AUDITING AND STATISTICS– INTERDISCIPLINARY TEACHING CONCEPT

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Abstract

This paper explores educational aspects of teaching statistics to auditors and controllers. It specifically focuses on employing certain methods of statistical inference in auditing, predominantly from the viewpoint of illuminating the relevant fields of statistics to university students of auditing. Key sections of this paper deal with teaching confidence intervals and Benford's Law to auditors.

Keywords: Sampling methods in auditing, education aspects of statistical inference, confidence intervals, Benford's Law

Introduction

Links between statistics and other sciences have been a frequent topic of research, discussions and practical applications[1]. In other words, it is an interdisciplinary area. Combinations of different disciplines must, of course, be reflected in teaching statistics within different fields of study. The authors of this paper have extensive experience with teaching statistics in a number of economic universities. That is why they would like to point out in this paper the interdisciplinary combination of statistics and auditing, that is, one specific area of teaching statistics to non-statisticians.

The key aspect of teaching statistics to students in non-statistical fields of study at universities focused on economics, all over the world, endeavours to show when and how statistical procedures are used in the area of economics in a realistic and plausible way. However, what we can in reality often see demonstrated to students is a range of artificial pseudo-applications, which usually have very little in common with the economic practice. Such pseudo-applications, logically, raise students' doubts and stand in the way of popularising statistics to the general public. Hence all educators of statistics at universities must be very careful in choosing their

[1] Cf., e.g., Gattuso (2011), Hernandez (2006), and Hindls, Hronová (2015)

examples. They have to be consistent in seeking a real interdisciplinary intersection between statistics and practical economic areas.[2]

Several reasons can be identified that lead to the above-mentioned application problems in teaching statistics to students in non-statistical economic fields[3]:

- In teaching, technical aspects of statistical techniques are preferred to examples of their real applications; the teacher must, of course, explain the methodological substance of the statistical procedures, but a reasonable proportion of theory with respect to real examples is also very important;
- In many instances, teachers themselves are not sure that their examples are realistic even though they present them as such to students;
- Sometimes teachers may not have enough experience with the application they teach, unless they have hands-on practical knowledge based on work in corporate or state-administration areas;
- The educational environment excessively emphasizes the computational aspects of the statistical procedures in question (usually comfortably solved with the aid of statistical software packages);
- Teachers insufficiently point out the pitfalls hidden in the contents and interpretation of economic indices, or belittle methodological problems related to the occurrence of economic indices in corporations, state administration, etc.;
- Possibilities implied by statistical conclusions for decision-making processes by managements are overestimated ("statistics does not control the world, it only shows how it is controlled" – Karl Pearson[4]).

However, the real world provides us with a number of real areas in which statistics is necessary. There are even areas in which statistics cannot be replaced with anything else. Such areas, among others, include auditing or statistical quality control. In particular, we have in mind here sampling in audits, or Benford's Law. A combination of statistics and auditing is convincing proof of mutual interdisciplinary links between two different areas. This combination can and must also be shown in teaching. The authors of this text have long years of experience with teaching statistics to auditors and controllers not only in the Czech Republic but also abroad.

Interval estimates and auditors' requirements

Statistical tools and methods used in auditing and controlling are not complicated and are included in the primary toolbox obtained in the basic courses of statistics at economic faculties. However, errors encountered in

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[2] "Like other professionals, teachers need to know statistical content, but they also need to know pedagogical strategies for helping others learn statistics." Groth (2013).
[3] A more detailed treatment of this kind of issues can be found in Hindls, Hronová (2015).
[4] Cf. Hebák, Hindls (1990)

the teaching of those basic courses[5] are reflected in the level of students' (lack of) preparedness to cope with statistical applications in auditing. Namely, we have in mind utilisation of statistical inference and probability calculus in the sampling methods within auditing and controlling.

