the computing power of computers was low, the only feasible approach in practice was deriving analytical expressions for the sampling variance (or at least a good approximation thereof) for a certain sampling design and a certain estimator, and estimating these expressions. Deriving such analytical expressions actually still is the preferred approach, whenever this is possible. The problems with this approach are that this has to be repeated for each specific sampling design and estimator, and that this is often too complicated, especially for more complex sampling designs and estimators.

The increased computing power of computers has made it possible to estimate sampling variance of an estimator by means of replication. Balanced half-samples have been used by the U.S. Bureau of the Census since the late 1950s (Wolter, 2007, Rao, 2012).

The jackknife is another replication method. Although some earlier theoretical work has been done on the jackknife, Durbin (1959) seems to be the first who used the jackknife in finite population estimation.

Probably the best known and most often used replication method is the bootstrap proposed and developed by Efron (1979) (see also Efron and Tibshirani, 1994). The use of the bootstrap approach for without-replacement samples from finite populations is not straightforward and quite some work has been done to make it possible to apply the bootstrap approach in this setting. In their excellent overview paper, Mashreghi, Haziza and Léger (2016) classify the bootstrap methods for survey data of finite populations in three groups: pseudo-population bootstrap methods, direct bootstrap methods and bootstrap weights methods. In pseudo-population methods one or more pseudo-populations are constructed by copying the units of the observed sample. Next, bootstrap samples are drawn from the constructed pseudo-population(s) by mimicking the original sample design (see, e.g., Booth, Butler and Hall, 1994). Direct bootstrap methods – as their name suggests – rely on selecting bootstrap samples from the observed sample or a rescaled version thereof (see, e.g., Rao and Wu 1988, Sitter, 1992). Finally, bootstrap weights methods modify the original survey weights to obtain a new set of weights that are then used for estimation purposes (see, e.g., Rao, Wu and Yue, 1992, Beaumont and Patak, 2012).

Traditionally, sample survey theory has considered inference for target parameters of a given finite population. An area that has received increasing attention over the past 50 years is the use of survey data for analytical purposes, i.e., where the finite population itself is not of particular interest. In practice, variance estimation and inference for analysis on complex survey data often was – and occasionally still is – done using simple ad hoc solutions. Nowadays, well-founded approaches are available in the literature (see, e.g., Chambers and Skinner, 2003) and also in statistical software, such as the R package `survey` (Lumley, 2010). A concept that is necessary in this context is that of a superpopulation model. We suppose that a finite target population of size N is drawn from this model. A survey sample of size n is then drawn, possibly by some complex design, from this finite population. Often, the same design-based estimator can be used to estimate either a parameter of the finite population (e.g., "the number of serious traffic accidents that occurred last year") or a parameter of the superpopulation model (e.g., "the expected number of serious traffic accidents to occur within one year"), but the associated sampling variance is different. This distinction becomes relevant for inference when the sampling fraction n/N is not negligible or, more generally, when some units in the population have large inclusion probabilities. The latter situation is quite common for business surveys. Standard design-based bootstrap methods do not capture the overall variability (due to the model and sampling design) when the sampling fraction is large. Beaumont and Charest (2012) developed a bootstrap variance estimation method for model parameters that can be used for large (or small) sampling fractions.

3 The present and concluding remarks

There is one important recent development that we have not discussed so far: the use of nonprobability samples, alone or in combination with probability samples. Probability samples, which are drawn according to a well-designed sampling design, enable statisticians to draw valid conclusions about population parameters of interest by using well-known estimators such as the HT or the GREG estimator. Unfortunately, the collection of probability samples is time-consuming, expensive and affected by non-response. Nowadays, many nonprobability samples, which do not come from a known sampling design, are available at low cost and within a short time. Examples are Big Data, register data and opt-in online surveys. Since the "sampling design" (if any exists) of such a nonprobability sample is unknown to the statistician, it is a major challenge to produce valid and accurate estimates for population quantities of interest.

Nonprobability samples have been used for many decades already, for instance in marketing research where quota sampling and snowball sampling are often used. However, nowadays many

more nonprobability samples, and many other applications besides those in marketing research, such as applications in official statistics, are considered.

The main problems of nonprobability samples are that they are likely to be selective regarding the population and that the selection probability of units is usually unknown (Elliott and Valliant, 2017). This means that estimators for population quantities of interest are likely to suffer from selection bias. To solve the issue of selection bias, some approaches focus on predicting the target variables or parameters at the population level, whereas other approaches focus on estimating the inclusion probabilities of the units in the nonprobability sample. The two approaches can also be combined to achieve doubly robust estimation (Chen, Li and Wu, 2020). For reviews of existing methods, we refer to Elliott and Valliant (2017), Cornesse et al. (2020), Valliant (2020), Rao (2021) and Wu (2022). Research on the use of nonprobability samples is very much alive and seems a promising way to improve quality of survey estimates and at the same time reduce costs.

Nonprobability samples also generate a lot of related research. For instance, since some nonprobability samples are quite large, 'sampling' variance becomes less important, whereas selection bias, coverage bias and measurement bias become more important (see, e.g., Rao, 2021). Another rather new field of research is combining a nonprobability sample with a traditional survey sample when the target variable is available in both samples (see, e.g., Wiśniowski et al., 2020).

Given the limited space, we hardly discussed non-response in this paper (see, e.g., Little and Rubin, 2002, Raghunathan, 2016). We point out that non-response is obviously closely related to survey sampling. In fact, a sample survey can be seen as missingness by design, since the units not included in the sample are 'non-respondents' by design. We did not discuss small area estimation at all, even though this has become an important topic ever since the seminal paper by Fay and Herriot (1979) and small area methods are nowadays widely used at national statistical institutes (see Rao and Molina, 2005).

In this paper, we have given a brief overview of survey sampling during the last 50 years. Due to space restrictions, we had to limit ourselves to describing only some of the most important papers on this topic. We realize that this does not do justice to the work done by many excellent survey statisticians. For more extended reviews of survey sampling, we refer to Rao (2005), Rao and Fuller (2017) and to the first sections in Rao (2021).

Acknowledgement

We thank Jean-François Beaumont for his very useful and valuable comments on our paper.

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Historical Overview of Small Area Estimation in the 50th Birthday of the IASS

Isabel Molina[1] **and J. N. K. Rao**[2]

[1]Institute of Interdisciplinary Mathematics, Department of Statistics and Operations Research, Faculty of Mathematics, Complutense University of Madrid, Spain, isabelmolina@ucm.es

[2]School of Mathematics and Statistics, Carleton University, Ottawa, Canada, jrao@math.carleton.ca

Abstract

To celebrate the 50th birthday of the IASS, this paper presents a historical overview of SAE methods, focusing on the main ideas and theories that have had a significant impact in the SAE methodology. Starting from estimators obtained under design-based theory, we describe simple indirect methods, including synthetic and composite estimation procedures. Then we go through model-based SAE methods, starting with area-level models, then going through unit-level models and finally describing the more up-to-date procedures for the estimation of complex non-linear indicators, such as poverty and inequality indicators. Due to the applied nature of SAE, we enhance applications of the methods, describing important government programs that regularly produce SAE estimates.

Keywords: Area effects; Mixed models; Model-based inference; Poverty mapping; Small domain.

1 Introduction

Launched at the 39th ISI conference held in Vienna in August, 1973, the IASS was founded as a section of the ISI by Tore Dalenius, Ivan Fellegi, Morris Hansen, Leslie Kish and P.C. Mahalanobis, so this paper is written to celebrate its 50th birthday.

As Anders Christianson notes in “Aims and history” of the IASS (http://isi-iass.org/home/aims/), apart from being devoted to promote survey sampling, “the most important reason for the creation of the IASS was to address major limitations of sampling theory”. The field of small area estimation (SAE) was actually born to address a major limitation of traditional design-based sampling theory, to meet the (public and private) demands of estimates at more disaggregated levels than those for which surveys were originally planned. “Quick and cheap” disaggregated yet reliable statistical information was needed worldwide in policy making, for the formulation of assistance and development programs, or directly for the allocation of government funds in an efficient way.

SAE came out of the shelter of sampling theory in the hands of other disciplines and theories, such as demography and model-based inference, and started growing exponentially by the second half of 20th century, partly thanks to the development and expansion of linear and generalized linear mixed regression models. By the 21st century, this growth has been also stimulated by the pressure that international organizations, like The United Nations, have put on countries to meet the Millennium Development Goals from 2000 to 2015, and the Sustainable Development Goals after 2015. Appropriate monitoring of the progress of these goals relies on timely, accurate disaggregated statistical information.

The IASS has also promoted the expansion of SAE by co-sponsoring several SAE conferences and organizing SAE sessions and short courses on SAE within the IASS meetings. The importance of SAE within the IASS is also witnessed by the many SAE researchers that have been or are currently involved in the IASS committees.

This increasing need of detailed statistical information has lead to the development of a variety of SAE methods that are specific for the type of estimates that need to be produced and the possibilities offered by the information that is available for that. In the US, many of these SAE methods have long been used in official programs to produce regular estimates. For example, the Small Area Income and Poverty Estimates (SAIPE) Programme of the U.S. Census Bureau (https://www.census.gov/programs-surveys/saipe.html), which started back in 1993, produces estimates of school-age children in poverty, regularly for the counties and school districts. The Local Area Unemployment Statistics (LAUS) Program of the Bureau of Labour Statistics produces local monthly and annual employment, unemployment, and labor force statistics. The County Estimates Program of the National Agricultural Statistics Service (NASS) produces county crop yield estimates. The Substance Abuse and Mental Health Services Administration produces estimates of substance abuse in states and metropolitan areas. The US Department of Health and Human Services produces health status, health care access and family income estimates. The latter estimates are used to formulate an energy assistance program for low-income families. For an excellent account of the use of indirect estimators in US Federal Programs, see Schaible (1996).

In Canada, reliable monthly unemployment rates for small areas are used to determine the rules used to administer the employment insurance (EI) program. In Latin America, many countries are currently producing small area estimates of poverty. For example, in Mexico, there is a mandate to produce poverty estimates by municipality every 5 years, and the Mexican National Survey of Household Income and Expenditure (ENIGH in Spanish) alone cannot provide estimates for the municipalities with adequate quality. In Europe, the SAE methodology expanded greatly thanks to projects funded by the European Commission, like EURAREA (https://cros-legacy.ec.europa.eu/content/eurarea_en), SAMPLE (http://www.sample-project.eu/) and AMELI (https://cros-legacy.ec.europa.eu/content/ameli_en). The Italian National Statistical Office uses since 2006 unit-level SAE methods to obtain employment and unemployment indicators for Labour Market Areas(https://www.istat.it/en/archivio/276035). Central and eastern European countries, which moved away from a centralized decision making, have also played a prominent role in the expansion of the SAE methodology, participating in European projects and organizing several conferences related with SAE; for example, the first two international conferences on SAE were held in Warsaw in 1992 (Poland) and in Riga (Latvia) in 1999. Worldwide, the World Bank and the United Nations, specially the Economic Commission for Latin America and the Caribbean (ECLAC), the Economic and Social Commission for Western Asia (ESCWA), UN Statistics Division (UNSD) and UN Population Fund (UNPF), among possibly other, have sponsored multiple activities aimed at building capacities for countries to produce accurate disaggregated socio-economic statistical information, see e. g. the UN Toolkit on SAE (https://unstats.un.org/wiki/display/SAE4SDG).

Here we make a very limited historical overview of the literature on small area estimation, starting from direct methods based on area-specific survey data, going through simple indirect methods that include synthetic and composite estimators, more advanced indirect methods based on models at the area and unit levels, with the many different variants depending on the target indicators and the available data, and finishing with procedures designed for the estimation of general, possibly non-linear, area parameters. We place emphasis on the ideas and theories that represented breakthroughs in SAE, focusing specially on mainstream model-based SAE methods and mentioning practical applications of many of the methods.

Books on SAE include Mukhopadhyay (1998), Rao (2003), Longford (2005), Chaudhuri (2012), Rao and Molina (2015), and the recent book by Morales et al. (2021). Good accounts of SAE theory are also given in the books by Fuller (2009), Chambers and Clark (2012), Pratesi (2016), Jiang (2017) and Sugasawa and Kubokawa (2022).

Important reviews on SAE are given in Ghosh and Rao (1994), Pfeffermann (2002, 2013), Jiang and Lahiri (2006), Datta (2009), Lehtonen and Veijanen (2009) and Ghosh (2020). Reviews focused on SAE for welfare and poverty are given by Guadarrama, Molina and Rao (2014), Pratesi and Salvati (2016), Rao and Molina (2016), Molina (2019), Molina, Rao and Guadarrama (2019) and, more recently, Molina, Corral and Nguyen (2022).

2 From direct estimation to early indirect methods

The first estimates based on sample surveys that were intended for subpopulations were "direct", in the sense that they used only the survey data from the subpopulation of interest without "borrowing strength". These estimates are developed under the umbrella of sampling theory, which has long history. For nice accounts of this theory, see the books by Cochran (1977), Särndal, Swensson and Wretman (1992), Thompson (1997), Lohr (1999) and Wu and Thompson (2020). Direct estimators have several advantages, when applied to areas with large sample sizes. The usual direct estimators have good design properties (at least design consistency as the area sample size n_d increases) and avoid making distributional assumptions for the study variable. Another important advantage of direct estimators is that they use "all-purpose" expansion weights, in the sense that the same expansion weights are used for the estimation of totals or means of whatever variable of interest, making the production of large amounts of statistical information automatic.

Generalized Regression (GREG) estimators and more general calibration estimators (Deville and Särndal, 1992; Lehtonen, Särndal and Veijanen, 2003) applied to domains were designed to improve the efficiency of direct domain estimators, owing to the knowledge of the domain totals of some auxiliary variables. These procedures adjust the sampling weights, and the adjusted weights can be used similarly to estimate totals or means of other variables of interest. Nowadays, expansion weights are typically calibrated using the known totals of certain auxiliary variables and are also adjusted for non-response. However, the resulting calibration estimators are still inefficient for areas with small sample size n_d. Even if a more efficient allocation of the total survey sample size n among the different areas at the design stage of the survey (which is recommendable if estimates need to be produced for those areas) might ameliorate the SAE problem, "the client will always require more than is specified at the design stage" (Fuller 1999; p. 344).

The way of addressing the scarcity of data within some of the areas is to obtain indirect estimates, which "borrow strength" across areas, by making some homogeneity assumptions that link the areas through common parameters. These common parameters are estimated with a larger sample size, which leads to more efficient small area estimators. The idea of sharing information within a larger area appeared already in the first demographic methods dating back to 1950, such as the Vital Rates (VR) method due to Bogue (1950). This method assumed that the ratios between the birth/death

rates in two time periods in the small area of interest were constant within a larger area covering that small area. These first indirect methods used only census data and demographic information from administrative records, and were absent of sampling. Detailed accounts of the traditional demographic methods are given by Purcell and Kish (1979), National Research Council (1980), Rives, Serow, Lee and Goldsmith (1989), Statistics Canada (1987), Zidek (1982) and Rao (2003).

