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EVALUATING EDITING AND IMPUTATION PROCESSES: THE ITALIAN EXPERIENCE

Invited paper

Submitted by ISTAT, Italy[1]

I. INTRODUCTION

1. Statisticians working in the context of data editing and imputation (E&I) in National Statistical Offices (NSOs) agree that the two main goals of performing E&I on observed survey data are, on one hand, improving the final data *quality* and, on the other hand, providing information about the overall survey process (including the E&I process itself). Therefore, any E&I process has to be designed and applied in order to meet these requirements as much as possible. The assessment of the capability of an E&I process to reach these objectives implies performing evaluation studies aimed at verifying the E&I processes performance from different points of view. Hence, the evaluation phase has been recognised as a central problem during the last few years, particularly because both the increasing demand of information about the E&I process characteristics and impact on data quality, and the need to control the final results variability due to the E&I process itself.

2. In this paper we limit the discussion to the evaluation of those E&I activities performed at the data editing stage, i.e. excluding all the checks used in any previous stage of the whole survey process (data capture, data entry phase).

3. We do not give a unique definition of *process quality* here: a different meaning is attached to this term depending on the evaluation objectives and other elements discussed throughout the paper. On the basis of some experiences gained or still in progress in ISTAT, we identify some general problems within the context of the evaluation of E&I procedures, and indicate the solutions adopted in ISTAT for dealing with different evaluation objectives.

4. The paper is structured as follows: in section II the evaluation problem is put into a general context taking into account the complexity of the E&I phase and the main different evaluation objectives. Sections III, IV and V deal more in depth with some particular evaluation objectives, with a discussion based on the Italian experience. Section VI contains some general conclusions and open problems.

II. EVALUATION OF E&I PROCESSES: GENERAL PROBLEMS

5. The problem of the evaluation of E&I processes has been discussed in depth during the last few years in both a theoretical and application context. The first problem to be faced is to define the concept of *quality* of an E&I process.

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6. Nordbotten (1999) defines the quality of statistical data editing as "a measure of how well the statistical process succeeds in satisfying users and producers needs": users expect information about data reliability, producers want information on E&I process reliability for improving resources allocation and overall production performance.

7. A unique definition of the quality of an E&I process cannot be provided: it depends on the particular E&I aspect we want investigate and evaluate. Hence the problem of evaluating the quality of an E&I process becomes dependent on the definition of the specific characteristic of the E&I process we want to highlight. Granquist (1997) performs a broad analysis of evaluation objectives through the description of several applications and studies presented in literature.

8. In our paper, we report the Italian experience on the following set of evaluation objectives:

1) verifying the statistical properties of a given E&I approach for a given E&I problem;
2) choosing the best set of techniques for a given survey application;
3) monitoring and optimizing the performance of a given E&I methodology;
4) obtaining information on non-sampling errors sources;
5) measuring the impact of the E&I phase on the original raw data.

Objectives 1 through 4 are related to the producer's need for information about the process reliability, while objective 5 aims at providing users with information about the reliability of the final data.
In practice, each objective corresponds to one of the phases that normally are to be carried out when building up and applying an E&I procedure. Depending on the phase, different quality and/or documentation needs are to be satisfied, as described in the following.

9. Typically, in the *planning* phase, objectives 1 and 2 are to be achieved in order to analyse and measure the potential performance, the possible benefits and the operational characteristics relating to the use of a new or even a traditional methodology when applied to a given E&I problem or to a particular survey context. For example, objective 1 is faced when the statistical properties of a new E&I method are to be tested and verified on real or simulated data reproducing the theoretical situation the method is designed to deal with. Objective 2 is typical of studies in which the evaluation aims at assessing the quality of an E&I process in terms of its capability of correctly deal with a real E&I problem.
Relating to this point, it is worthwhile to underline that the evaluation problem is generally a complex task because of the typical complex structure of any E&I procedure. In fact, an E&I process generally consists of many sub-phases, each of them performing a particular step of the whole data E&I process (Jong, 1996; Di Zio et al., 2002). The simplest distinction refers to the error localization and error imputation phases, but many other sub-processes can be identified, depending on the variables nature (ordinal, nominal, continuous), the error typologies (systematic or stochastic, influential or not influential, etc.), the survey characteristics (e.g. census, sampling surveys, panels), and so on. Therefore, an E&I process can be viewed as a completely integrated set of different techniques dealing each with a different E&I sub-problem but having the common aim of improving the overall quality of final results. Correspondingly, the problem of evaluating an E&I process can be split into the evaluation of simpler sub-problems, each of them focused on a specific E&I sub-phase. It is obvious that different evaluation criteria and priorities among them will be used depending on the particular sub-phase and on the specific E&I method under analysis. For example, if our goal is to evaluate the performance of a technique for identifying influential data, the most relevant quality criteria will be the capability of the method of preserving aggregates and of reducing the costs and the respondent burden by reducing and rationalizing the interactive editing activities. On the contrary, if our aim is to verify the quality of an imputation method, the most important quality criteria will be the preservation of both micro data and (marginal or joint) distributions.