Auditing and controlling cannot make do without such sampling methods. However, in teaching auditors, the lack of knowledge that should have been obtained in the basic courses of statistics comes to light. Experience shows that a few simple principles must be applied when teaching auditors:

- Consistently – from the very beginning – explain the vital character of such statistical procedures in that part of audit in which sampling takes place. In particular for large sets of accounting items and in situations in which internal checks and reliability tests (such as of software) in the accounting systems are insufficient;
- Carefully – while briefly and only from the practical viewpoint – recall binomial (or Bernoulli), Poisson and normal (Gauss-Laplace) probability distributions;
- Treat responsibly explanations of confidence intervals. A simplification based on a sufficiently large size *n* of the sample is fully sufficient here (numbers of items in the accounting records ensure fulfilment of this assumption as a matter of course). Estimates of merely two parameters may be focused on in teaching, namely:
  - The ratio □ of items with a given property within the whole (in auditing, e.g., the proportion of defective items out of all may be considered, etc.);
  - The mean value □ of normal distribution (in a sampling audit it represents an estimate of the limit for the total error of the account balance, etc., for which it is necessary to estimate the average error per document) while the variance is unknown (the latter may be determined as a sampling characteristic from the sample of the accounting times to be checked, such as documents);
- In conclusions of the teaching, a brief overview of testing statistical hypotheses should be recalled as it will be needed in explaining Benford's Law;
- In education environments, as far as practical, no software support should be utilised, even though the contemporary accounting and auditing software (such as IDEA, DATEV, etc.) of course provide us with an option to use it. On the one hand, there is not enough time to use software when teaching the basic principles of sampling methods; and on the other hand it is premature and even superfluous from the educational point of view. Students

[5] More detailed information about this problem can be found in Ziliak, McCloskey (2009).

will certainly find their own ways to use the software in the future, in their own work.

The key statistical tool for sampling methods in auditing is represented by interval estimates. The course for auditors is not a direct continuation of the basic (general) course of statistics of students at economic faculties (the time separating them may be several semesters, depending on the accounting and auditing curriculum); the methodology of confidence intervals has to be briefly reinforced. This must include directly linking these concepts with auditing and controlling aspects from the very beginning of the course for auditors. An ideal bridge here is based on risk matrices in auditing (there are two such matrices and we describe them below).

From there a natural step-by-step way leads to confidence intervals. In particular, the width of a confidence interval is worth explaining, as well as its relationship to the sampling size and the selected level of confidence (which may be rather low in auditing, say, even smaller than 80% to 90%, see the explanations below).

All of the things mentioned above must necessarily be accompanied by realistic examples from the auditing and controlling practice in corporations with actual data from corporate accounting (or data from technical inspections in manufacturing companies, etc.).

When the notion of risk in statistical inference (i.e., risk control area) is explained, certain problems arise. Naturally, that notion is necessary for constructing the above-mentioned confidence intervals for the parameter □ of the binomial (Bernoulli) distribution, or for the parameter □ of the normal distribution.

The problems can be successfully overcome with the aid of the risk matrices. The teacher should adequately focus on such matrices. There are two such matrices: the matrix of confidence tests, and that of factual correctness. On those matrices we can show not only the general phenomenon of risks in auditing and controlling, but also the relationships of those matrices to estimating parameters □ (related to the confidence test matrix, in which the risk of the error of the first kind represents the risk of apparently low confidence of the accounting system), or □ (related to the matrix of factual correctness based on the estimating deviations of the account balance).

However, the teaching should also point out another specific feature of the use of statistical estimates in auditing and controlling. As a matter of fact, auditing methodology allows for choosing lower levels of confidence □ □ □□ (in other words, a higher value of risk □ in constructing the confidence intervals). It must be explained to students very carefully why this is possible. Reasons[6] for choosing lower confidence levels in auditing are purely practical and therefore easy to grasp for students of auditing and controlling, who already have sufficient knowledge of those subjects. Practice in auditing and consulting companies moreover shows that the sizes of samples, say, accounting documents, are usually quite small. Typically there are tens (not hundreds) of documents. This is also related to the price of the audit and the deadlines within which the closing financial statements must be audited in corporations. At that stage of their curriculum, students are very well aware of such circumstances because they are knowledgeable in general aspects of accounting and auditing. Therefore there is no need to waste time on extensively explaining those aspects.

From there the way to explaining admissible error □ is more or less direct in the process of educating. For the purposes of auditing, however, it is necessary to consistently and carefully distinguish between both- and one-sided confidence intervals (the one-sided may be left-hand- or right-hand-sided, depending on the factual substance of the respective problem). All of the above must be thoroughly illustrated on realistic examples from accounting, auditing and controlling practice.

At this point we can finally come to the determination of the necessary (required minimum) sampling size *n*. Both students and run-of-the-mill practitioners are enormously interested in this value. But its explanation in the education process should never be made too hastily. Experience shows that this information should only be revealed to students when they have acquired the knack of the confidence intervals and risk treatment (with the aid of the risk matrices).