The VR method is "synthetic", because the change in the birth/death rate between two time periods is assumed to be the same for all the small areas contained in the larger area, without allowing for specific area behaviour. According to Gonzalez (1973), "An estimator is called a synthetic estimator if a reliable direct estimator for a large area, covering several small areas, is used to derive an indirect estimator for a small area under the assumption that the small areas have the same characteristics as the large area". Post-stratified synthetic estimators, which assume that the means of the study variable do not vary within large post-strata and only vary between post-strata, are perhaps the simplest synthetic estimators based on survey data. The US National Center for Health Statistics (1968) pioneered the use of synthetic estimation for developing state estimates of disability and other health characteristics from the National Health Interview Survey (NHIS), because NHIS sample sizes in many states were too small to provide reliable direct state estimates. Synthetic estimators can have very small design variances, but their design bias can be substantial because the assumptions behind synthetic estimators are typically strong and unrealistic. Since their design bias is not negligible, design MSE estimates that account for both bias and variance should be used to accompany the synthetic point estimates. Apart from the potentially large bias, a problem is that obtaining efficient and area-specific design MSE estimates is still a challenge for these estimators.

Composite estimators, defined as a weighted average of a synthetic estimator and a direct estimator for the same area, were proposed as a compromise between the small design variance but potentially large bias of synthetic estimators and the small design bias but inefficiency of direct estimators. Curiously, averaging different predictors is nowadays one of the main ideas behind modern machine learning procedures.

In the composite SAE estimators, optimal weights are sought from a design-based standpoint. However, the optimal weight depends on the true design MSE estimates of the two estimators involved, encountering again the problem of estimation of the design MSE for synthetic estimators. Griffiths (1996) studied composite estimators and applied them to the estimation of labor force characteristics for US congressional districts.

Purcell and Kish (1979) considered a common weight for all the areas and obtained the optimal weight that minimized the total design MSE for all the D small areas. The resulting composite estimators have good overall efficiency for the D areas, but not necessarily for each small area. In SAE, it is desirable to reduce the largest MSEs, which typically correspond to the areas with the smaller sample sizes, and this is not ensured by these composite estimators.

Composite estimators shrink direct estimators toward the synthetic ones. The idea of shrinking appears already in the James-Stein (JS) method proposed by James and Stein (1961), see also Efron and Morris (1972) and the famous application by Efron (1975) to the estimation of batting averages of major league baseball players in US during 1970 season. In the JS method, direct estimators are shrunk toward a fixed guess of the true quantity for area d, which can be taken as the average across areas of the direct estimators in the absence of auxiliary information, or to the regression-synthetic estimator when auxiliary information is available. This method applies again a constant weight to the two estimators involved, but in SAE, it is much more appealing to consider area-specific weights, with weight attached to the synthetic estimator that grows for the areas with small area sample sizes and decreases for the areas with large sample sizes (giving then more weight to the direct estimator). Following this idea, Drew, Singh and Choudhry (1982) proposed the sample-size dependent

(SSD) estimators, which are composite estimators defined with simple weights that depend on the area sample size. They applied these estimators to produce estimates for Census Divisions from the Canadian Labor Force Survey. In practice, as it happened in the application by Drew, Singh and Choudhry (1982), SSD estimators borrow little or no strength, because the weights attached to the direct estimators often turn out to be either equal or close to one.

The advent of computers produced an explosion in the number and complexity of SAE procedures, most of them based on regression models. The first SAE models actually lead also to composite estimators, but with optimality properties under model assumptions for the study variable. These estimators dominate the above composite estimators by borrowing substantial strength from the other areas. They can achieve large efficiency gains, provided that the model assumptions hold. An important drawback of model-based estimation procedures is that all the modelling and estimation process, including model validation, is specific to each variable of interest, not allowing for automatic production. This might be one of the reasons why there is a delay in the introduction of SAE procedures in the production processes of National Statistical Offices.

3 From the first explicit model to modern area level models

Perhaps the first application of a model for SAE is due to Hansen, Hurwitz and Madow (1953), p. 483, based on the 1945 Radio Listening Survey. The target was to estimate the median number of radio stations heard during the day in the family houses from 500 U.S. counties. They had estimates x_d, $d = 1, \ldots, D = 500$, obtained from a mail survey conducted in the 500 counties, which were biased due to only 20% response rates and incomplete coverage. Unbiased estimates y_d were obtained from an intensive survey conducted in 85 of the counties. A linear regression model for y_d with x_d as auxiliary variable was used, by regarding the y_d as true values for the 85 sample counties. The fitted regression parameters were then applied to predict the number of radio stations heard during the day in the remaining 415 counties, where the mail survey estimates x_d were available. The resulting predicted values do not account for the fact that y_d are subject to sampling error.

The use of linear mixed models (Searle, 1971; Searle, Casella and McCulloch, 1997; Jiang, 2007) that account for unexplained area heterogeneity really represented a breakthrough in the SAE methodology. The best linear unbiased predictor (BLUP) of a mixed effect (a linear combination of fixed and random effects) under a linear mixed model was obtained by Henderson (1950), in a different context from SAE, related with the prediction of the milk yield of dairy cows. On a completely different context, dealing with estimation of mean per capita income in US areas with less than 1,000 inhabitants, Fay and Herriot (1979) also considered a linear regression of the true area means μ_d in terms of certain area-specific covariates x_d (linking model). However, to account for the (important) sampling errors of the direct estimators y_d of μ_d, they considered an additional sampling model for y_d in terms of μ_d, which, together with the linear regression for μ_d, yields a linear mixed model, known popularly as the Fay-Herriot (FH) model. Based on this model, Empirical BLUPs (EBLUPs) of the true area means μ_d were obtained.

The FH model is still very popular nowadays, because it requires only aggregated data at the area level, accounts for the survey design, through the direct estimators, and accounts for potential unexplained between-area heterogeneity. As a consequence, the resulting EBLUP is a weighted average of the direct and the regression-synthetic estimator, with area-specific weights. Actually, the weight attached to the regression-synthetic estimator is larger for areas where the direct estimator is inefficient (large sampling errors) and smaller for areas where the direct estimator is efficient. The property of approaching the direct estimator as the area sample size grows is appealing, because it ensures design consistency as the area sample size n_d grows. Moreover, if the model parameters were known, EBLUPs based on FH model cannot be less efficient than the direct estimators in

terms of MSE. FH model parameters are estimated by fitting the model to the direct estimators for all the areas (hence borrowing strength). As a consequence, the efficiency of the estimated parameters increases as the number of areas grows. Perhaps the main issue with FH model is that the sampling variances of direct estimators need to be given and are typically deemed as fixed values (without sampling error). Generalized variance function (Vaillant, 1987) is typically applied to smooth these sampling variances, and the smoothed variances are then treated as the true ones. However, when comparing the resulting EBLUPs with direct estimators in applications, it is unclear whether the comparison should be done using the estimated sampling variances or the smoothed versions.

The FH model is regularly used in the US Census Bureau, within the SAIPE project, see Bell (1997). It was also used by Ericksen and Kadane (1985) and Cressie (1989) to estimate the decennial census undercounts in each US state, and Dick (1995) employed the model to estimate Canadian census undercounts. To mention just a few applications of the FH model to estimate welfare indicators, Molina and Morales (2009) estimated poverty rates and gaps in Spanish provinces by gender, Jedrzejczak and Kubacki (2013) estimated income inequality and poverty rates by regions and family type in Poland, and Casas-Cordero Valencia, Encina and Lahiri (2015) estimated poverty rates in Chilean comunas based on the FH model with arcsin transformation of the direct estimators.

Other ways of "borrowing strength" were explored in multiple extensions of the FH model, like the multivariate versions, and models including temporal and/or spatial correlation. Recently, the FH model was extended to include area level covariates obtained from "big data" typically based on non-probability sampling. Marchetti et al. (2015) used big data based on mobility comprised of different car journeys in Italy automatically tracked with a GPS device.

The introduction of Generalized Linear Models (GLMs) by Nelder and Wedderburn (1972) (see also McCullagh and Nelder, 1989), represented a huge step that expanded the use of statistical models in general. After that, two-level GLMs were then applied to estimate mortality or disease rates and obtain corresponding mortality/disease maps. The first proposal, based on a Poisson-Gamma model, was perhaps due to Clayton and Kaldor (1987), who also introduced a model with Conditionally Autoregressive (CAR) area effects. Generalized linear mixed models, or the more general two-level GLMs, have then long been used in many disease mapping and small area applications, with many variants developed, e.g. multivariate versions, or including temporal and/or spatial correlation, etc.

4 Unit level models

The concept of a superpopulation model for two-stage sampling introduced by Scott and Smith (1969) led to important advances in SAE, specially when estimating non-linear area parameters based on unit-level data. The first unit-level model for SAE was proposed by Battese, Harter and Fuller (1988), which was a linear regression model with random area effects, popularly known as the nested error model. They used this model to obtain EBLUPs of county means of crop areas under corn and soybeans, using farm-interview data and auxiliary information obtained from LANDSAT satellite images. Although EBLUPs under a linear mixed model were derived by Henderson under the "infinite" population setup, Royall (1970, 1976) developed EBLUP theory under the finite-population setup without focusing on small areas, see Vaillant, Dorfman and Royall (2001). Current mainstream SAE procedures apply this theory to small areas, by assuming a superpopulation model that links all the areas through common parameters. These common parameters are estimated with the overall survey data from all the areas, which yields substantial increases in the efficiency of model-based estimators compared to direct estimators.

When the area sampling fractions are negligible, the EBLUP of an area mean $\bar{Y}_d$ obtained under the finite population setup with superpopulation model defined by the nested error model, approximates the EBLUP of a mixed effect from the same model under Henderson's infinite population setup, but

this is not the case for non-linear area parameters. To mention just a few other applications of the nested error model, it has been used by Militino et al. (2006) to estimate the area occupied by olive trees in non-irrigated areas at the central region of Navarra in Spain and by Mauro et al. (2015) to estimate means of forest variables of interest by forest regions, based on remote sensing auxiliary data.

Until the first decade of the current century, model-based SAE procedures had focused mainly on means or totals of the variable that is used as model response, since EBLUPs were designed to estimate only linear functions of the model response variables. However, many poverty and inequality indicators cannot be expressed as linear functions of the response variable. Even if the interest was to estimate simple area means of a given variable of interest, once a non-linear transformation (such as log) is taken as response in the model (often done for monetary variables to achieve approximate normality), EBLUPs might not be useful anymore. Note that taking the inverse transformation of EBLUP predictions might lead to severe bias, see Molina and Martín (2018).

Probably the first SAE procedure that was designed for the estimation of general parameters is that of Elbers, Lanjouw and Lanjouw (2003), known as ELL method. This method was based on the nested error model of Battese, Harter and Fuller (1988), but where the random effects in the model were associated to the sampling clusters (or 1st stage units), and including heteroscedasticity. ELL method was used until 2020 as the default method for mapping poverty or inequality at the World Bank and perhaps was the most extensively used method across the globe for that purpose. This is partly because of the simple point and click software `PovMap` software (Zhao, 2006), which was also extremely computationally fast and efficient in terms of memory.

Banerjee et al. (2006) reviewed the research conducted at the World Bank and did already raise concerns about the ELL method, suggesting that it was not accounting for potential area effects. Actually, as Molina and Rao (2010) showed, even if taking the clusters as the small areas of interest in the ELL method, the ELL estimators of the welfare means under a nested error model for the welfare without any transformation, are synthetic. Banerjee et al. (2006) also raised concerns about the ELL estimated standard errors, which were not accounting for the correlation between the observations in different clusters within the same area. These two problems were solved by the Empirical Best (EB) method and the bootstrap MSE estimation procedure proposed in Molina and Rao (2010), work that was developed under the support of the SAMPLE project.

Similar to the ELL method, EB combines survey data with census (or administrative records) auxiliary data, uses a unit-level model for the welfare variable (or a one-to-one transformation of it) and it is able to estimate very general (and several) indicators that depend on the welfare, based on the same model. Nevertheless, apart from being approximately unbiased, EB estimators are nearly optimal, in the sense of minimum mean squared error under the model. Consequently, EB provides estimators with better efficiency than ELL estimators when the nested error model assumptions hold, and in certain cases the gains in efficiency with respect to ELL may be quite large, as illustrated by Molina and Rao (2010) and later in Corral, Molina and Nguyen (2021). The EB method was implemented within the `sae` R package (Molina and Marhuenda, 2015) in the homoscedastic case, as well as in Stata (Nguyen et al., 2018, https://github.com/pcorralrodas/SAE-Stata-Package). Many SAE methods have been implemented in multiple R packages, as well as in other software packages, but a software review is out of the scope of this paper.

The EB method has been applied to estimate poverty indicators in Spanish provinces by gender (Molina and Rao, 2010), mean income in Mexican municipalities (Molina and Martín, 2018), mean income and (non-extreme) poverty rates for census tracks by gender in Montevideo, Uruguay, and poverty rates and gaps in Palestinian localities by gender (Molina Peralta and García Portugués, 2020).

Corral, Molina and Nguyen (2021) extended the model-based simulation experiment of Molina and Rao (2010) to more realistic scenarios with a much better explanatory power of the model and including also contextual variables, with much larger area population sizes and much smaller sampling fractions, generating errors from a Student's t_5 instead of a normal distribution, and also decreasing the overall sample size and the area sample sizes. Additionally, Corral et al. (2021) performed a design-based validation study, using the Mexican Intracensal Survey as a fixed census, and then drawing from it 500 samples using a realistic sampling method. The superiority, in terms of MSE, of the EB over the traditional ELL in all these experiments lead to a revision of the World Bank methodology for poverty mapping and the corresponding software (https://github.com/pcorralrodas/SAE-Stata-Package). This revision incorporates several variants of the EB estimators of Molina and Rao (2010) and the parametric bootstrap procedure for MSE estimation of González-Manteiga et al. (2008).

The nested error linear regression model has been extended to models with non-parametric mean functions. Opsomer et al. (2008) proposed penalized spline regression models. Recently, Krennmair and Schmid (2022) have used machine learning methods; in particular, mixed-effects random forests, for SAE.

5 Concluding remarks

We have made an overview of SAE methods, going from the basic direct and indirect methods to the modern model-based procedures for SAE, including methods developed for the estimation of non-linear area indicators and variants of the basic methods. Really important topics in SAE like model fitting methods and their properties, methods for MSE estimation or calculation of prediction intervals, have not been covered owing to space-time restrictions, details of those topics can be found in Rao and Molina (2015). Moreover, we have mainly focused on frequentist or empirical Bayes procedures. Descriptions of Hierarchical Bayes (HB) SAE methods can be found in Ghosh and Meeden (1997), Malec et al. (1997), Ghosh et al. (1998) and also Rao and Molina (2015).