10. Once a given technique or an integrated set of techniques have been selected as elements of the overall E&I strategy, the strategy itself has to be *designed, implemented* and *tested* through an iterative evaluation process aimed at tuning and improving its performance (objective 3). In this case, the evaluation criteria and the corresponding measurements will be defined and implemented in order to facilitate the continuous monitoring of the effects of each E&I sub-process.

11. A very important objective in the evaluation context relates on obtaining useful information on the non-sampling errors nature and patterns from an E&I process (objective 4). Once the final E&I procedure has been defined through the above mentioned tuning process, it is possible to identify the most likely sources of non-sampling errors, due to lacks in one or more survey data processing phases, by analysing the errors type and structure. A typical product of objective 4 is the so-called *error profile*, i.e. a description of the characteristics of all identified errors and their internal structure (Cirianni et al., 2000). This information is generally used either for improving the survey organization in future survey repetitions, or when specific studies on particular error types or mechanisms are to be carried out (objectives 1 and 2).

12. Objective 5 is the minimal requirement that each statistical survey has to accomplish. In fact, the evaluation of the effects of an E&I procedure on a given set of survey data allows to obtain basic products like:

- the documentation of the E&I processing flow;
- the measurement of the impact on data of the E&I process;
- an assessment of data quality to be provided to data users.

13. For each evaluation goal, a critical aspect is represented by the problem of the identification of *standard indicators* quantifying the corresponding quality criteria independently from both the particular application and method under evaluation. Many researches have been done with respect to the different evaluation contexts (Chambers, 2000; Stefanowicz, 1997; Madsen et al., 2000; Fortini et al., 1999; Nordbotten, 1997; Nordbotten, 2000). The need to define generalized measures is increasing for many reasons:

- the increasing need of internal and external comparability of the impact of E&I processes;
- the increasing need of international comparability of data E&I processes;
- the development and application of new techniques requiring the assessment of their usefulness and statistical properties;
- the increasing demand of information on data processing coming from end users.

14. The assessment of quality and quality reporting are central problems not only at the NSO level, where the effort is concentrated in the definition and dissemination of *statistical guidelines* and *quality reports* (National Center for Education Statistics, 1992; Statistics Canada, 1998), but also in an international perspective: as an example, great attention is devoted to these aspects at Eurostat, where increasing importance is given to the problem of non-sampling error documentation and measurement (LEG, 2001).

15. Once the evaluation objective and the corresponding quality criteria have been identified, a further decision relates to how the evaluation has to be carried out. In other words, the particular evaluation approach has to be chosen. A general distinction can be made between *observational* and *experimental* study (Biemer et al. 1995). In the first context, the investigators study the phenomenon as they find it. For the purpose of this paper, we mean that the assessment of the quality of an E&I process is based only on observed data, eventually enriched with all available information on surveyed units and variables (e.g. coming from historical or administrative sources of information, or collected through re-interviews or complete data revision processes) (Granquist, 1995; Granquist, 1997; Biemer et al. 1995; Poulsen, 1997). In the experimental approach, we generally investigate the phenomenon having a certain control on the mechanism ruling some key aspects of the phenomenon itself. In our context, it means that we simulate the situations we would investigate, and make inference from the simulation results obtained for assessing the quality of a procedure (an E&I procedure, or a single technique) (Kovar et al., 1996).

16. Given the evaluation objective, the choice is sometimes mandatory. For instance, if the objective is to choose the 'best' technique for dealing with a specific E&I problem, an experimental approach is more appropriate than an observational one. On the contrary, measuring the effects on data of an E&I process is a typical observational study. In other cases, however, there are other elements influencing the choice of the approach; the most important are the available resources (budget, human, tools, other costs), the timeliness requirements, and the available external information.

III. EVALUATING THE QUALITY OF E&I METHODS: THE SIMULATION APPROACH

17. In this paragraph the objectives 1) and 2) mentioned in the previous section are synthetically discussed and a general description of the evaluation approaches used until now in ISTAT for dealing with them is provided. As already mentioned in section II, both these objectives aim at providing useful information to data producers in the planning phase of an E&I process: this information is generally used for improving the efficacy (in terms of quality of results) and the efficiency (in terms of costs) of each E&I phase and hence of the overall E&I process.