So, how many, say, accounting items (documents) have to be chosen? Here we again must be consistent in distinguishing between both- and one-sided (left-hand- or right-hand-sided) confidence intervals. Demonstrations of procedures employed in large audits are suitable at this stage of teaching. They will enhance the importance of similar considerations in students' heads.

In the conclusion of the course, sufficient time should be given to examples from the auditors' practice. Systematic exercise (of case studies with accounting data) will not only create good skills but also consolidate the

[6] There are three such reasons from the viewpoint of practice, and they are specific for auditing: 1) sampling methods may be considered a complementary tool in auditing; 2) the audit of a company is usually carried out by the same accounting firm for several consecutive years, and the risk is thus reduced on the basis of the auditors' experience with and knowledge of the company to be audited; 3) error variability in accounting and information systems tends to be small to very small, thus reducing the risk of an erroneous conclusion by the auditor.

acquired knowledge. Let us once again emphasize that all examples must be realistic[7]!

One more point is important and should be openly communicated to students: the sampling method is just a complementary method for auditors. In other words, the teacher must repeatedly emphasize that the importance of sampling methods must not be overestimated! Audit as such has pre-set accounting and controlling procedures that are the pivots on which the auditor's statement is based, while sampling methods have complementary or even indicative significance.

Benford's Law

Benford's Law (sometimes also called Benford's Test) is a well-known mathematicallaw (alternatively the *First-Digit Law*, FD, of which there are nine, or *First-Two-Digit Law*, FTD, of which there are ten). It claims that in certain collections of naturally arising data the first digits are one, two, etc., more often than seven, eight or nine. In other words, the higher the first digit, the less frequently it occurs. The first digits do not occur with relative frequencies of 1:9 = 11.11%, which would correspond to the uniform distribution, but are governed by Benford's Law. See Kossovsky (2015) or Mullerová, Králíček (2014) for more details.

Benford's Law is said to often hold for data in the area of natural sciences, but it is also claimed to hold for data coming from economics. Collections of numbers obeying Benford's Law may be, for example, river lengths, but also amounts written on receipts, share prices at stock exchanges, data on national accounts, etc.

Using in audits sampling methods for accounting documents and subsequently confidence intervals may, to a certain extent, play an indicative role. So may Benford's Law, which has been becoming more and more popular recently. Here we want to pause briefly. Not so much regarding the implementation of the Law (there is enough special literature to this end), but rather concerning evaluation and interpretation.

First of all, one comment should be made. While a number of authors take Benford's Law with reservations, many others use the Law or, at least, believe in its usefulness. Positions of both groups should be openly disclosed to students, using realistic examples from economic areas (we should be ready and have such examples at our disposal). Such examples need not be coming from corporate accounting but, say, from national accounts and macroeconomic aggregates, as seen in some EU member countries in recent years.

[7]The necessity to use realistic examples in teaching statistics to non-statisticians is pointed out, among other places, in Hernandez (2006) or Hindls, Hronová (2015).

Having taught Benford's Law to our students and evaluated the obtained results (students quickly cope with the technical aspects of Benford's Law and are often intrigued), there is one more educational challenge: how to test and illuminate the meaning of the calculated statistics. Two options – both explained below – are available to us. They are both correct from the viewpoint of statistics, but they may differ in their interpretations by auditors. The main core lies in the testing procedure.

Whichever option we prefer, it is useful to first briefly recall to students the methodology of testing statistical hypotheses. We can assume that the "initial" knowledge our students have about testing hypotheses is about the same as the above-mentioned "initial" knowledge about interval estimates.

Then we can explain the principles (and the history, which is of an independent interest) of Benford's Law[8]. It is quite useful to let students count *first digits* FD or *first two digits* FTD in a small example and complete the test only afterwards. Here it is very educational to forego the aid of software and try to work in the "pen-and-paper" system.

As soon as students cope with the technicalities of Benford's Law and learn how to run calculations and tests, both options for evaluation should be demonstrated to them. Here they are:

1. χ^2 – goodness-of-fit test based on the statistic:

$$G = N \sum_{d=1}^{9} \frac{(p_d - \pi_d)^2}{\pi_d} \approx \chi^2_{1-\alpha}[8],$$

2. Z-test, based on the statistic:

$$Z_d = \frac{\sqrt{N}\left(|p_d - \pi_d| - \frac{1}{2N}\right)}{\sqrt{\pi_d(1-\pi_d)}},$$

where

p_d are relative frequencies of occurrence for the *first digit* FD or the *first two digits* FTD, where π_d are probabilities of occurrence for FD or FTD according to Benford's Law, N is the number of sums in question (e.g., times written on accounting documents), and $\chi^2_{1-\alpha}[8]$ is the relevant $(1 - \alpha)$% quantile of the χ^2 distribution.