Even if the usual SAE models that include area effects are more flexible than the corresponding regression models without the area effects (which lead to synthetic estimators), we cannot forget that properties of all model-based estimators depend on the model assumptions. Hence, the assumed model needs to be carefully checked with the available data, e.g. by using customary residual plots, see Rao and Molina (2015) for model diagnostics in the basic SAE models, although more research is probably needed on this important issue.

In the case of clear model departures, the model should be changed to accommodate to data features or the final estimates should be taken with a lot of caution. This is related to another important issue, which is the estimation of area parameters in non-sampled areas. Note that the model assumptions cannot be checked for non-sampled areas and, unless additional information is available, we cannot be sure that these areas satisfy the assumed model. Moreover, as already discussed, synthetic estimators used for those areas are inefficient if area effects are significant. Hence, unless legally bound, a general recommendation is not producing estimates for non-sampled areas.

Once the sample is drawn from the population, the model for the sample part $\mathbf{y}_s$ of the population vector $\mathbf{y} = (\mathbf{y}_s', \mathbf{y}_c')'$ (for which a superpopulation model is assumed) is simply obtained by marginalization; that is, integrating out with respect to the sample complement part $\mathbf{y}_c$. The sample model for $\mathbf{y}_s$ then has the same shape as the superpopulation model when sampling is ignorable, but this does not hold for non-ignorable (informative) sampling. Similarly, the model for the respondents might be different from the model for the sample units under non-ignorable non-response. Methods for SAE accounting for the sampling design have been discussed already. However, concerning model checking, skeptical survey samplers might raise the concern that the superpopulation model cannot be checked under informative selection and/or non-ignorable non-response, because population data

are not available. In this regard, it is important to point out that only the sample/respondents model needs to be checked with the available sample/respondents data.

Another important point is that, when estimating non-linear area parameters based on unit-level models, the values of the auxiliary variables are required for each population unit. This microdata is typically obtained from the most recent census or from administrative records, which are usually protected for privacy reasons, and this protection limits the practical applicability of these methods. Another important issue is that outdated information in the census file for inter-censal years might yield severely biased small area estimators. Corral et al. (2021) analyzed the empirical properties of the common approaches for that case, but further research is probably needed on this important issue.

Finally, conventional MSE estimates of model-based estimators are obtained assuming that the corresponding model assumptions hold, even if we know that "All models are wrong, but some are useful". Hence, these MSE estimators might be understating the real uncertainty. Molina and Strzalkowska-Kominiak (2020) and others proposed to use the same idea of "borrowing strength" behind SAE, for the estimation of the design MSE of small area means, which accounts for model uncertainty. Design MSE estimation for general non-linear indicators is an interesting topic that also deserves further research.

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Is it Time for Young Survey Statisticians to Shine in the Society?

Mahmoud Torabi[1]

[1]University of Manitoba, Canada, Mahmoud.Torabi@umanitoba.ca

Abstract

In survey sampling, policy decisions regarding allocation of resources to subgroups in a population, called small areas, are based on reliable predictors of their underlying parameters. However, in some subgroups, due to small sample sizes relative to the population, the information for reliable estimation is typically not available. Consequently, we need to predict the characteristics of small areas based on the coarser scale data. Mixed models (including cross-sectional, spatial data, and so on) are the primary tools in small area estimation (SAE) and also borrow information from alternative sources (e.g., previous surveys, administrative, and census). In this short paper, I will review my scientific background in this subject with also providing some comments and suggestions for young researchers.

Keywords: small area estimation, spatial statistics

1 Scientific background. Fist of all, this is my honor to write this short paper regarding my Hukum Chandra prize. I was born and raised in Tehran which is the capital city of Iran. In my time, there were three main streams in high school to choose. I chose Mathematics-Physics while other options were Experimental Sciences and Human Sciences. After high school graduation, I participated in the national entrance exam (AKA Konkoor) for a university program. We had 100 options to choose a program and a university after writing the national entrance exam. I was accepted to Statistics program at the National University of Iran (AKA Shahid Beheshti University). Although I chose Statistics, however, I had limited information regarding the program; I should say that I was not accepted to other popular programs in those days such as Engineering (electronic, communication, civil, mechanic). I successfully graduated with BSc and MSc from the National University of Iran before pursing my PhD in Statistics at Carleton University in Canada under supervision of Dr. Jon Rao. In my PhD program, I worked on some interesting problems in small area estimation which resulted in 6 publications in statistics journals. After PhD graduation, I accepted a post-doctoral fellowship (PDF) from University of Alberta, Canada, to investigate the impact of various health research topics in the province of Alberta, Canada. I then joined the Department of Community Health Sciences at the University of Manitoba, Canada, in 2010 as an Assistant Professor of Biostatistics. I am currently Professor of Biostatistics while I hold this position since 2020.

At the University of Manitoba, I established an excellent research team including my collaborators (methodologists and health clinicians) and also my high quality personnel (MSc, PhD, and post-doctoral). It is evident that my transition from applied statistics to Biostatistics started when I accepted a PDF position at the University of Alberta. As a biostatistician, we have developed various bio/statistics models/methods to answer various questions from the public. The team I lead is developing new models and techniques in the context of population health research to effectively integrate the knowledge we generate into health care practice which is fundamental to the health and well-being of the population.

2 Research background. I have developed an original and innovative research program in small area estimation and spatial statistics. In small area estimation (SAE), policy decisions regarding the allocation of resources to subgroups of a population depend on reliable predictors of their underlying parameters. However, in some subgroups, called small areas due to small sample sizes relative to the population, the information needed for reliable prediction is typically not available. Consequently, survey (or administrative) data on a coarser scale is used to predict the characteristics of small areas. Mixed models, which are the primary tools in SAE, are used to borrow information from alternative sources (including survey, administrative, and census) to provide reliable prediction. Such predictions have many applications, e.g. in disease mapping the main objective is to find reliable rates of disease such as cancer in small areas. It also has other applications in agriculture, economics, policymaking, and allocation of funds. The team members I lead have developed novel statistical methods in the context of SAE and applied our innovative approaches to population-health data such as asthma and cancer. In spatial statistics, my program of research is on the development of new and original biostatistics methods for big data over space and time. In population and public health, the identification and measurement of patterns of disease are important goals. These patterns facilitate the understanding of disease and better understanding may lead to the formulation of etiological hypotheses. We may be able to explore the causes of different diseases by identifying the characteristics that increase disease risk (e.g., pollution) and improve disease control. My team members under my direction have developed novel biostatistics methods to better understand big and complex spatial and temporal data. Our innovations have allowed us to better predict spatial and temporal trends of disease, identify corresponding risk factors, and plan for interventions/preventions.

3 Interaction with late Hukum. As explained above, my main research focus has been in SAE and spatial statistics. In particular, my research areas were aligned with late Hukum who was unfortunately died during the covid. I met Hukum in different occasions and in particular in SAE conferences. His personality was unique; he was very kind and a humble person. We discussed few projects from time to time for possible collaborations, but we got busy and could not pursue those ideas. He was a good researcher and made valuable contributions in the context of SAE and spatial statistics. He was attentive in scientific sessions with smile and also open for research discussion. Truly, our SAE community missed him as his character was unique. May his soul rest in peace.

4 Conclusion. As a researcher who has been in academia for more than 10 years, I can attest that the SAE community is growing rapidly as the subject is applicable to many professional organizations and sectors. Many young, energized, and strong researchers are currently working in this important subject, and I can anticipate even more researchers will be involved in this subject area. As it is also evident from the SAE community, senior researchers are mentoring junior researchers, and the future of community is very bright in this direction. Shortly, we will see a transition that young researchers take a full responsibility of the community with support of senior researchers.

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Cochran-Hansen Prize – Memories from the Beginning

Maiki Ilves[1], Kristiina Rajaleid[2], and Imbi Traat[3]

[1]Statistics Estonia, Maiki.Ilves@stat.ee
[2]Stockholm University, Kristiina.Rajaleid@su.se
[3]University of Tartu, imbi.traat@ut.ee

The Cochran-Hansen Prize of the IASS is awarded every two years for the best paper on survey research methods submitted by a young statistician from a developing or transition country. The history of the prize goes back to 1999, and 14 persons have received the prize so far (http://isi-iass.org/home/cochran-hansen-prize).

Estonia became re-independent in 1991. Before that, during Soviet power, no survey statistics nor official statistics, neither in theory nor in practice, was dealt with. Gradually, this area started to develop. **Imbi Traat** in Tartu University started courses in survey sampling in 1993. Baltic-Nordic network in survey statistics (https://wiki.helsinki.fi/display/BNU/Home), initiated by **Gunnar Kulldorff** from Umeå University, helped a lot in a rapid development of the new area. Students had a great interest in a newly launched subject that had practical applications, requiring specialised statisticians. They wrote good Bachelor and Master theses, and as soon as the information about Cochran-Hansen prize arrived to Tartu University, we were ready to apply for it. Estonia was classified as transition country that time.

In fact, the information about the prize came to us from the Tallinn University, where **Enel Pungas** was the one of the two first receivers of the Cochran-Hansen prize in 1999. She was a master student in demography that time. She submitted her study on the data collection aspects and effects in the Estonian Family and Fertility Survey 1997. Enel received the award – participation in the IASS Summer Courses in Jyväskylä, and possibility to buy scientific literature. Now she works in the Ministry of the Interior as head of the Population Facts Department. She is thankful for those possibilities and recognition in her young days.

The two students of Imbi Traat who received the prize tell their memories below.

Kristiina: I was awarded the Cochran-Hansen prize in 2001 for the paper “On the order sampling design” which was based on my Bachelor thesis. I presented the study in the meeting of the International Statistical Institute in Seoul, South Korea. In conjunction with the meeting, I had the possibility to attend two courses on topics in survey sampling which I appreciated a lot. Also, this was my first journey to such a faraway country with a culture so different from my own. I still remember a breath-taking concert with Korean dance and music, the food (first time to eat with chopsticks!), the city (an amazing mix of modernity and tradition). And my first ever jetlag… After 2001, I continued my studies in mathematical statistics at MSc level. In 2010 I earned a PhD in Medicine (public health science / epidemiology) from Karolinska Institutet in Stockholm, Sweden.

Currently I am working as researcher at Stockholm University, among other projects I am involved in a large national longitudinal survey on work environment and well-being.

Maiki: I received Cochran-Hansen prize in 2005 for my research paper “Variance and its estimator for a practical self-weighting two-phase design”. The research for this paper I carried out at Statistics Estonia as a part of my bachelor studies, based on a real-life problem in the Estonian Labour Force survey. My supervisor for this work was Imbi Traat, at the time an associate professor at Tartu University. She was the one who brought my attention to the IASS competition for young survey statisticians. I am very grateful for her believing in me and encouraging me to apply.

My prize included a plane ticket to Sydney to attend the 55th WSC (then called Session) of the ISI in April 2005. In addition, I was given the possibility to attend two short courses given adjacent to the congress, and was as well awarded a check to buy books of my choice. As a result, I became the owner of a copy of the famous “yellow book” by Särndal, Swensson and Wretman.

Even so many years later, still working in Statistics Estonia, now working more with people as Head of the Development Department, I remember very well that journey, the 33 hours one-way trips and the event itself. It was my first plane trip, my first visit to Australia, my first ISI experience, and my first presentation to so large an audience. What I remember of Sydney was the permanently cloudless sky, the very friendly local people, and the beautiful nature. For a young person without international conference experience, this ISI congress was overwhelming: so many people and so many sessions to choose from, and not to mention presenting my contribution in front of a large, highly knowledgeable audience. I was very grateful to the attendees who had supportive and encouraging comments on my work and presentation. I am also glad that I made some memorable contacts at the congress and stayed in contact with some of them even after the event. All in all, it was a very inspiring experience, and I am very grateful to IASS for this opportunity.

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The History and Impact of the *Survey Methodology* Journal

Jean-François Beaumont[1]

[1] Statistics Canada, jean-francois.beaumont@statcan.gc.ca

Abstract

Survey Methodology is a peer-reviewed statistical journal that was founded in 1975 at Statistics Canada to provide a venue for discussing practical issues arising from the implementation of sample surveys. After a brief introduction, I will describe the historical context in which the journal was established, its evolution over the years and then its impact on survey practice in Canada and around the world. I will conclude by announcing some special discussion papers and special issues that are currently being planned for publication in forthcoming issues.

Keywords: History, *Survey Methodology*.

1 Introduction

Survey Methodology is a biannual peer-reviewed statistical journal founded in 1975 at Statistics Canada. As currently stated on its website (www.statcan.gc.ca/surveymethodology), the journal aims to publish innovative theoretical or applied research papers, and sometimes review papers, that provide new insights on statistical methods relevant to National Statistical Offices and other statistical organizations.

Survey Methodology was initially established to provide a venue for discussing practical issues arising from the implementation of sample surveys. Indeed, the editorial policy of the very first issue of the Journal states:

"*The objective of the Survey Methodology Journal is to provide a forum in a Canadian context for publication of articles on the practical applications of the many aspects of survey methodology. The Survey Methodology Journal will publish articles dealing with all phases of methodological development in surveys, such as, design problems in the context of practical constraints, data collection techniques and their effect on survey results, non-sampling errors, sampling systems development and application, statistical analysis, interpretation, evaluation and inter-relationships among all of these survey phases. The emphasis will be on the development strategy and evaluation of specific survey methodologies as applied to actual surveys.*"

The scope of the journal has significantly expanded over the years. It now covers a wide range of topics of interest to survey methodologists and statisticians around the world, including more modern topics such as the use of multiple data sources, statistical data integration, as well as research, development and application of machine learning methods for the production of official statistics. A current list of topics of interest is provided on the *Survey Methodology* website. The journal would not have flourished without the contribution of dedicated Associate Editors who provide invaluable

recommendations for determining the suitability of papers submitted to *Survey Methodology*. Like the scope, the Editorial Board has significantly expanded over time, starting with three internal members in 1975 and now including over 30 internationally renowned Associate Editors whose fields of expertise cover the diversity of topics included in the journal's scope.

The first issue of *Survey Methodology* appeared in June 1975. It has been published every year, in June and December, ever since. From June 1975 to December 2022 inclusively, a total of 909 papers were published, including 8 discussion papers, 6 special issues and 23 special sections of an issue. In recent years, between 50 to 70 papers are submitted annually, mostly from authors outside Statistics Canada, with an acceptance rate around 30%. Authors are welcome to submit their paper in either French or English. Starting with the December 1981 issue, all accepted papers have been translated and published in both languages.