18. The evaluation experiences performed until now in ISTAT can be classified in both the observational and experimental context. In the observational context, the evaluation of E&I approaches or strategies have been performed essentially in two areas: for a given E&I problem, starting from raw data, verifying the usefulness of a new methodology by comparing its results with results obtained by using the traditional E&I approach (Di Zio et al., 2001); 2) for a given E&I problem, starting from raw data, evaluating the best E&I technique among different approaches by comparing their effects of (Cirianni et al., 2001).

19. It has been mentioned that the experimental approach is the natural framework where the evaluation of the quality of E&I methods can be embedded. In particular, in ISTAT a simulative approach is at present adopted (Della Rocca et. al., 2000; Barcaroli et al., 1997) in many studies. The adopted simulative approach consists of the following steps:

i) corrupt original true values with errors or missing values;
ii) apply the E&I strategy in order to obtain the edited data;
iii) compare some quantities computed on the original true values with the same quantities computed on the final edited values.

Before entering into a more detailed discussion on the theoretical aspects related to the use of this approach, we want to stress some practical aspects.

20. The simulation approach is effective for both the evaluation objectives 1) and 2) mentioned in section II. In fact, the first objective consists of verifying the behaviour of a technique with respect to some theoretical situations of a given E&I problem; for example, if we want to evaluate the performance of two techniques with respect to the presence of random errors, we can simulate random errors in data and comparing the results obtained with the two techniques. For the second evaluation objective, that is to choose the best set of techniques for a given survey application, we try to simulate real situations and evaluate the method (or set of methods like an integrated E&I procedure) with respect to them. To reach this goal it is important to analyse the *error profile* of the survey we are going to investigate. In this case, it would be possible to reproduce, at least for the main aspects, the error mechanism affecting data.

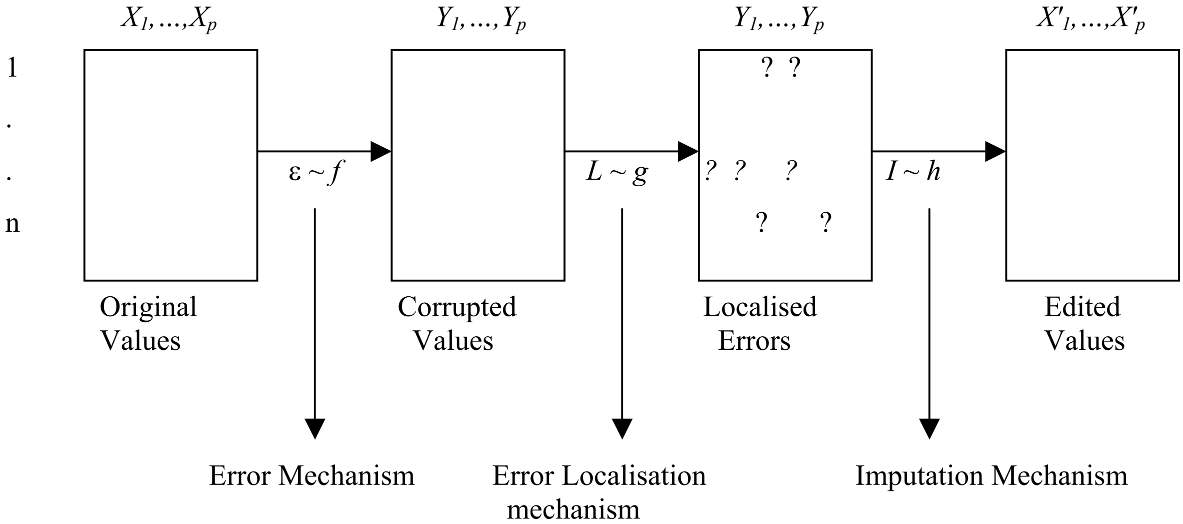
21. The main advantages of this approach with respect to other ones are low costs and the possibility of controlling some critical aspects of the applications. Drawbacks mainly relate to the effort required for modelling the error patterns and characteristics.

22. Some interesting experiences in this area have been gained in ISTAT in different contexts: comparing the performance of different approaches to a given E&I problem (Manzari et al., 2002), assessing the capability of a new approach of dealing with some specific kinds of errors (Manzari, 1999; Coppola et al., 2002) and, in the context of the European EUREDIT project (www.cs.york.ac.uk/euredit/), evaluating the best method in an overall survey context. In the latter case, the evaluation criteria and the corresponding performance indicators are those described in Chambers (2001). The proposed indicators have been implemented in a generalized software that allows to evaluate any given E&I technique in terms of its capability of preserving data at both micro and macro levels.