Even though both tests intuitively lead to similar conclusions, there is a difference between them regarding the auditors' practical needs. This difference should be explained to the students. It should be left to their

[8] Cf., e.g., Benford (1938), and Kossovsky (2015).

decision which option they will take (unless rejecting Benford's Law as a whole – some auditors take that stand).

The said difference is based on the fact that the first approach (*G*-statistic) is a comprehensive assessment of Benford's Law validity for a given set of *First Digits* or *First Two Digits* taken from accounting documents. The particular digit for which the deviation from Benford's Law is the highest must be looked up among values

$$\frac{(p_d - \pi_d)^2}{\pi_d},\ d = 1, 2, \ldots, 9, \text{ or } d = 0, 1, \ldots, 9.$$

Moreover, it is not a test of a statistical hypothesis "in the strict sense". In the auditors' practice the set in question will not, as a rule, be a sample from *First Digits* but rather the set of all *First Digits*, that is, first digits extracted from all accounting documents. Generally, it is no problem for the auditor to have the software extract all *first digits* of amounts written on documents. No sampling therefore takes place, and all documents are processed (hence we use symbol N in teaching, denoting the number of units of the whole population, not symbol n, traditionally used for the size of the sample).

The second approach (Z_d-statistic) evaluates the deviation for each individual *First Digit* independently, and it is immediately obvious which first digits do or do not comply with Benford's Law. The same principles apply if the entire procedure is utilised for checking the compliance of real accounting data with Benford's Law for the *First Two Digits* FTD. This approach should be introduced to the students as the more suitable option that leads more quickly to the objective, i.e., testing according to Benford's Law.

Conclusion

Teaching statistical methods for auditing meets a favourable response from students. More favourable than that we encounter in basic courses of statistics at economic universities. This outcome is given by students' seeing specific utilisation of statistical techniques, but also by their realisation that they cannot avoid such techniques in auditing practice or replace them with anything else. Examples taken from auditors' practice assure students that the techniques are not artificial and can help them in real life situations. They perceive this approach as an interdisciplinary area between statistics and auditing. Another recommended element is inviting an auditor as a guest teacher. They can provide another assurance that such statistical techniques are really used and that students do not learn them in vain.

References:

Benford, F. The Law of Anomalous Numbers. Proceedings of the American Philosophical Society. Vol. 78, N° 4 (Mar. 31, 1938), pp. 551-572.

Gattuso, L. L'enseignement de la statistique: où, quand, comment, pourquoi pas? Statistique et Enseignement, 2011, Vol. 2, N° 1. ISSN 2108-6745.

Groth, R. E. A day in the life of a statistical knowledge for teaching course. Teaching Statistics, 2013, Vol. 35, N° 1, pp. 37-42.

Hebák, P., Hindls, R.: Importance of statisticians' education and status (In Czech: Význam vzdělání a postavení statistiků.) Statistika, 1990, Vol. 70, N°. 2, pp. 13-22.

Hernandez, O. Teaching statistics to undergraduate students of the social sciences. In: Working Cooperatively in Statistics Education. Proceedings of the 7th International Conference on Teaching Statistics (ICOTS-7), 2006.

Hindls, R., Hronová, S., Seger, J., Fischer, J. Statistics for economists (In Czech: Statistika pro ekonomy.). 8th edition.. Prague: Professional Publishing, 2007. ISBN 978-80-86946-43-6.

Hindls, R., Hronová, S. Are we able to pass the mission of statistics to students? *Teaching Statistics*, 2015, Vol. 37, N°. 2, pp. 6-14. ISSN: 1467-9639.

Kossovsky, A. E. Benford's Law. Singapore: World Scientific Publishing, 2015. ISBN 978-98-145-8368-8.

Mullerová, L., Králíček, V. Auditing. Prague: Oeconomica, 2014. ISBN 978-80-245-2018-6.

Ross, A. K. Benford's Law, A Growth Industry. The American Mathematical Monthly, Vol. 118, N° 7, pp. 571-583.

Ziliak, S.T., McCloskey, D.N. The Cult of Statistical Significance. Contribution presented at the Joint Statistical Meetings, Section on Statistical Education. Washington, D.C., 2009.