2 Historical context

Research and development in survey methods was booming at Statistics Canada at the end of the 1960s and early 1970s (Platek, 1999; Platek, 2009) and also throughout the world (Kalton, 2000). Some of the research efforts undertaken by Canadian methodologists at the time led to publications in well-known mainstream peer-reviewed statistical journals (e.g., Beynon, Ostry and Platek, 1970; Fellegi, 1972; Fellegi, 1973; Fellegi, 1974; Fellegi and Holt, 1976; Fellegi and Sunter, 1969; Gray and Platek, 1968; and Ostry and Sunter, 1970) such as the *Journal of the American Statistical Association*. However, there was no international journal dedicated to methodological issues arising when conducting sample surveys (Kalton, 2000), except for the brief existence of *Sankhya* C from 1974 to 1978, which covered survey sampling theory and methods (Rao, 2023). There was a growing need for such a venue, which would allow survey methodologists, not only those from Statistics Canada but also in other statistical organizations, to disseminate their theoretical and empirical research findings in this field. The time was ripe for the launch of a new journal; *Survey Methodology* was thus established in 1975 by Richard Platek. Its first editor was Mangala Prasad Singh, known as M.P. Singh, who remained in this position for 30 years until his death in 2005. The June 2006 issue of *Survey Methodology* contains a special article, with testimonials by a few colleagues and friends, to honour the memory of M.P. Singh and recognize his numerous accomplishments during his career at Statistics Canada, in particular those related to *Survey Methodology*.

The 1970s also saw the emergence of several professional associations for survey methodologists (Kalton, 2000), such as the International Association for Survey Statisticians (IASS), founded in 1973 and celebrating its 50th anniversary this year, and the Survey Research Methods Section of the American Statistical Association (ASA), established in 1978. Subsequently, other journals focussed on sample surveys were launched for the greatest benefit of the community of survey methodologists and statisticians around the world (among others, *The Survey Statistician* in 1978, the newsletter of the IASS, the *Journal of Official Statistics* in 1985, published by Statistics Sweden, and the *Journal of Survey Statistics and Methodology* in 2013, sponsored by the ASA and the American Association for Public Opinion Research). Rancourt (2023) provides a portrait of the history of *The Survey Statistician* and points out the close connections between the IASS and *Survey Methodology* at the end of the 1970s; *Survey Methodology* was distributed at a preferential rate to IASS members and used as the prime vehicle for the publication of papers presented at the International Statistical Institute conference.

3 Milestones through the years

Papers published in the first issues of *Survey Methodology* were mainly written by authors from Statistics Canada, but the journal flourished rapidly under the leadership of M.P. Singh. Within 15 years or so, authors from all over the world, including famous statisticians such as Wayne Fuller (e.g., Fuller, 1990), Graham Kalton (e.g., Kalton, 1986), Leslie Kish (e.g., Kish, 1988), Danny Pfeffermann (e.g., Pfeffermann and Burck, 1990), J.N.K. Rao (e.g., Rao, 1985; and Rao, Wu and Yue, 1992), Don Rubin (e.g., Rubin, 1986) and Carl-Erik Särndal (e.g., Särndal, 1992), were

submitting their papers for consideration in *Survey Methodology*. This allowed the journal to acquire an international stature and become a key source of information for survey methodologists at Statistics Canada and around the world.

M.P. Singh implemented many initiatives to raise the profile of the journal and make it more interesting to readers. For instance, he would frequently arrange for the publication of discussion papers or special issues/sections on important topics such as the special section of the June 2001 issue on composite estimation for the Canadian Labour Force Survey. He also initiated the short notes section, which allowed authors to submit shorter papers without the full development of a regular paper and with a streamlined review process. The first short notes section following his initiative was published in the June 2005 issue; it contained three short articles. To be more accurate, a short communications section had already appeared once, in the December 1987 issue, but this idea was never repeated until it was reinstated permanently in 2005.

A major initiative taken by M.P. Singh, in collaboration with the American Statistical Association and Westat, was the introduction of the Waksberg Award in 2001 in honour of Joseph Waksberg, who made outstanding contributions to survey statistics and methodology. Since 2001, this prestigious Award is given annually to a prominent survey statistician chosen by a four-person committee appointed by *Survey Methodology* and the American Statistical Association. The recipient of the Award writes a review paper for *Survey Methodology* and usually presents it at Statistics Canada's Symposium.

The journal continued to thrive under subsequent editors, namely, John Kovar (2006-2009), Mike Hidiroglou (2010-2015), Wesley Yung (2016-2020) and myself since 2021, with the publication of other discussion papers and special issues/sections, among others, the special section of the December 2011 issue on alternative survey sampling designs organized in collaboration with the U.S. Census Bureau. More recently, a special discussion paper on statistical inference with non-probability survey samples (Wu, 2022), a topic that has increasingly been drawing attention of survey statisticians in the past 20 years, was published in the December 2022 issue. The paper was accompanied with five discussions by international experts in the field. It is also worth mentioning the joint special issue with the *International Statistical Review*, published in May 2019, in honour of Prof. J.N.K. Rao's contributions. Incidentally, Prof. Rao is by far the most prolific author for *Survey Methodology*, as he has written or co-written an impressive number of 31 papers during the period covering the first issue in June 1975 to the December 2022 issue. This includes a recent invited review paper on the major developments in sample survey theory and methods covering the past 100 years (Rao and Fuller, 2017), which was discussed by four eminent survey statisticians.

In 2006, the journal became available online and completely free of charge. The printed version continued to be produced and made available via a paid subscription until December 2012. Historical issues have then been gradually added to the free online catalogue. In 2019, *Survey Methodology* adopted the Scholar One system for a more efficient management of papers submitted to the journal.

4 Impact

The journal has had a significant impact on Statistics Canada's programs over the years. For instance, the stratification method of Lavallée and Hidiroglou (1988) is still implemented in many business surveys. It allows for efficient stratification that improves the quality of survey estimates for skewed variables typically encountered in economic surveys. Another example is the method of Rao, Wu and Yue (1992) for computing bootstrap weights. It is used in a large number of social surveys and allows for estimating the variability of survey estimates for stratified multistage sampling designs. A third example is the method of Särndal (1992) for estimating the precision of survey estimates in the presence of imputation. It is the methodological foundation of the System for Estimation of Variance due to Nonresponse and Imputation (SEVANI), which was developed between 2005 and 2010 (Beaumont and Bissonnette, 2011). There are many other examples where papers published in *Survey Methodology* had a direct influence on methods implemented in statistical programs of Statistics Canada and certainly other statistical organizations.

The journal has also been an important learning source for methodologists at Statistics Canada. A number of papers have long been known to be key readings for young methodologists, either learning on the job or preparing for competitive processes. The papers by Brackstone (1987) on the use of administrative data and the discussion paper by Singh, Gambino and Mantel (1994) on small area estimation have probably been the most circulated among them, especially during the 10 to 15 years following their publication.

The international impact of *Survey Methodology* is perhaps more difficult to assess without further investigation. Platek (1999) states: "In a number of countries, the journal, almost from the beginning, provided a base for teaching and training new statisticians.". It is also my perception, strengthened by a few conversations with survey methodologists or statisticians from different countries, working in National Statistical Offices, universities or other statistical organizations, that *Survey Methodology* has been known to be an essential tool for showcasing and sharing innovative ideas and experiments related to sample surveys. This is confirmed by the yearly number of views (about 50,000 per year) and downloads (about 20,000 per year) of *Survey Methodology* papers (excluding views and downloads from Statistics Canada's network) and by noting that authors come from different countries in the world. Another useful indicator is the number of citations for papers that had a significant impact in the survey practice. For example, according to Google Scholar, Kalton (1986) and Rao, Wu and Yue (1992), two of the most influential papers published in *Survey Methodology*, had both been cited 699 times as of May 1, 2023.

5 Conclusion

Survey Methodology is recognized as a high-quality journal in the international community of survey statisticians. This is not taken for granted and efforts are continuous to keep the journal relevant, attractive and increase its readership. For instance, the review process has recently been revised and streamlined to remain competitive and attractive for authors considering *Survey Methodology* to showcase their research findings. I am sincerely grateful for the cooperation and commitment of all the Editorial Board members and referees who have made tremendous efforts to keep the review process as efficient as possible.

Over the next few years, we plan to increase the frequency of special discussion papers and special issues, as well as continue the publication of the yearly Waksberg Award paper. For instance, in the June 2023 issue, a special paper by Natalie Shlomo on statistical disclosure control and privacy will be published to honour the memory of Chris Skinner, a giant in survey statistics. Chris was the winner of the 2019 Waksberg Award, but could not write his paper and present it before he passed away in 2020. Shlomo's paper will be accompanied with testimonials from Danny Pfeffermann, J.N.K. Rao and Jae-Kwang Kim. The paper and testimonials were presented at Statistics Canada's 2021 International Methodology Symposium.

Another special paper, by Pascal Ardilly, David Haziza, Pierre Lavallée and Yves Tillé, is being planned for the December 2023 issue to honour the memory of another giant in survey statistics, Jean-Claude Deville, who passed away in 2021. The paper will review the most important of his contributions to the field, which include among others, calibration and cube sampling. It will be followed by discussions/testimonials from colleagues and friends. The December 2023 issue will also feature a special section with a few selected papers presented at the 2021 Colloque francophone sur les sondages. The Guest Editor for this special section is Alina Matei.

In 2024, a special issue is planned for three papers that were presented at the 2022 Morris Hansen Lecture event on the use of non-probability samples. All three papers will be discussed by international experts in the field. An introduction by Partha Lahiri, the Guest Editor for this special issue, will precede the papers. A special discussion paper by Carl-Erik Särndal, entitled "Progress in survey science: yesterday – today – tomorrow", is also currently being planned for publication in a future issue in 2024 or 2025 along with discussions from eminent survey statisticians. Finally, the June 2025 issue will be dedicated to celebrate the 50th anniversary of *Survey Methodology*. Stay tuned!

At last, I would like to express my sincere gratitude for the kind invitation to write this article from Danuté Krapavickaité and Eric Rancourt, the Editors of *The Survey Statistician*. Let me conclude by taking this opportunity to thank all the readers as well as all the authors who considered *Survey Methodology* for the publication of their research papers. It goes without saying that the journal would not have been the same without their contributions and continuous interest in its content.

I look forward to reading your future submissions to *Survey Methodology*!

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50 Years of Keeping Survey Statisticians of the World Informed: *The Survey Statistician*

Eric Rancourt[1]

[1] Statistics Canada, eric.rancourt@statcan.gc.ca

Abstract

Since its inception, the International Association of Survey Statistician (IASS) has regularly produced a biannual newsletter called *The Survey Statistician (TSS)* to inform its members. *TSS* is now conceptualized as the IASS sponsored journal. This article provides a summary of the history of *TSS*, from its format and content to the list of editors and important sections such as Ask the Experts, Country Reports, New and Emerging Methods and Book/Software Reviews. The paper provides some counts and facts related to the development of *TSS* without pretending to be an exhaustive account of all that surrounds its history and extensive devotion of its numerous contributors.

Keywords: Ask the Experts, Book/Software Reviews, Country reports, Editors, New and Emerging Methods.

1 Introduction

The Survey Statistician has been one of the primary tools to maintain IASS members' connections and inform them about the varied activities of the association. Since its modest debut in 1974, *TSS* has constantly evolved, enriching its content with news, articles on new and emerging methods, book and software reviews, survey activities in countries and questions from members being answered by experts. Through the years, in addition to format and style changes, *TSS* changed content to address the preference and demands of members thanks to dynamic editors.

The role of *TSS* was modified since the first version which was more of an account of the meetings that took place. Nowadays, it is a solid newsletter that provides information on recent survey statistics developments, activities with news on some members as well as forthcoming conferences, events and activities of the IASS. Linking with other developments, it also includes tables of content of leading journals relevant to survey statistics. Since the first issue of *TSS*, 96 issues (including the current one - #88) of *TSS* have been produced during its 50-year existence. This corresponds to producing two issues per year, except for one occasion in each of the 70s, 80s, 90s and 2000s.

2 The Early Days

When the IASS started, its newsletter was simply called Newsletter and was produced eight times from 1974 to 1978. Information on this can be found in the 25 years history book of the IASS (IASS, 1999). These provided a summary of the invited papers at the IASS meetings as well as a few other information items. In the first issue, IASS President Morris H. Hansen, made a strong call to members

to provide information for the bulletin and be active in the association. The issue also provided the list of executives and the list of sessions of the first meeting in Vienna. Some details can be found in Rao (2023). Issue #1 of the Newsletter contained an announcement about the new *Sankhya C* which would publish articles on survey sampling. Finally, it included the 1975 program for the Warsaw ISI meeting and a questionnaire about IASS members.

As the Newsletter improved, it was decided that it would be revamped into a more comprehensive and informative product. For this purpose, issue #8 contained a first version (called issue #0) of what became *The Survey Statistician*, with issue #1 in 1979. From that point on, the sections of the newsletter became almost permanently set to include News, information on the Annual General Meeting, Country information, Question/Answers, paper summaries and some articles.

3 Editors and Structure

3.1 Editors

Many people contributed to the success of *TSS*. We present below a table of all the editors to date. Other members have contributed as specific Section Editors. Some will be presented later, but it is not possible to be exhaustive in a short article such as this one.

Table 1. Editors of *The Survey Statistician*

1979-1985	Jacques Desabie
1985-1990	Gildas Roy
1990-1992	Anne-Marie Vespa-Leyder
1992-1995	Denise Lievesley
1995-1999	Mike Brick
1999-2000	Mike Brick and Leyla Mohadjer
2000-2003	Leyla Mohadjer and Jairo Arrow
2003-2008	Steve Heeringa
2008-2010	Dan Hedlin
2010-2014	Natalie Shlomo and Frank Yu
2015-2018	Natalie Shlomo and Eric Rancourt
2018-2023	Danutė Krapavickaitė and Eric Rancourt

Today, the *TSS* editorial board consists of two editors, three section editors and a technical editor. Also, the IASS scientific secretary serves as an editor of the section *New and Emerging Methods*.

3.2 Structure

TSS has been produced twice a year since 1974 except for a few years (only 4) where there was only 1 produced. The main reason was that originally, the issues normally came out in June and December, but a few late issues created some drifting. Eventually, the change of reference period to January and July helped stabilize production and became permanent.

In terms of language, the bulletins have been produced in English with a French version added after a few issues. This continued with *TSS*, and Spanish was also added at some point. Spanish versions were produced until late 1990s and French versions until 2012. INSEE and Statistics Canada took care of the French versions and the *Instituto Nacional de Estadistica* in Spain the Spanish version.