23. In the following, we will stress some theoretical aspects related to the use of the above cited simulation approach, in order to highlight some of its potentialities.
Let us suppose we have observed p variables on n units. Let $X=(X_1, \ldots, X_p)$ be the vector of original true values, let $Y=(Y_1, \ldots, Y_p)$ be the vector of corrupted values and let $X'=(X'_1, \ldots, X'_p)$ be the vector of edited final values. As so far introduced, for evaluating the E&I procedure, we generally compare the

generic quantities $Q(X)$ and $Q(X')$ through a suitable generic loss function $D(Q(X), Q(X'))$. One of the possible choice is for instance $Q(X) = X$ and $D(Q(X),Q(X')) = (X - X')^2$ the square of the difference between original and edited values.
It is worthwhile noting that, the X' values can be thought as a realisation of a random vector from a multivariate probability distribution depending on different random mechanisms: the corruption of the original values with probability law f (error mechanism), the error localisation method (with probability law g when it is not deterministic) and the imputation method (with probability law h when it is not deterministic); this process is shown in the following Figure 1.

Figure 1: Editing and imputation process in a simulative context



24. In this context, to statistically evaluate the quality of the E&I process we have to consider all the stochastic mechanisms affecting the results. Thus if we want to evaluate fairly the performance of the E&I process through a suitable generic function $D(Q(X), Q(X'))$, we should need to compute it with respect to the distributions of the stochastic mechanisms present in the process. One natural way, allowing to take into account the different random mechanisms, is to compute the expected value of D:

$$E_{\varepsilon, L, I}[D(Q(X), Q(X'(\varepsilon, L, I)))] \qquad (1)$$

where (ε, L, I) represent the random mechanism as in Figure 1. It is clear that choosing $D(Q(X),Q(X')) = (Q(X) - Q(X'))^2$, we obtain the well known Mean Square Error.

Generally, we are not able to compute analytically the expected value (1) because of the difficulty of modelling the joint distribution of the random variables $X'(\varepsilon,L,I)$. On the other hand, we are often able to draw observations from the joint distribution of the random variable $X'(\varepsilon,L,I)$. In this context we can use a Monte Carlo integration method to approximate the expected value (1) (Rubinstein, 1981). If we repeat m times the E&I process, we obtain $(X'^{(1)}, \dots, X'^{(m)})$ that can be thought as a m sample drawn from the distribution of $X'(\varepsilon,L,I)$, hence for m sufficiently large

$$\frac{1}{m}\sum_{i=1}^{m} D(Q(X), Q(X'^{(i)})) \cong E_{\varepsilon,L,I}(D(Q(X), Q(X')))$$

25. As illustrated in Figure 1, since the process is hierarchical, it could be interesting to assess the impact on the final data of each single stochastic mechanism. This can be achieved through the usual formulae with respect to the natural conditioning arising from the stream depicted in Figure 1. For example if we suppose that the imputation mechanism is not stochastic, we can decompose the total variance in a part induced by the error localisation mechanism and by the corruption method used, i.e.

$$Var_{\varepsilon,L}(D(Q(X),Q(X'))) = E_{\varepsilon}[Var_{L|\varepsilon}(D(Q(X), Q(X')))] + Var_{\varepsilon}[E_{L|\varepsilon}(D(Q(X), Q(X')))]$$

where $E_{\varepsilon}[Var_{L|\varepsilon}(D(Q(X),Q(X')))]$ gives the part of total variance expressed by the variability of the error localisation random mechanism, and $Var_{\varepsilon}[E_{L|\varepsilon}(D(Q(X),Q(X')))]$ quantify the part of total variance expressed by the variability of the error introduction random mechanism. All these quantities can be expressed as integrals and thus computed by a Monte Carlo integration method.

IV. TUNING AN E&I PROCESS

26. E&I processes are recognised as very costly and time consuming. The importance of optimizing their effectiveness and efficiency has been continuously underlined in literature, and possible ways of improving the performance of E&I activities in terms of quality and resources allocation have been discussed by many authors (Granquist, 1995; Lepp et al, 1993). Some general problems relating to the design and application of E&I processes have been highlighted in Granquist (1995) together with possible solutions: in particular, the Author identifies three types of costs connected with editing (producer costs, respondent cost and losses in timeliness) and suggests some possible actions the survey managers can do in order to improve the cost-benefit efficiency of editing processes (evaluation methods, developing improved edits, improving questionnaire design, limiting manual follow-up to those flagged records with the heaviest potential impact on estimates).

27. It is well known that E&I strategies are complex integrated processes consisting of several sub-phases: therefore, there is not a unique way to apply a given E&I strategy to a given set of data, depending on the specification of a series of elements as the hierarchy among units/errors/variables, the edit rules (logical, mathematical, statistical), the stratification variables, imputation algorithms, and so on. Therefore, once the E&I process has been planned and its components have been defined (in terms of approaches, methods, algorithms to be used for dealing with the different E&I problems), the actual operational characteristics of the process itself are to be *designed* and *implemented,* and the performance of the E&I strategy has to be *tested* and *tuned* on the actual observed data. These tasks are generally accomplished through an iterative evaluation process in which the subject matter expert deals with the above -mentioned E&I elements for improving the performance of the technique or the integrated set of techniques making up the overall E&I strategy.

28. The evaluation of the performance of an E&I process in this context can be reformulated in terms of what is happening to data *during* its execution (Nordbotten, 2000; Thomas, 1997). In particular, the evaluation objectives can be resumed in the following points:

- verifying the effectiveness of the adopted editing methods in terms of results reliability;
- verifying that the E&I process results correspond to those expected in the planning phase in terms of costs and timeliness;
- verifying that resources are allocated in the appropriate way through the E&I process sub-phases.

29. To reach these aims, a great help in specifying and setting the E&I process comes from the acquired knowledge obtained by previous *quality evaluation studies* or *past experiences* in the application of the selected methodology in a survey process similar to the specific current one. The existing documentation can assist the edit officer in choosing some solutions and in discarding some others. However, the subject matter expert has to deal with new collected data, so, although the hints provided by the existing documentation, he needs information suitable to analyse alternative settings and to choose the one which provides the *best* E&I process in his production context, that is to evaluate the E&I process.

30. Therefore, it is good practice to supply each E&I process with E&I diagnostics in order to continuously monitor its execution and be able of identifying as soon as they appear possible problems. The diagnostics are helpful tools whatever the survey features and the E&I system used.

31. These diagnostics represent performance indicators to be used for monitoring the reliability and suitability of the applied techniques. They quantify the most appropriate quality criteria for the technique/approach under evaluation. Performance criteria that can be used in this evaluation context, in which generally only raw and edited data are available, are, for example, data processing costs, timeliness, amount of creative and over-editing, respondent burden, preservation of micro and macro data, edits consistency and usefulness, data coherence with other sources of information. It is obvious that while some of these criteria are common to many E&I sub-phases, like data processing costs and

timeliness, other ones are specifically used in some phases: for example, preservation of both microdata and data distributions are particularly critical in automatic data processing, while respondent burden and aggregates preservation mainly relates to selective editing and interactive editing phases (de Pol, 1997; Engstrom, 1995; Latouche et al., 1995).

32. During last few years, ISTAT researchers essentially worked in two main directions: improving the trade-off between timeliness and data quality in automatic editing (in both households and business surveys) and reducing costs and time related to the manual/interactive editing (particularly in business surveys).

33. In the latter context, studies and applications have been performed also in the context of the reduction of respondent and production costs due to the manual/interactive editing in particularly in business surveys. In this context, the problem of improving the identification of relevant units (in terms of their impact on estimates) has been faced through the approaches of *macro editing* (Barcaroli et al, 1995) and *selective editing* (Luzi et al., 1999; Di Zio et al., 2001; Cirianni et al., 2000). Encouraging results have been obtained in all the applications. Further research is needed in this area.

34. In the field of automatic data processing, a lot of experience has been gathered in ISTAT in the use of performance measures produced by generalized software dealing with random not influential errors. Generalized software facilitates the standardization of approaches and methods used for specific E&I problems, giving the user guarantees about quality requirements through the use of theoretically consolidated algorithms, and allowing the economy of resources and time by eliminating the need of developing ad hoc code.

35. A further advantage of using these systems relates to the possibility of checking the redundancy and the consistency of edits. Redundancy between edits does not affect the correctness of their definition but can affect the efficiency of the E&I process. On the contrary, inconsistency between edits means that can be errors in some edit definition and this, generally, affects the efficacy of the E&I process. An overall description of possible problems and drawbacks related to the incorrect use of edits is done in Granquist (1995). Here we refer to the use of validity checks and consistency edits used in automatic data E&I for identifying fatal errors.

36. Another important advantage related to the use of generalized software is generally the standardization of evaluation and documentation measures through the production of minimal sets of indicators and reports useful in monitoring and calibrating the effects of the data processing actions performed on data. Examples of these reports are those produced by systems like SCIA (Riccini et al., 1995) and GEIS (Kovar et al. 1996), actually used in ISTAT for dealing with random errors respectively in categorical and continuous variables. Both software are based on the Fellegi and Holt approach (Fellegi and al., 1976), thus they gives some guarantees to the user about the results quality (minimum change of original data, final data plausibility with respect to the user-defined edits, preservation of original distributions under specific conditions). Experimentations are in progress for developing a new generalized software, called DIESIS (Bruni et al., 2001) for dealing with mixed categorical and continuous data, based on both the Fellegi and Holt and the data-driven approach.