In terms of distribution, thanks go to INSEE, the US Bureau of the Census, the Bureau of Labour Statistics, Statistics Canada, the Australian Bureau of Statistics, the Central Statistical Bureau of Latvia and Poznań University of Economics and Business who have in turn been involved and responsible for production and circulation.

As far as the appearance of the newsletter is concerned, the cover displayed the Table of contents from the first issue until issue #15. That is also when country reports started, and sections became more regular. Then issue #32 in July 1995 was the first one with the IASS logo and 5 years later, issue #45 introduced the design of the world map overlaid by people, equations, and a chart. This cover has stood the test of time as it still constitutes today's cover of *TSS*.

4 Major Sections

Over the years, TSS has presented several interesting sections. From the President's letter and the Letter from the Editors (published in the early days, then stopped for a long time and reinstated in 2010) to the News and Conference listings and many other sections, these have provided much needed and interesting inputs to members. The core of TSS has been made of the following sections: Ask the Experts; Articles (New and Emerging Methods since July 2010); Book & Software Review; Country Reports; and In other Journals. This structure has remained unchanged since issue #62, July 2010.

4.1 Ask the Experts

The Question-and-Answer section later becoming the Ask-the-Experts section was created and coordinated by Leslie Kish from 1978 to 1994. During that time, 42 questions were published. Eventually they were republished as a stand-alone booklet (Kish, 1995). Kish took his questions from people he met during conferences and also included a fair number himself, thanks to his acute awareness and understanding of member needs. In 1995, Vijay Verma took it over until 2001 at which point there was a pause. Then in 2004, Anders Christianson re-birthed the series and with Steven Heeringa as *TSS* editor and I looking after the Web site, we worked as a team to help each other with our three responsibilities. During that time, other special guests (e.g., Bill Winkler and Phil Kott) were invited by Anders to contribute answers on specific topics. Following another pause, Robert Clark revived the section from 2010 to 2014. From 2015 to 2018, Kennon Copeland handled it, and I continued it in 2019 and 2020. Since 2021, Ton de Waal has been coordinating the section.

Over the years, a wide array of topics covering all aspects of the work of survey statisticians was covered. These dealt with questionnaires, coverage, designs, editing and imputation, estimation, confidentiality and more recently on-line surveys, non-sampling error, bias, and the use of non-probability samples just to name a few. In total, about 95 questions were posed and answered, an average of about one per issue overall but closer to two per issue when taking into account the years without them. The Ask the Experts Section also has a bespoke tab on the IASS website given its importance on communicating survey statistics: http://isi-iass.org/home/ask-the-experts/.

4.2 Articles – New and Emerging Methods

The presence of articles in *TSS* varied greatly depending on objectives of the executive and editors but also on the active offers of scientific journals as options to publish articles. In the first Newsletters from 1974 to 1978, IASS session structures with a summary of papers presented were included, and authors were encouraged to use the then-existing *Sankhya C* for their complete paper. It was later decided not to include articles in *TSS* and rather use *Survey Methodology* journal from Statistics Canada as the prime vehicle for papers. At that time, it was made available at a preferential rate to IASS members (see Beaumont, 2023 for more details on the history of *Survey Methodology*). Then from issue #30 to #53, short papers came back to *TSS,* and this was stopped again from #54 to #61. Since issue #62, *TSS* has featured at least one article per issue. Of note is the fact that in recent years (since issue #81 in 2020), people have been encouraged by the editors to submit articles that undergo a review. The goal is not to create a refereed journal but rather to elevate the rigor in presentations of new and emerging topics. Only a very small number of articles which are not in line with the direction are rejected. At the same time, *TSS* constitutes a medium for announcements, short communications, questions, experience sharing. The *News and announcements* section is devoted to this.

Overall, 133 articles have been published in *TSS* on current topics of interest to IASS members. This does not include the 36 book and software reviews (see next section) that were published. So, in all, *TSS* has produced close to 170 articles, an average of well over 3 per year during the existence of the IASS. This is very good given that a much larger number of articles have been published by members in numerous journals.

Since issue #81 in January 2020, open access reviewed articles started to be published. This has allowed access to and possibility to download single articles at a time (rather than the complete *TSS*). Also concerning articles, a new *TSS* invited session was organized at the World Statistics Congress in 2021 on *Issues with big amounts of data for survey statistics.*

4.3 Book & Software Review

The Book and Software Review section started (as Software Review) in issue #35 in 1996 with a review paper by Jim Lepkowski and Judy Bowles on Sampling Error Software for Personal Computers. For seven years this section covered the most well-known survey software and tools such as *SAS*, *SPSS*, *STATA*, *SUDAAN*, and *WesVar* to name a few. Then, until 2011, the section was left out except once to present *R*.

With issue #64, the section was renamed and enhanced to include book reviews as well as approaches, guidelines, checklists that are useful to survey statisticians. Since then, almost all issues presented either a book, a software or a survey tool. Books covered a wide variety of modern and classic parts of survey sampling theory and methods such as disclosure, designs, treatment of nonresponse, registers, record linkage, Small Area Estimation, and web surveys. Software presented included *R*, *RShiny*, *Python*'s *samplics* and the *R* package *survey*. In total, 16 software, 15 books and 5 other tools have been reviewed.

4.4 Country Reports

Informing members on survey activities that are taking place in other countries has been a very popular section of *TSS*. In the 50 years of the IASS, over 600 country reports have been produced by more than 70 countries. Moreover, some of the reports often covered more than one survey and have highlighted interesting implementations of survey methods and approaches. Early editions of *TSS* had countries providing articles which sometimes were in the form of reports and sometimes more in the form of an article. This could happen thanks to a network of country representatives established in 1976. Country reports as we know them today really started in 1989 with issue #21. By 1993, the tasks had become in need of a coordinator and Gordon Brackstone (Statistics Canada) managed the section from 1993 to 2001. Ever since, Canada looked after this, the responsibility being passed on to John Kovar (2002-2009), Pierre Lavallée (2010-2016) and Peter Wright (2016-2023).

Contributions by countries were many. Through the years, seven countries (Australia, Canada, New Zealand, The Philippines, Poland, Spain, and US) provided over 25 reports with Australia and New Zealand each providing over 40 and Canada more than 65. Twelve countries provided between 10 and 25 reports (Argentina, Brazil, France, Germany, Hungary, India, Israel, Italy, Japan, Latvia, Malaysia, and UK), while 31 countries did between 2 and 9 reports and 23 other countries provided one.

4.5 In other Journals

Immediately with *TSS* issue #1, people started listing articles related to survey methodology. At that time, it was simply in the form of a bibliography. Then, starting with issue #15, abstracts were produced and listed. It is with issue #34 in 1996 that the section *In other journals* was created to present the table of contents of some of the main journals publishing articles in survey methodology. The main journals in this section have been *Survey Methodology*, the *Journal of Official Statistics* and the *Journal of Survey Statistics and Methodology*. Today the section continues to inform on recently published articles of interest.

5 Conclusions

The Survey Statistician has been a strong presence uniting the members of the IASS. From its modest origin as a few-page leaflet to a solid almost magazine-style paper newsletter, *TSS* has been available on-line since 2000 and exclusively in this format since 2021 when the last paper issue was published in July of that year. It has also been officially registered with an International Standard Serial Number (ISSN 2521-991X) for the world periodicals since issue #67 in 2014. This has made *TSS* an official periodical, a higher status than a manuscript.

Under the leadership of many editors, *TSS* has thrived and hopefully will continue to keep many survey statisticians informed and interested in the IASS. Further, many other members of the associations have contributed to make it what it is today. With continued participation by many members and the new generation of statisticians writing, asking, submitting, congratulating, recognizing, sorrowing and reading, it will continue to succeed.

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Survey Sampling History at Iowa State University

Jae Kwang Kim

Iowa State University, USA, jkim@iastate.edu

Abstract

Iowa State University (ISU) has played an important role in research and education in survey sampling. In this article, we give a brief history of the Statistical Laboratory Survey Section (now known as the Center for Survey Statistics and Methodology) and its impact on the survey sampling community. Some reflections on my journey in survey sampling are also presented.

Keywords: Center for Survey Statistics and Methodology, National Resources Inventory.

1 Introduction

Iowa State University (ISU) has played an important role in research, practice, and education in survey sampling. The Statistical Laboratory (Stat Lab) at Iowa State College was established in 1934 to promote statistical research and provide consulting to other university units, and led by George Snedecor. The Survey Section of the Statistical Laboratory, which later became the Center for Survey Statistics and Methodology (CSSM), was established in 1938 as a result of a cooperative agreement between the Statistical Laboratory and the U.S. Department of Agriculture (USDA).

In this article, I give a brief history of Stat Lab and its impact on the survey sampling community. Some reflections on my journey in survey sampling are also presented.

2 History

2.1 Early Years, 1938-1948

The Department of Agriculture was one of the early organizations in the U. S. to initiate research and development work on probability sampling, and they established a cooperative research program with the Statistical Laboratory at Iowa State University in 1938. Initial work under the cooperative agreement with the USDA led to the development of the Master Sample of Agriculture (King and Jessen, 1945), a national area sample of land that was subsequently used in numerous economic surveys of American agriculture, as witnessed by Fuller (1984).

Jessen (1942) investigated the problem of approximating the optimum sizes of sampling units for agricultural studies. The paper guided the development of the Master Sample of Agriculture and stimulated the later development of designs and theory for rotating samples for surveys taken on successive occasions for time series estimation.

Iowa State is also one of the few universities that has featured training in sample survey theory and methods as an important part of statistical training, as noted by Hansen (1987). Under George Snedecor, Iowa State was also a center for statistical treatment of experimental work. The emphasis in applied statistics at Iowa was then on sample surveys and experimental design. William G. Cochran then joined the Rothamsted Experimental Station and lectured on sample surveys and experimental design. *Sampling Techniques* by Cochran (1953) was developed from the lectures at Iowa State University. In 1946, Cochran left Iowa to organize and head the graduate program in experimental statistics at North Carolina State College at Raleigh. Theodore Bancroft took over from George Snedecor as the Head of the Department of Statistics (established in 1947) and the Director of the Statistical Laboratory during 1950-1972.

2.2 1950s-1960s

Survey research and consulting continued to grow through the efforts of the groups in many disciplines and areas. The early 1950s saw survey statistics research highlighted in Ph. D. dissertations in other disciplines on campus, a practice that has grown significantly since. Other efforts in the 1950s and 1960s included survey research, methodology, and practice in areas such as employment trends in the state of Iowa, home economics studies across the nation, farm practice surveys, and surveys for researching social welfare in the state of Iowa, just to name a few. Interest from international venues also increased after the 1950s, as research fellows from across the globe began visiting the department to take courses in survey methodology and work with faculty and students on applied research projects. For example, the seminal paper of Horvitz and Thompson (1952) was published when the authors were graduate students at ISU and they were influenced by the lectures from Midzuno who visited ISU from Japan. P. V. Sukhatme also visited from India and wrote his famous book (Sukhatme, 1953) at ISU, which was published by Iowa State College Press. His brother, B. V. Sukhatme, joined as a faculty member of ISU later and revised the book (Sukhatme and Sukhatme, 1970) and advised graduate students.

In 1956, the Survey Section began cooperating with the US Soil Conservation Service (now the USDA Natural Resources Conservation Service) to develop survey methods and provide operational support for the National Resources Inventory (NRI), a longitudinal survey of agricultural and other natural resources on nonfederal lands. CSSM continues to work on the NRI project today, and the survey has been the inspiration for many methodologies related to sampling and estimation (Nusser and Goebel, 1997). Results from these surveys are used extensively in the construction of Farm Bills in the US. A second major, ongoing collaboration began in this period with the US Census Bureau on improving survey sampling and methodology in census practices.

H. O. Hartley joined ISU in 1953 and became deeply involved in research and teaching. Hartley made several major contributions, including the famous paper on unbiased ratio estimation published in Nature (Hartley and Ross, 1954). This paper motivated Mickey to develop a whole class of unbiased regression estimators (Mickey, 1959), which was done at ISU. Hartley also wrote seminal papers on domain estimation (Hartley, 1959) and dual frame surveys (Hartley, 1962) while he was at Iowa State. Hartley's contribution to survey sampling is well summarized by Rao (1983). Hartley is the Ph. D. advisor of J. N. K. Rao. Rao stayed at ISU for 5 years (1958-1963), three years as a student and two years as Assistant Professor (AP). Rao, Hartley, and Cochran (1962) published a paper on a very simple procedure of unequal probability sampling scheme without replacement that allows them to estimate the variance of the resulting estimator of total. During his AP tenure, Rao shared an office with Wayne Fuller, who just joined the Statistics Department as an AP, and they remained good friends to each other throughout their professional careers. Hartley also advised Edward Bryant on two-way stratification (Bryant et al, 1960), which received a lot of attention at that time. Edward Bryant later founded Westat.

Figure 1: Wayne A. Fuller

2.3 1970s-1980s

With the arrival of more powerful mainframe computers, namely the IBM 360, as well as advances in statistical computing, the Survey Section began to develop and implement more sophisticated survey and data analysis. SUPER CARP, the first mainframe computer program developed by Mike Hidiroglou in the Survey Section, allowed the implementation of many estimation methods used in survey sampling in an automated manner. The program used the software developed to compute regression estimation in the context of survey sampling. The software was also expanded to allow for estimation and estimated standard errors for totals, ratios, means, and proportions for subdivisions of a sampled population. It also contained several procedures appropriate for data observed subject to measurement errors. It was operational by 1976: See Hidiroglou, Fuller, and Hickman (1978). In 1985, SUPER CARP underwent major revisions and updates of algorithms that allowed its deployment on IBM-PCs. Later, EV (errors in variables) CARP was released as companion software to Wayne Fuller's book, *Measurement Error Models* (1987). Many graduate students, including Cary Isaki, Mike Hidiroglou, Kirk Wolter, Elizabeth Huang, Yasuo Amemiya, Sastry Pantula, David Dickey, and John Eltinge, worked on this project and its related topics under the supervision of Wayne Fuller. Kirk Wolter served as the president of the International Association of Survey Statisticians (IASS) during 1999-2001.

Wayne Fuller has since made many important contributions to survey sampling. Wayne Fuller can be credited for introducing the regression idea to adjust the design weights to construct calibration weights. Huang and Fuller (1978) developed an iterative method for constructing range-restricted weights that meet the benchmarking constraints and the design consistency. Isaki and Fuller (1982) laid the foundation for establishing the optimality of the regression estimator. Battese, Harter, and Fuller (1988) developed a framework for a unit-level model approach to small area estimation.