37. Among the operational tools provided by these software for monitoring and evaluating the reliability of an automatic data E&I process there are:

i) the *number* of *passing* and *failing* records;
ii) the *edits failing frequencies*;
iii) the *imputation frequency* and the *edits* mostly involved in the imputation process with the corresponding *frequency* of such involvement;
iv) the *frequency distributions* before and after imputation and the *transition matrices* containing the frequencies of occurrence between values before and after imputation (for qualitative variables);

38. All these tools allow the subject-matter expert to analyse the usefulness and the reliability of the automatic editing strategy through the observation of its effects on data: for example, an excessive proportion between the number of *failing* and *passing* records provides the first insight that something is

going wrong in data or in the E&I process, the *edits failing frequencies* can reveal errors in edits definition as well as can help in checking the nature of the errors in data (random or systematic), the analysis of the *edits failing frequencies*, together with the change in relevant aggregates, is also useful for over editing reduction, the analysis of the *transition matrices* is useful to evaluate some aspects of the corrections made: if concentration of frequencies are noted in cells not lying on the main diagonal and the marginal distribution does not show the same pattern, this can be due to errors in edits definition and/or the presence of systematic errors in the data.

V. ANALYSING THE IMPACT OF E&I PROCESS

39. Increasing attention has been paid to the identification of standard quality indicators and the production of standard quality reports at both NSO level and Eurostat level. Many studies can be found in literature dealing with the problem of assessing and documenting the impact on data of E&I procedures (among the most recent ones, Madsen, 2000; Nordbotten 2000; Lindell, 1997; Whitridge et al., 1999; Cirianni et al. 2000), and several indicators have been proposed for evaluating the effects of E&I procedures on raw data. In this case, we can say that the term *quality* relates to the transparency, reliability and suitability of the E&I procedure with respect to the planned and designed E&I objectives.

40. Regardless of the adopted editing procedure, the production of standard quality indicators for evaluating and documenting the data processing activities performed on collected data is always recommended. Generally, these standard indicators are to be produced for satisfying both data users and producers needs. Such quality measures are in fact applied with the following main purposes:

i) providing users with information about the E&I process characteristics, the final data quality and the data modifications due to the E&I process;
ii) providing subject-matter experts with information about the errors characteristics in order to allow the identification of their possible sources;
iii) providing the subject-matter experts with detailed documentation on the process impact on data (and hence on data quality) in each survey repetition in order to allow the data and process quality monitoring over the time;
iv) providing NSO with information about the quality level of each surveys in order to allow the data and process quality comparison among *similar* surveys.

41. According to Granquist and Kovar (1997), all these objectives aim at "gathering intelligence related to significant difference in the data for analytical purposes" and "providing feedback that can lead to improvements in data collection and processing".

42. In fact, all researchers and subject matter experts agree on the importance of editing activities as source of information on the error sources: the analysis of error patterns and characteristics generally allow the identification of possible lacks and problems in some survey phases (including the E&I phase). This allows the planning of the appropriate modifications of the survey organisation/methodologies in future survey repetitions to prevent errors from arising.

43. Furthermore, the analysis of the impact of E&I methods on collected data in terms of time, costs, and modifications produced on the statistical properties of raw data allows the statisticians to verify the reliability and the usefulness of the adopted methodologies and planning revised or new approaches for improving the performance of the E&I process.

44. Similarly, the comparative analysis of the quality indicators for a given survey over time can highlight structural modifications in the surveyed phenomena or occasional organisational problems needing permanent or occasional adjustments to the survey organisation, to the E&I procedure or to the data analysis.

45. The comparison of standard measures among similar surveys in a same period is a powerful tool that survey managers and NSO can use for identifying structural of methodological lacks in their surveys or data processing strategies, thus stimulating their revision and the improvement through the introduction of new approaches and/or techniques.

46. The main problems common to all the objectives i.÷iv. can be summarised in the following points:

- identifying a set of appropriate standard quality indicators;
- providing data producers with tools for computing the indicators in a standard way;
- making the data producers compute standard quality indicators.

47. During last few years ISTAT has worked mainly in the following directions:

i) providing the survey managers with an information system especially dedicated to documenting and analysing the quality of the survey production process, obviously including the E&I phase;
ii) providing the subject-matter experts with a generalized tool for analysing the impact of their own data E&I processes on the statistical properties of collected data;
iii) encouraging the production and the use of standard indicators and measures for documenting the E&I strategies and their impact on observed data, and monitoring the effects of E&I procedures over the time.