2.4 1990s-2000s

New faculty members, including Sarah Nusser, F. Jay Breidt, and Jean Opsomer, joined the Survey Section in the 1990s. During this period, survey statistics education and research continued to flourish at CSSM. The wide diversity of projects undertaken included survey consulting on projects such as local efforts to analyze and improve ISU campus services; consulting projects with departments and bureaus of the state of Iowa to develop statistical pictures and gather information about Iowa residents' behaviors and preferences to farm production surveys and Iowa business and economic survey research; ongoing long-term research projects with national agencies such as the USDA / NCRS and the Census Bureau, as well as new projects with the National Cancer Institute, the Centers for Disease Control, the National Institutes of Health, the Bureau of Land Management, and the

National Science Foundation, amongst many others. In November 2002, the Survey Section of the Stat Lab officially became the Center for Survey Statistics and Methodology. Wayne Fuller officially retired in 2001, but he continued working as a part-time consultant at the CSSM.

On the research side, a measurement error model was applied to estimate the usual daily intake distribution (Nusser Carriquiry, Dodd, and Fuller, 1996). This work served as the basis of ongoing work by Alicia Carriquiry and Fuller that still influences approaches to dietary assessment in the United States and many other countries. The NRI's longitudinal 2-stage stratified cluster sample, which is observed every 5 years, was redesigned to an annual survey with supplemented panels. Design and estimation of the supplemented panel survey became very important for NRI application (Nusser, Breidt and Fuller, 1998; Fuller, 2003). Breidt and Opsomer (2000) developed nonparametric regression estimation methods and collaborated on many research problems in survey sampling. Regression weighting methods were further developed for the U. S. Census (e. g., Isaki, Tsay, and Fuller, 2004). Fractional hot deck imputation was developed by Kim and Fuller (2004). Emily Berg wrote a Ph. D. thesis on small area estimation under the supervision of Wayne Fuller (Berg and Fuller, 2014). An advanced-level textbook on survey sampling written by Fuller (2009) was finally published.

2.5 2010s-present

Cindy Yu, Jae Kwang Kim, Zhengyuan Zhu, and Emily Berg joined ISU and became a new generation of CSSM faculty. Each has influenced continuous methodological developments in different ways - Kim via missing data analysis, Zhu via spatial data models, and Berg via her expertise in small area estimation. CSSM provided statistical consulting to other agencies, including the National Agricultural Statistical Service, the Bureau of Land Management, the Bureau of Justice Statistics, and the Food and Agriculture Organization (FAO) of the United Nations.

Kim expanded the departmental curriculum with a graduate-level course on handling missing data, and the lecture notes matured into a textbook (Kim and Shao, 2021). Kim used his expertise in missing data and developed a series of methods for data integration (Kim, 2022). Under the directorship of Zhu, the CSSM continues to expand, and the funding size is now about 5 million USD per year.

3 Reflections

I consider myself to belong to the third generation in the survey sampling community. The first generation at ISU includes William Cochran and H. O. Hartley. The second generation at ISU includes J. N. K. Rao and Wayne Fuller. Standing on the shoulders of giants, I learned the essence of survey sampling theory and methods. When I was a graduate student at ISU, the Statistics Department offered a very specialized curriculum in survey sampling, with separate MS and Ph. D. courses in sampling, and Jay Breidt's lectures were very clear and excellent. I wrote my dissertation under the supervision of Wayne Fuller and have benefited a lot from Fuller's excellent insights and rich research experience.

The second generation flourished in the "Golden Age of Survey Research" (Singer, 2016) when the response rates were high and other data sources were unavailable. As a third-generation member, as Kalton (2019) pointed out, I faced two main challenges in survey sampling. One is the declining trend in response rates and the related increases in the costs of surveys based on probability samples. The other challenge comes from the emergence of an alternative source of information, including large administrative data and low-cost web panel samples. Thus, naturally, I became interested in the research topics addressing these new challenges: handling missing data and adjusting selection bias in the voluntary samples through data integration or weighting.

Imputation for handling item nonresponse is a topic of my Ph. D. thesis. I worked on a consulting

project for the U. S. Bureau of Census on estimating the variance of the census long-form survey estimates after nearest neighbor imputation (Kim, Fuller, and Bell, 2011), which is based on ignorable missingness assumption. Before joining ISU in 2008, I had the opportunity to work on a project related to election exit polls in Korea. This sparked my interest in nonignorable missing research and led to several papers over the years at Iowa (Kim and Yu, 2012; Morikawa and Kim, 2021). An invitation from J. N. K. Rao to visit Ottawa in 2007 was also an eye-opening experience for me. Combining information from two independent surveys (Kim and Rao, 2012) started with the visit to Rao. Consulting projects from Statistics Korea and the USDA National Agricultural Statistics Service, data integration methods were developed using the measurement error model (Kim, Park, and Kim, 2015) and multilevel models (Kim, Wang, Zhu, and Cruze, 2018), respectively. A visit to the Australian Bureau of Statistics in 2016 sparked my interest in data integration research incorporating big data (Kim and Tam, 2021).

As a sampling statistician in academia, I now see another challenge approaching us: how to teach survey sampling and educate the next generation so that they can understand the value of survey sampling. In the era of machine learning and AI, students are more interested in learning modern techniques than classical subjects. Thus, in addition to the decline in survey participation, we are facing a decline in interest in survey sampling research among the next generation. How do we improve our teaching, modernize our textbook and find interesting research problems to attract young "smart" students into survey sampling? I think these questions should be seriously addressed by the survey sampling community in academia.

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Sample Surveys in Post-Apartheid South Africa

Jairo Arrow

Retired Deputy Director-General, Statistics South Africa, Vice President IASS
jairo.arrow@gmail.com

Abstract

South Africa conducted its first non-racial housing and population census in 1996. Statistics South Africa (StatsSA) currently conducts two major household sample surveys: the General Household Survey (GHS) and the Quarterly Labour Force Survey (QLFS). International support has played a key role in the development of statistical production in South Africa. StatsSA still faces challenges in terms of building and maintaining a robust statistical infrastructure.

Keywords: sample surveys, post-apartheid, Statistics South Africa, sampling frames, international support, CPI crisis

1 Introduction

Over the past fifty years, survey statistics in Africa have evolved significantly, driven by changing socio-economic and political dynamics on the continent. The earliest surveys in Africa were conducted by colonial administrations. The statistics so collected were not intended to inform policy outcomes for the betterment of the local population but to strengthen the colonial grip on agricultural production, trade, and the local population. The minority Apartheid state in South Africa was not any different from the British, French, or Portuguese colonial powers in the collection and compilation of statistics. My contribution covers the South African post-apartheid period. That said, I would nevertheless touch briefly on the history of sample surveys on post-colonial African during the last fifty years.

2 A brief overview of sample surveys in Africa

The first Sub-Saharan African country to obtain independence from Britain was Ghana in 1957. But it took another thirty years before the country ran its first sample household survey, the Ghana Living Standards Survey (GLSS), in 1987. Although Ethiopia was never colonized the country conducted its first sample household survey, the Ethiopian Rural Household Survey (ERHS), in 1980, which came two decades after the Ethiopian Housing and Population Census of 1960. In North Africa the earliest sample household surveys were conducted in Egypt and Morocco in 1958/59 and 1960, respectively. The first sample household survey conducted in the Southern African region was the Living Standards Measurement Survey (LSMS), which was carried out in Botswana in 1984. South Africa conducted its first sample household survey, the October Household Survey, in 1993.

The first business sample survey conducted on the African continent was the so-called Ghanaian Manufacturing Census in 1962. Since then, many African countries have conducted business sample surveys to collect data on the structure and performance of their economies.

When compared to other continents, in terms of the conduct of household sample surveys, independent African countries do not fare badly. The USA, for example, conducted its first household sample survey in 1940. In Latin America, the first household sample survey was undertaken by Mexico in 1951. India, on the Asian Continent, conducted its first household sample survey in 1950/51, which was even earlier than the UK Family Expenditure Survey (FES) which took place in 1957.

3 Statistics South Africa – Constructing a modern statistical system in post-apartheid South Africa

On April 27, 1994, South Africans lined up in meandering queues patiently waiting to cast their vote for a parliament in "*which the colour of a man's skin*" was immaterial. But what was the turnout? Nobody could tell because there was no comprehensive population register for the whole country. Neither was there a dwelling nor a business sampling frame. Post-apartheid South Africa was still facing the lack of these fundamental building blocks of a modern statistical system when I joined the Central Statistical Services (CSS) in 1997. The CSS, which later morphed into Statistics South Africa (Stats SA), had hitherto served only the white population. The CSS counterparts in the Bantustans, or homelands for blacks, were statistical agencies only in name.

On 9 October 1996, South Africa conducted its first non-racial housing and population census. It was estimated that 10.7% of the people had been missed in the count. This was the beginning of regular population censuses intended to be conducted every five years. Accordingly, the second housing census took place on 9 October 2001. The count was characterised by a relatively high undercount of the population, estimated at 16.7%. The quality of the census, judged by the undercount had deteriorated. This poor performance was blamed on the lack of resources at StatsSA, both human and financial. The next round of the population count was postponed to 2011, and to fill the gap, Stats SA conducted a large household sample survey, the Community Survey (CS 2007), in October 2007. The third census took place in October 2011. The sampling frame used was a collection of geographical units, called Enumeration Areas (EAS). Enumeration areas were created by dividing the country into small geographic areas. In the runoff to the count, South Africans were keen to have better results, but they were again disappointed when the undercount was in the two-digit range of 14.6% The second large sample household survey (CS 2016) was conducted in October 2016. Due to the COVID-19 pandemic the population census planned for 2020 was delayed and took place in February 2022. The results will be published this year, 2023. StatsSA currently conducts two major household sample surveys: the General Household Survey (GHS) and the Quarterly Labour Force Survey (QLFS).

4 The Business Registration Reform Project

When I started at Stats SA in 1997, as a director in the Economic Statistics department, the sampling frame for Economic Statistics was the Business Address Register (BAR). Through a careful analysis of business and economic surveys, we concluded that the BAR was inadequate and fell short of the main characteristics of a sampling frame: regular updating, comprehensive coverage, and proper classification of units by size and industry. These concerns led to important legislative changes. In 1999, Parliament amended and passed the Income Tax Act, giving Stats SA access to all tax categories (Income Tax, VAT, PAYE, and Customs) for statistical purposes only. The Department of Trade and Industry (DTI) was responsible for business registration through its agency, Companies and Intellectual Property Registration Office (CIPRO), now called the Companies and Intellectual Property Commission (CIPC).

There was no single and authoritative view of the business landscape. An interdepartmental project team was set up and President Zuma in his state of the nation address to Parliament in 2007 announced the establishment of a Business Registration Reform Project as one of the goals of his administration in the coming years. This project was to be executed by five government departments:

SARS, the National Treasury, the Department of Trade and Industry, the Department of Labour alongside Stats SA. The objectives of the project were:

- The establishment of a single registration authority for primary business registration.
- Review of the current legal definition of 'primary business registration' to include tax registration.
- Expansion of the type of business entities included in the legal definition of primary business registration.
- Compliance with all primary business registration requirements through a single transaction.
- The introduction of a mandatory unique business identifier for all legal and commercial transactions.
- Expanding the number and type of registration channels available for the purpose of primary business registration.
- Increased data and information sharing across government entities.

A legislative framework was proposed by an inter-department project team, which envisaged a law governing the registration of businesses in South Africa under a single government agency. But the project was abandoned in 2011 when departmental rivalries stood in the way.

5 International support in establishment of sampling frames

Important changes that occurred in the framework of statistical production perhaps would not have occurred had it not been for the material support from the international statistical community. The Australian Bureau of Statistics (ABS) was the first international statistical agency on the scene. Senior ABS staff provided advisory support for extended periods to Stats SA statisticians and senior management. Statistics Sweden also played a key role in the transformation of statistical production environment by dispatching advisors to Stats SA. Together with Statistics New Zealand, Statistics Sweden seconded senior staff to help set up the current Business Sampling Frame which is now the omnibus sampling frame for the business surveys at Stats SA.

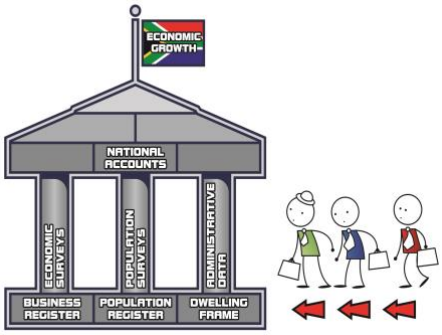
6 The CPI crisis

As StatsSA was feeling more and more confident in its role as the 'top statistical agency' in Africa, as the newly appointed head of the agency, the Statistician-General, Mr Pali Lehohla, claimed. Around 2002-03 a less well-known economic researcher at a small investment bank, Investec, was consistently casting doubts on the quality of the consumer price index (CPI). StatsSA fiercely denied the allegations of misstating the price index as baseless and mischievous. A small team of Stats SA methodologists carried out a detailed analysis of the CPI and came to the same conclusion that the CPI was indeed misstated. This was a huge setback in the trustworthiness of the national statistical collection.

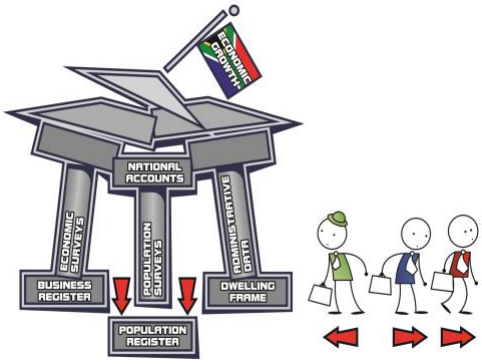
The CPI crisis led to a general distrust in the official statistics produced by the statistical office. Thereafter employment statistics came under strong criticism. A small firm of labour brokers even launched its own series called the Adcorp employment index, which for several years served as a parallel source for employment statistics in the private sector.

7 The role of the sampling frames as a foundation for production of quality statistics

The creation of a credible resilient statistical system is like building a house. The statistical office mandated to compile national statistical indicators becomes synonymous with the factfinder of the society. The statistical office is then the authoritative source of statistical indicators. It becomes the primary destination users seeking reliable and trustworthy statistics would turn to. Many countries do not have a population register but nevertheless successfully conduct household surveys based on robust statistical standards and classifications.



On the other hand, a weak statistical system is like a house with faulty foundations (sampling frames) and leaking roof (National Accounts). The resultant statistical indicators are not trusted by users, who turn to myriad other sources of information, some which might not stand rigorous scrutiny.



In the 1970s, most African countries focused on conducting large-scale national surveys to collect data on key economic and social indicators, such as income, employment, education, and health. However, data collection was often hampered by logistical challenges, including poor infrastructure, limited resources, and political instability.

8 The World Statistics Congress 2009

The 57th Session of the International Statistical Institute, as the World Statistics Congress was then known, was held in Durban, South Africa. It was unmistakable proof of a South African statistical system that had come of age. It was an historical event in other respects: it was the first in Africa and under the first female ISI President, Denise Lievesley. I was fortunate enough to serve as the Executive Secretary of the Organizing Committee. This event was not just an important moment for South Africa but also for the entire African statistical system.

9 Some challenges facing the statistical system.

The past fifty years years have indeed witnessed significant progress in the development of survey statistics in Africa. Many African countries have invested in building stronger statistical systems, including the development of national statistical plans, the establishment of statistical agencies, and the adoption of innovative technologies and methodologies for data collection and analysis.

However, there are several challenges still facing statistical agencies in Africa in terms of building and maintaining intellectual human capital. StatsSA has attracted skilled staff from across the continent, e.g., Ethiopia, Nigeria, Kenya. Additionally, it runs an internship programme which has attracted young graduates from South African universities, who undergo a one-year training programme at Stats SA. This programme has helped StatsSA grow its own crop to address skills shortages in the statistical system.

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Development of Sample Surveys in Australia and New Zealand over the Last 50 Years

Dennis Trewin

Australian Statistician (2000-2007) and IASS President (1995-1997)
dennistrewin7@gmail.com

Abstract

This note outlines the development of sample surveys in official statistics in Australia and New Zealand since the inception of the IASS. It highlights the increasing need to not just rely on sample surveys although they remain important as a component of mixed mode methods. Accordingly, sample survey methodologists need to broaden their skills to maintain their relevance.

Keywords: sample surveys, mixed mode, non-sampling errors.

1 Introduction

Both countries have centralised statistical systems and the majority of sample surveys are conducted by the national statistical offices. Hence, this paper concentrates on developments in these two offices. Given the context of this issue of *The Survey Statistician*, the paper is also more about past history than recent history. A good reference for Australia is ABS (2005).

As an inaugural member of the IASS in 1973, I have seen many changes in survey methods over the last 50 years. Nevertheless, both Australia and New Zealand (NZ) were relatively mature in their adaption of probability-based sample surveys by 1973 under the leadership of Ken Foreman at the Australian Bureau of Statistics (ABS) and Steve Kuzmicich at Statistics New Zealand (SNZ). The importance of their work was recognised because, for much of their careers, they held quite senior positions and were regarded as part of the executive team as well as being chief methodologists.

By 1973, a national household survey was in place in Australia and had been held since 1960. It was used to conduct the quarterly labour force survey (LFS) and a series of supplementary surveys. In New Zealand, the LFS came later whilst they relied on registered unemployment data. In both countries, a number of special household surveys such as household income and expenditure surveys (HIES) had already been conducted. Multistage area frameworks were used with a mesh block as the primary sampling unit (PSU) in NZ whilst Australia used the larger Census Collectors Districts (CDs) and used field work to create blocks within selected CDs.

Probability sampling methods were also used to conduct surveys of businesses such as the monthly retail surveys. In Australia, the first business surveys using probability sampling were conducted in 1947 and in 1956 in NZ. Sampling methods were also being used in the Australian Census to conduct post-enumeration surveys and to support quality control of Census processing.

2 Developments in Household Survey Methods

Household surveys enabled a massive increase in social statistics in both countries. Following the 1971 Australian Population Census, a significant effort was made into developing a multi-stage area sampling frame that could be used for multiple surveys as well as providing a rotating sample for the main survey – the quarterly labour force survey which had started in the early 1960s and became monthly in 1978. A stratified self-weighting design was used. Households remained in the sample for eight consecutive surveys before being rotated out. Independent population age x sex benchmarks were used to adjust for under-enumeration which was particularly high for young male adults. The new design provided for a 40% reduction in variance without any increase in sample size.

During this time a program of special household surveys was developed in both countries on topics such as household expenditure and income, health, time use, disability and education.

The enumeration methods have also evolved over time. Fifty years ago, face to face interviewing was exclusively used. Telephone interviewing was introduced in Australia in 1994 but a face to face interview was still used for the first time households were in the survey in order to obtain approval to conduct future interviews by telephone and obtain contact details. Before implementation, considerable effort was put into measuring any accuracy impacts from the change in collection mode. The existence of an identified impact delayed the introduction of telephone interviewing, but it turned out to be largely a first survey effect. Computer-Assisted Paper Interviewing (CAPI) was introduced in 2004 also enhancing the availability of para data to assist with survey design. Telephone interviewing was introduced in New Zealand a little later but face to face interviewing remained the dominant interviewing method. The accuracy of telephone lists was never high enough to be seriously considered as a sampling frame. The possibility of respondents completing the survey over the internet was introduced in 2014 in Australia following analysis showing measurement effects were relatively small.

An address frame of residential dwellings was developed for the 2016 Australian Population Census. It proved to be quite accurate and has been updated since then largely using external lists such as Australia Post and machine learning methods with satellite imagery as the data source. Since 2018, this frame has been used for the household survey program enabling more sophisticated means of controlling sample rotation and overlap between surveys. SNZ retains its 2 stage area sampling method for household surveys.

Methods for making estimates of aggregates and their sample errors have changed considerably over time as methods developed and more benchmark data became available. Model assisted GREG estimators are now mostly used.

3 Developments in Business Survey Methods

In Australia, probability surveys were first used for the business surveys (e.g. capital expenditure) in the 1940s and a little later in New Zealand. In the early years, the major cause of inaccuracies were missing units on the sampling frames. There was no great source for updating the frame. In Australia, a major effort in the late 60s and the early 70s was the development of an Integrated Business Register, providing for the hierarchy of enterprise groups, enterprises and establishments complete with industry codes, that could be used as a frame for all economic censuses and surveys. Tax data became available to support updates but still required considerable follow-up effort before new businesses could be added to the frame with confidence. Similar developments happened in New Zealand but it was not until the mid-1980s that the required tax data access was available. Prior to then, field checks by CPI staff were commonly used.

The existence of a Business Register enabled the application of a method, referred to as collocated sampling in Australia, to provide for the rotation of sampled businesses after they had been in the sample for a designated period of time (e.g., 3 years) (Brewer et al., 1972). Furthermore, it enabled

the control of overlap across surveys. Independently, Statistics Sweden had developed a very similar method. A simplified version was used in SNZ.

All the traditional economic censuses (e.g., manufacturing census) were converted to sample surveys in both countries across the following decade. More recently, most economic surveys tend to be economy-wide rather than industry specific.

Mail was the dominant data collection method with telephone interviewing mostly used to follow up non-response. The exception was the monthly retail survey where most of the data collection for small businesses was by telephone. Consequently, it was the first application of Computer-Assisted Telephone Interviewing (CATI) in the ABS, introduced after an extensive study of possible mode effects. About the same time, in both countries, the very largest enterprise groups were profiled so that their enterprise group-enterprise-establishment structure matched their financial accounting arrangements to the extent possible and their data collection was managed by so called large business units.

Despite the considerable efforts to integrate the data collections that provide source data for the national accounts, the statistical discrepancies within the accounts were still larger than desired. In the late 1980s, there was an extensive investigation into the reasons in Australia. It was found that a major reason was the inconsistent treatment of the missing units on the frame (mostly new businesses), businesses that were no longer operating, and non-response. Among other things, this led to a delay in detecting a turning point in the important survey of capital expenditure impacting government fiscal policy at the time. Standard procedures were developed by Methodology, including the estimation of new business provisions by industry, which were provided to all the surveys by an organisational unit especially set up for this purpose. Further data confrontation methods across collections, using the national accounting framework, were also put in place prior to the finalisation of the national accounts. This was a form of output editing but looking at multiple collections simultaneously. It resulted in considerably more accurate national accounts. An important outcome of the investigations was Ministerial support for greater access to tax data. Similar issues in SNZ led to proposals for a more systematic approach to economic collections.

4 Population Census

Statistical quality control methods for processing were first put in place for the 1961 Australian Population Census. Acceptance sampling methods were used which involved the acceptance or rejection of coded forms based on error counts determined by expert coders. Rejected lots were reprocessed. Studies showed that expert coders were not necessarily more accurate. At the 1976 Census, this was changed so the sample checks were used to provide information on the level and type of errors only. This information was used to identify ways in which the quality of processing could be improved e.g., retraining or improved coding instructions.

A Post-Enumeration Survey (PES) has also been conducted by the ABS since the 1966 Census. Its importance increased substantially following the 1976 Census. Following detailed demographic analysis, it was determined that Census counts were far more accurate estimates of the population if they were adjusted for undercount (at an age group x sex x State level) using PES data. Subsequently, the official population estimates for Australia have been adjusted using PES data after every Census. It was the first country to do so. The analysis also found, contrary to conventional wisdom at the time, the Censuses in the latter half of the twentieth Century were far more accurate than the first half. SNZ conducted their first PES in 1991. In SNZ, the PES is used for Census evaluation purposes only.

SNZ conducted surveys on Disability and Use of Maori Language using frames determined by responses to questions placed in the 2016 Census.

SNZ had field enumeration problems in the 2018 Census resulting in large non-response. They used administrative data to ‘rescue’ their 2018 Census supported by major methodological work. Based on this positive experience with the use of administrative data, the 2023 census is being designed

to make more use of this data and thereby reducing the reporting load on the public and possibly improving the accuracy of some aspects.

5 Increasing Interest in Non-sampling Errors

There has been long standing interest in both countries in measuring, understanding and controlling non-sampling errors. As part of the effort to control non-sampling errors, pilot testing was a standard procedure for new surveys or when introducing new methods. Until relatively recently, there was always a strong emphasis on maintaining high response rates to minimise non-response bias. They remain high by international standards although now survey designs focus more on ensuring samples are sufficiently representative of the population by using techniques such as adaptive sampling.

A research study into editing for the Retail Census showed that it introduced more errors than it discovered as the editing clerks learnt how to game the editing system so that each record passed the computer edits. Studies of other collections were consistent with this finding. The resources devoted to editing across all collections were considerable and did not contribute much to overall accuracy. These studies led to the introduction of more cost-effective macro-editing approaches that focussed on the most significant errors reducing costs as well as improving accuracy.

The increased effort into understanding and quantifying measurement errors led to consideration of the optimisation of Total Survey Error (TSE) rather than sampling error. This was inspired by Dalenius' work (1967) and preceded the more recent interest in TSE. In the ABS, it was applied to the design of the new Construction Industry Survey (see Linacre and Trewin, 1993) where one important decision from the TSE work was to use a more expensive field enumeration method for smaller businesses but with a smaller sample size. Subsequently, it has been recognised in design work that there are far better returns from methodological investments in frame maintenance and other non-sampling errors than clever work on sample designs.

This research also showed the importance of good management to reducing non-sampling errors. It was not just about design (see Trewin, 2001).

6 Use of Administrative and Big Data

In recent decades, there has been many innovative uses of administrative data. It has always been used to compile statistics in subject fields such as Foreign Trade and Births Deaths and Marriages. It has also been used to provide proxy indicators for compilations like the national accounts. Furthermore, it has been used to develop and maintain sample frames and benchmark data to help improve the efficiency of sample surveys. In more recent years, innovative uses include:

1. Data substitution (tax data). Considerable effort has been put into maintaining a good and trustworthy relationship with the Tax Offices. Access to tax data has increased considerably over time especially with the introduction of a Goods and Services Tax in both countries which provided monthly and quarterly data. One important use was data substitution. Studies showed the tax data was reliable (perhaps more reliable than data collected by the ABS and SNZ) especially if edited for the more significant anomalies such as coding errors.
2. Linked Data Sets. The links may be between two administrative data sets or between administrative data and Census/survey data sets. This has resulted in the creation of new richer data sets for the production of official statistics and supporting research;
3. Longitudinal Data Sets. A specific application has been the creation of longitudinal data bases; and
4. Big Data. There have been no real applications to date but its use in small area estimation is being actively investigated.

7 Longitudinal and Linked Data Sets

Neither the ABS nor SNZ have conducted many longitudinal surveys, but they have provided support to other agencies. However, in recent years administrative data has been used to create longitudinal data sets, sometimes using their own data sets, using linkages at the individual level across data sets. For example, Business Longitudinal Data Bases have been created in both countries. SNZ has created an Integrated Data Infrastructure combining administrative data for individuals.

As an example of longitudinal data sets involving survey data, longitudinal data files have been created from the monthly labour force survey taking advantage of the fact that 7/8th of the sample is common from one month to the next. A longitudinal data base of Census records has also been developed in Australia using statistical matching techniques. Starting with the 2006 Population Census, a 5% sample of Census records was retained without name and address identifiers but with sufficient information to allow statistical matching across the individual data sets. It also enabled linking across Censuses thereby establishing a longitudinal data set. Linkages with Death Records has enabled much more detailed morbidity analysis including for Indigenous persons in both countries.

Even when linking variables are available, they are subject to error or linking data not being specified consistently. Therefore, the development of algorithms to maximise the accuracy of linking has become a very important job for methodologists.

8 Researcher Access

Among the major changes to ABS and SNZ legislation in the 1980s were legal provisions to enable them to release unidentifiable microdata. This provided constraints on access which some researchers found too limiting. Recognising inadequate use of microdata has high costs, in the early 2000s data laboratories were introduced where researchers could work in a safe setting with supervision and checks to ensure the confidentiality requirements were met. This was later extended to use of Remote Access Data Laboratories so that it was not necessary for researchers to visit the Statistical Offices.

It is also important that researchers have good quantitative knowledge of measurement and other errors so they can be taken into account in the analysis (see Biemer and Trewin, 1997).

A more recent development has been ABS and SNZ becoming custodians for linked data bases data sets (including links with some of its own data sets). Data laboratories are often the only way to access these valuable data sets.

9 Non-ABS and Non-SNZ Surveys

Increasingly, surveys are being conducted by other government agencies. Following the introduction of the 1975 Statistics Act in New Zealand, a survey control function was introduced. Every proposed survey by other agencies had to be submitted to the Minister of Statistics for approval of the sample and survey design. SNZ did the analysis necessary to make a recommendation to the Minister. At the request of Government, the ABS introduced a similar function in 1997. The emphasis was very much on ensuring these surveys were fit for purpose rather than a design that was up to the standard of the official statistical agency.

10 The Future

The role of the survey methodologist has changed massively over the 50 year period. It is no longer sufficient to be an expert in sample design. Mixed mode data collection techniques will become very prevalent generating new methodological challenges. Sample surveys are only one source of data for official statistics and are often used in combination with other data sources. For example, further use of administrative data and big data (e.g. scanner data and satellite images) can be expected, sometimes involving machine learning applications. This would include linked data sets.

Maintaining the quality of surveys to be fit for purpose will be a big challenge. Non-response is already a big issue and will become even more of a challenge as will the maintenance of good quality frameworks. Sample designs and methods that adjust for these types of deficiencies will grow in importance. The demand for data from researchers will increase requiring the development of methods to improve access with confidentiality protection arrangements that meet public scrutiny.