48. The centralized information system SIDI (Brancato et. al, 1998) has been designed and developed to support the quality control activity through the monitoring of the survey production process, the documentation of data production activities and the dissemination of suitable information on data quality to the final users. The adopted approach focuses on the production process according to the concept that the quality of final data benefits of improvements in the process. To this purposes, SIDI manages not only quantitative information (quality indicators) but also qualitative information (metadata on the survey production process characteristics). Relating to the E&I phase, a synthetic description of the standard quality indicators at present included in SIDI is provided by Fortini (1999). These indicators, together with metadata on the E&I approaches adopted in each survey, are as much general as possible for allowing the evaluations reported in points i),iii),iv). All indicators use only raw and *clean* data and allow the survey managers to analyse the impact of the editing activity both on the statistical units and on the observed variables.

49. Relating to point II, in order to both facilitate and standardize the production of evaluation indicators measuring the E&I statistical effects on data, the design and development of a generalized software implementing some specific indexes has been started up. These indexes quantify quality criteria like micro data preservation, marginal data distribution and aggregates preservation, relations between couples of variables, taking into account the work on evaluation criteria done in the context of the EUREDIT project.

50. As regards the third field of activity, as mentioned in section II, detailed reports on the effect of automatic data E&I procedures are automatically produced by some generalized software available in ISTAT. These reports can be used for both documenting the automatic E&I activity impact on observed data and for analysing error typologies. For this reason, in ISTAT the use of such generalized software is encouraged. However, even in case of *ad hoc* software, the production of similar descriptive measures and reports is recommended, as well as for all the E&I sub-phases other than the automatic one. Relating to the latter, particularly in case of business surveys, future research will be concentrated in the analysis and development of impact measures in a generalized framework.

References

Barcaroli G., Ceccarelli C., Luzi O. (1995) “An edit and imputation system for quantitative variables based on macroediting techniques”, *Proceedings of the International Conference on Survey Measurement and Process Quality*, Bristol (UK), 1-4 Aprile 1995, pp.12-17.

Barcaroli G. and D’Aurizio L. (1997) “Evaluating Editing Procedures: the Simulation Approach”, *UN ECE Data Editing work Session*, Prague 1997.

Biemer, P., Fecso, R.S. (1995) “Evaluating and Controlling Measurement Error in Business”, in Business Survey Methods, Edited by Cox, Binder, Chinappa, Christianson, Colledge, Kott, Jhon Wiley & Sons Inc, pp.267-275.

Brancato G., D'Angiolini G., Signore M. (1998) "Building up the quality profile of ISTAT surveys", *Proceedings of the conference Statistics for Economics and Social Development*, Aguascalientes (Mexico), September 1-4.

Bruni R., Reale A., Torelli R. (2001) "Optimisation Techniques for Edit Validation and Data Imputation", presented at the Statistics Canada Symposium 2001 "Achieving Data Quality in a Statistical Agency: a Methodological Perspective" XVIIIth International Symposium on Methodological Issues.

Chambers R. (2000) Evaluation Criteria for Statistical Editing and Imputation, T001.05, EUREDIT report.

Cirianni A., Di Zio M., Luzi O., Seeber A.C. (2000) "The new integrated data editing procedure for the Italian Labour Cost survey: measuring the effects on data of combined techniques", *Proceedings of the International Conference on Establishment Surveys II*, Buffalo, 17-21 June.

Cirianni A., Di Zio M., Luzi O., Palmieri A., Seeber A.C. (2001) "Comparing the effect of different adjustment methods for units with large amounts of item non-response: a case study", *Proceedings of the International Conference on Quality in Official Statistics* (First version), Stockholm, Sweden, May 14-15 2001.

Coppola L., Di Zio M., Luzi O., Ponti A., Scanu M. (2002) "On the use of Bayesian Networks in Official Statistics", to be presented at the DataClean Conference, Finland, May 2002.

Della Rocca G., Di Zio M., Manzari A., Luzi O. (2000) "E.S.S.E. Editing System Standard Evaluation", Proceedings of the SEUGI 18, Dublin, June 20-23.

Di Zio M. and Luzi O. (2001) "Some experiences in combining different methodologies for editing agricultural data", *Proceedings of the CAESAR Conference (Conference on Agricultural and Environmental Statistical Applications in Rome*) – Contributed papers, Rome, 5-7 June 2001

Della Rocca G., Di Zio M., Manzari A., Luzi O. (2000) "E.S.S.E. Editing System Standard Evaluation", Proceedings of the SEUGI 18, Dublin, 20-23 June 2000.

De Pol F., (1997) "Selective Editing in the Netherlands Annual Construction Survey", *Statistical Data Editing Methods and Techniques Vol. II,* Conference of European Statisticians, United Nations, 1997.