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The Contributions of Italian Statisticians to the Development of Survey Statistics

Luigi Biggeri

Emeritus Professor of Economic Statistics (University of Florence, Italy)
Past President of SIS, IASS (2003-2005) and ISTAT, luigi.biggeri@unifi.it

Abstract

In this short article I present, through flashes, a historical synthesis of the contribution of Italians to the development of survey statistics, from the starting stage up to the most recent years. The synthesis refers to both the practical and theoretical developments of the survey statistics, without claiming to be neither detailed nor complete.

Keywords: survey statistics, official and academic survey statisticians, Italy.

1 I start from the Middle Ages and the Grand Duchy of Tuscany to 1920

The first documented censuses show that in 1552 Cosimo I de' Medici organized the first population census of the then Florentine duchy. During the Grand Duchy of Tuscany various scientific societies of a general nature were also established, which included statistical studies. However, they were relatively short-lived due to their prohibition by the sub-sequent governments on the ground that the results of their research were subversive.

From the beginning of the 1800s and during the Italian Risorgimento, statistical knowledge and statistical activity developed a lot. Many scientists (philosophers, sociologists, economists, statisticians, demographers, and so on) devoted themselves to the establishment and management of statistical offices and subsequently participated very actively in the international congresses of statistics and demography.

In 1807 the Kingdom of Italy was one of the first European states to create a Statistical Office under the direction of the great statistician and philosopher Melchiorre Gioia. Then in 1826 a statistical society called the "Tuscan Society of Statistical Geography of Natural History" was established in the Grand Duchy of Tuscany. Both the Office and the Society were short-lived, for the reasons already mentioned above. Subsequently, starting from 1832, within a few years Statistical Offices (or similar) were created in the various states of Italy (Sicily, Subalpine Kingdom, Sardinia, Tuscany, Naples and the Papal State).

Finally, in 1861, when the Kingdom of Italy was formed as a unit, the Division of General Statistics was born (of which the first director was Pietro Maestri) who, assisted by a Superior Council of

Statistics (first president Cesare Correnti), which lasted until 1926 when the Central Institute of Statistics (Istat) was established.

It should be noted that in this period the statistical function had a close link with the government which is summarized in the formula "knowing to administer" or perhaps more precisely "knowing to govern".

Two annotations concerning this period seem important to me: the birth of the Civil State and the behavior and vision of the statisticians of the Risorgimento.

Civil Status office, as we still understand it currently today, was introduced in Tuscany during the period of French domination starting from 1808. Its birth was one of the great changes that marked the transition from the ancient regime to the contemporary age: with this institution indeed, civil institutions occupied land that had traditionally belonged to the Church.

For the statisticians of the Risorgimento, statistics were a fundamental tool of "civilization" which also served to evoke the "body" of that nation which they wanted to be the basis of a future independent State. Statistical knowledge, the collection and dissemination of statistics in the public sphere also constituted an indispensable tool for the transparent functioning of a power legitimized by popular consensus: the "discipline for democracy", in fact. In expressing these ideas some of them, in particular Maestri and Correnti, shared an almost utopian vision of statistics.

With regard to the participation and contribution of Italian statisticians to international congresses and international statistical bodies, let me remind you that the international congresses of statisticians began in 1853 in Brussels with the participation of around 150 scholars, 11 of whom were Italian. It was not until Florence was the capital of the kingdom of Italy that a congress of European statisticians (the sixth in the series) could be held there, attended by 632 Italian and 85 foreign statisticians. The contribution of the Italians has always been relevant, it is enough to refer to the performances of Maestri and Correnti and to the methodological contributions of Angelo Messedaglia.

As is well known, in 1885, during the celebration of the jubilee of the Statistical Society of London, the proposal was made to found the International Institute of Statistics (ISI). Luigi Bodio, who was head of the Italian statistical services which he had led to being among the best in Europe, assumed a leading role in the establishment of the ISI and in its development.

Bodio supported the proposal, but past experience led him to ask that the association should be free and independent of government decisions and that it should include the most eminent European and American statisticians, regardless of their nationality. Due to his well-known qualities as a scholar and his organizational skills, Bodio was elected general secretary of the ISI and remained in office for 20 years. In 1909he was elected President of the Institute by acclamation and was re-elected in the two successive elections, remaining in office until 1920, when he died. It is proof of the prestige Bodio enjoyed, but also of the level at which Italian statistics was assumed. In 1885, 13 Italians out of 106 nominations were nominated as members of the ISI. And in the elections of 1886, 23 Italians were elected out of the 154 elected. Furthermore, most of the first volumes of the ISI Bulletins were written in Italian.

2 The period from 1920 to the end of World War II

It was also characterized in Italy by important events in the field of the survey statistics, both from a methodological and institutional point of view. On the occasion of the ISI meetings, but not only, a dispute began between the conduct of only censuses versus the use of sampling to which Italian statisticians also contributed. As Leslie Kish wrote in the paper presented in 1995 at a meeting arranged by the Italian Statistical Society (SIS), "Neyman's 1934 paper marks a turning point for survey sampling...It was based on a 1929 paper of Gini and Galvani. In which the authors compared the results of the 1921 population census with the results of the same surveys carried out using a representative statistical sample of those surveyed. The results did not coincide and, perhaps, also

for this reason Istat, of which Gini was president, shelved the use of the sampling technique in the public statistics surveys.

At the beginning of the period, the Statistical Service was considered no more and no less than any bureaucratic body. The Fascist government had an interest in reorganizing the service conceived as a government service for the government and not a public service for the citizens, with a centralized arrangement. Therefore, in 1926 the government created the Central Institute of Statistics of the Kingdom of Italy, appointing Corrado Gini as president. In this way, and with a subsequent law of 1929, the main problems of the public production of statistics were resolved for the time, making available much statistical information necessary to carry out research in many fields of application (mainly demographic, economic and social) allowing many researchers whose results were also presented at international conferences, which confirmed the thesis of the originality and autonomy of Italian statistics.

3 Representative statistical sample

In 1944 Istat undertook, at the request and guidance of the Allied Commission, studies to carry out surveys using a representative statistical sample, to the satisfaction of its most representative statisticians including Benedetto Barberi, Lanfranco Maroi and Francesco Brambilla. From 1947 Istat intensified the study of the sampling technique and in 1948 established the "working group for sample surveys" within the Center for Research and Econometric Applications. Sample technique that was extended to many investigations in multiple fields of application. Many eminent statisticians collaborated with Istat, confirming the typical fruitful interaction in Italy between official statisticians and Academia. Among these we deem it appropriate to mention Marcello Boldrini who was also president of the ISI from 1959 to 1963.

In the following decades, the use of representative sample surveys developed more and more, and, in particular between the 1980s and 1990s, Istat made important advances in the field of surveys on families and individuals, launching "multipurpose" surveys. Progress in survey statistics has been continuous including the integrated system of registers and surveys; and in the use of Big data and citizen generated data and citizen science to produce official statistics.

4 In 1973 the IASS was founded and Italian official statisticians and academics also participated in its foundation

I remember that in the first years of life of the IASS over 100 Italians became members and a country representative was appointed. It was certainly an opportunity to organize the groups of Italians who intended to actively participate in the scientific meetings of the ISI and the IASS by proposing topics for the invited sessions and presenting papers. But also by carrying forward some important initiatives that I recall.

Under the impetus of survey statisticians, the Italian Statistical Society founded the SIS coordinating group on “Survey sampling methodology”, to contribute to the promotion and coordination of applied and methodological research on survey sampling.

The Survey Sampling Group decided to organize ITACOSM (Italian Conference on Survey Methodology) which is a bi-annual international conference, whose aim is promoting the scientific discussion on the developments of theory and application of survey sampling methodologies in the fields of economics, social and demographic sciences, of official statistics and in the studies on biological and environmental phenomena. The first edition of ITACOSM was held in Siena in 2009 and then the venue moved to Pisa in 2011, Milan in 2013, Rome in 2015, Bologna in 2017, Florence in 2019, Perugia in 2022, and Cosenza in 2023. In the first edition in Siena, the delegates were all Italians, apart from the 4 keynote speakers (Proff. Yves Tillé, Carl-Erik Sarndal, Yves Berger, and Tim Gregoire). In the last edition in Perugia, half of the 108 registered participants were not Italians. IASS has sponsored ITACOSM since the very beginning and the President or a member of the EC has always participated.

5 Concluding Remarks

Since the early 1800s, Italian statisticians have contributed a great deal to the development of survey statistics.

The latest developments concerned, as in many other countries, the use of Big data and citizen generated data and citizen science to produce official statistics. Istat will also develop these topics in the near future as stated during the webinar organized online on May 3, 2023, on "Big Data and new data sources to measure reality: A comparison on Trusted Smart Statistics". The introductory speech was carried out by Monica Pratesi, President of the IASS, and the webinar was followed by many Italian survey statisticians.

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The IASS – 50 Years of Activity

Danny Pfeffermann[1,2]

[1] Department of Statistics, Hebrew University, Jerusalem, Israel
[2] Southampton Statistical Sciences Research Institute, University of Southampton, UK
IASS President 2013-2015
[1] msdanny@mail.huji.ac.il; [2] msdanny@soton.ac.uk

Abstract

In this short article I review the activities of the IASS, discuss the problem of its reducing membership and propose some possible directions for new developments in the future.

Keywords: Activities; Data science; IASS membership; Nonprobability samples

1 Introduction

The International Association of Survey Statisticians (IASS) is celebrating this year its 50 years jubilee, a milestone for celebration, reflecting on its big achievements so far, with a look to the future.

I believe that I joined the IASS already around 1980, shortly after completing my PhD. Why did I join? Probably because my PhD supervisor, the late Professor Gad Nathan, told me to do so. Mind you, I knew nothing about statistical organizations at that time. In 1985, I was elected as Fellow of the ISI. During the years 2001-2003, I chaired the programme committee of the IASS and 10 years later, during 2013-2015, I served as the President of the organization. So, it seems that I was quite an active member of the IASS in those years, which is probably why I was asked to contribute this short article that is due to appear in the July issue of *The Survey Statistician.*

2 The IASS mission and activities

The IASS was founded in 1973 "to promote the study and development of the theory and practice of sample surveys and censuses." How is this done? Mostly through the ISI meetings (the world statistical congress, WSC), held every two years; the IASS is one of the sections comprising the ISI. These meetings provide a forum for discussion of survey statistics. They include several specific sessions on recent advances and applications in survey and census methodologies. Other than the ISI meetings, the IASS helps to sponsor regional meetings and workshops devoted to specific aspects of surveys, and it publishes twice a year the journal *The Survey Statistician*, which is devoted to survey sampling and censuses and is distributed to all the IASS members. I always found the country reports in the journal, on activities performed by their national statistical institutes to be particularly useful.

I assume that other authors will cover the history and big achievements of the IASS since its foundation. Hence, in what follows, I like to discuss briefly some possible directions for new developments in the future.

3 Membership in the IASS

The IASS needs to increase its membership quite extensively. Here is a contingency table of the registry in February 2023, with the cells defined by continent of living and gender.

Region	Female	Male	Total
South/Central America	11	18	29
Oceania	5	18	23
North America	21	71	92
Europe	54	79	133
Asia	8	31	39
Africa	8	21	29
Total	107	238	345

When I started my presidency in 2013, the IASS had 445 individual members and 23 institutional members. Now we have 21 institutional members, but the numbers of members in the various categories have dropped quite significantly. The registration profile is also gloomy when looking at the distribution of the IASS members by age. Based on 284 members with known ages, out of 205 males, 106 are older than 65, 81 are at the age of 41-65 and only 18 are younger than 41. Out of 79 females, 30 are older than 65, 38 are at the age of 41-65, and only 11 are younger than 41. Thus, the majority of our members are in the older age groups.

I don't know how many survey statisticians there are worldwide, but it is obvious that only very few of them choose to become members of the IASS. We need a larger membership for a number of reasons. First, since the outcome of our work affects directly so many applications and decision-makings, we should have broad representation from all the various areas. A broad representation will stimulate more joint research and collaboration efforts. A larger membership will of course allow for greater financial flexibility, which in turn will facilitate more diverse activities.

The IASS should continue its efforts to encourage more survey statisticians to join the organization. No reason why only 35% of its members are females, and why continents other than North America and Europe are so poorly represented. The fact that young survey statisticians tend not to join the IASS is particularly worrying. If this trend continues, the prospect of the IASS to continue its mission and activities is in real risk.

PhD supervisors should encourage their students to join us. This is a first step to increase young member's registry. Social networks can be used as another platform to promote the IASS and motivate registration. A reviewer of this article proposed allocating a special section in *The Survey Statistician* for young survey statisticians from developing countries to publish reviewed scientific papers (possibly with discussion by senior members). These are all just examples of what can possibly be done to increase our membership.

4 Nonprobability sampling

In recent years there is growing research on the use of nonprobability samples. Such samples are not representative, and they require different kinds of inference on finite population parameters of interest, but they have their merits in terms of costs, logistic and possible reduction in nonresponse. See e.g., Beaumont and Rao (2021), published in *The Survey Statistician*. I think that the IASS should pay increased attention to this kind of samples, organize conferences and workshops and

encourage publications in *The Survey Statistician*, with emphasis on practical applications. IASS members and survey statisticians in general will undoubtedly benefit from this activity.

5 Survey sampling and data science

The last two decades have witnessed the rapid growth of data science. One of the facets of this growth is that there are people agitating that the existence of all sorts of “big data”, and the new advanced technologies that have been developed to handle them, will soon replace the use of sample surveys. In an article I published in 2015, I overviewed the problems with the use of big data for the production of official statistics but clearly, when such data sources are available, accessible and timely, they cannot and should not be ignored. I have no diploma in prophecy, but my own view is that survey samples will always be needed, at least in the foreseen future, so our profession is secured for many years to come.

I think that the IASS should play a leading role in the promotion of new theories and practices for the integration of classical survey sampling theory with data science, with the ultimate goal of improving the data and subsequent evidence-based decisions upon data obtained from only one of the sources. In simple words, how to benefit from both worlds.

6 Possible merge with the IAOS

Finally, I like to raise the possibility of merging with the International Association for Official Statistics (IAOS), another section of the ISI. I already raised this idea while I was president, some executive members of the IASS supported the idea, other objected, and IAOS executives with whom I discussed it were not very enthusiastic about it either, so I did not push it any further. I might be wrong, but I personally think that both organizations will benefit from such a merge, and if only because it will make the merged section the biggest or one of the biggest sections of the ISI. I propose therefore to examine the pros and cons of such a merge and if found worthy, negotiate it with IAOS representatives. The reviewer of this article proposed improving the interaction with the IAOS by organizing a joint conference. This is a nice idea, which could form a first step in a possible future merge.

7 Concluding remark

I think that the IASS is a very worthy and much needed organization, and I wish it to expand both in size and in its activities in the coming years.

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