Engstrom, P. (1995) "A Study on Using Selective Editing in the Swedish Survey on Wages and Employment in Industry", Conference of European Statisticians, Work Session on Statistical Data Editing, 1995.

Fellegi I. P. and Holt D. (1976) A systematic approach to edit e imputation, *Journal of the American Statistical Association,* vol.71, pp. 17-35.

Fortini M., Scanu M. and Signore M. (1999) "Measuring and Analysing the Data Editing Activity in ISTAT Information System for Survey Documentation", Conference of European Statisticians, Work Session on Statistical Data Editing, 1996.

Granquist, L. (1995) "Improving the Traditional Editing Process, in *Business Survey Methods*, eds. B.G. Cox, D.A. Binder, B.N. Chinappa, A. Christianson, M.J. Colledge, and P.S. Kott, New York,: Wiley, pp. 385-401.

Granquist, L. (1997) "An overview of Methods of Evaluating Data Editing Procedures", *Statistical Data Editing Methods and Techniques Vol. II,* Conference of European Statisticians, United Nations, 1997.

Granquist L. and Kovar J. (1997) "Editing of Survey Data: How Much is Enough?", in *Survey Measurement and Process Quality,* eds. L. Lyberg, P. Biemer, M. Collins, E. de Leeuw, C. Dippo, N. Schwarz, and D. Trewin, New York: Wiley, pp. 415-435.

Kovar J. and Winkler E.W. (1996) "Editing Economic Data", Conference of European Statisticians, Work Session on Statistical Data Editing, 1996.

Latouche M., Bureau M., Croal J. (1995) "Development of cost-effective edit and follow-up process: the Canadian survey of employment experience", Conference of European Statisticians, Work Session on Statistical Data Editing, 1995.

LEG (2001) *Proceedings of the International Conference on Quality in Official Statistics* (First version), Stockholm, Sweden, May 14-15.

Lepp, H. and Linacre, S.J. (1993), "Improving the efficency and Effectiveness of Editing in a Statistical Agency, *Bulletin of the International Statistical Institute*, *Proceedingsof the 48th Session,* Florence, pp. 11-112.

Lindell, K. (1997) "Impact of Editing on the Salary Statistics for Employees in County Council", *Statistical Data Editing Methods and Techniques Vol. II*, Conference of European Statisticians, United Nations, 1997.

Luzi O. and Pallara A. (1999) "Combining Macroediting and Selective Editing to Detect Influential Observations in Cross-Sectional Survey Data", *UN/ECE Work Session on Statistical Data Editing*, Rome, June 2-4.

Madsen B. and Solheim L. (2000) „How to measure the effect of data editing",Conference of European Statisticians, Work Session on Statistical Data Editing, 2000.

Manzari A. (1999) "A New Imputation Methodology: an Experimental Application to Italian Population Census Data", Atti del Convegno della Società Italiana di Statistica "Verso i Censimenti del 2000", Udine, 1999 (*in italian*).

Manzari A. and Reale A. (2002) "Towards a new system for edit and imputation of the 2001 Italian Population Census data: A comparison with the Canadian Nearest-neighbour Imputation Methodology", *to be published in the IASS Proceedings*.

National Center for Education Statistics (1992) "NCES Statistical Standards"

Norbotten S. (1997) "Metrics for the Quality of Editing, Imputation and Prediction", Statistics Sweden Technical Report, SN, 3-Oct-97.

Norbotten S. (2000) "Evaluating Efficiency of Statistical Data Editing: A General Framework", United Nations, 2000.

Poulsen M.E. (1997) "Evaluating Data Editing Process Using Survey Data and Register Data", *Statistical Data Editing Methods and Techniques Vol. II,* Conference of European Statisticians, United Nations, 1997.

Riccini E., Silvestri F., Barcaroli G., Ceccarelli C., Luzi O., Manzari A. (1995) "The Methodology of Editing and Imputation by Qualitative Variables Implemented in SCIA", *ISTAT Technical Report.*

Rubinstein, R. Y. (1981). Simulation and the Monte Carlo method. J. Wiley & Sons, New York.

Stefanowicz, B. (1997) "Selected issues off Data Editing", *Statistical Data Editing Methods and Techniques Vol. II*, Conference of European Statisticians, United Nations, 1997.

Statistics Canada (1998) "*Statistics Canada Quality Guidelines*".

Thomas, J. (1997), "Statistical measurement and monitoring of data editing and imputation in the 2001 United Kingdom Census of Population", *Statistical Data Editing Methods and Techniques Vol. II*, Conference of European Statisticians, United Nations, 1997.

Whitridge P. and Benier J. (1999) "The impact of Editing on Data Quality", *UN/ECE Work Session on Statistical Data Editing*, Rome, June 2-4.