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Topic (iv): Data collection using mixed modes and multiple sources

**IMPROVING THE QUALITY OF DATA COLLECTION: MINIMUM
REQUIREMENTS FOR GENERALISED SOFTWARE INDEPENDENT
FROM THE MODE**

Contributed Paper

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I. Introduction

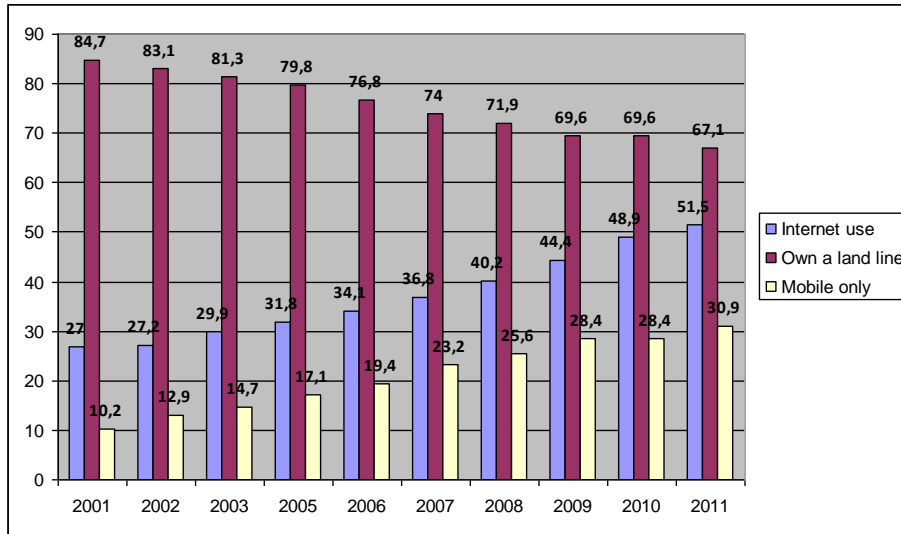
1. Due to the increasing trend in using mixed-mode to run data collection in statistical surveys, both for households and businesses, the availability of a generalised tool to design and implement electronic questionnaires is becoming a 'must'. This paper describes the mixed-mode strategy adopted by Istat both in terms of questionnaire design and of software solution. Criteria to evaluate if a generalised software is able to support the decisions taken in the design phase are described together with a case study on their application.

II. Mixed-mode: state of the art in Istat

2. Like other NSIs, Istat is facing problems of budget cuts, low response rates and low land line coverage. A possible way to solve them is represented by the adoption of a data collection strategy based on a mixed-mode approach.
3. Mixed mode, i.e. the combined use of a set of data collection techniques for the contact/reminder phases and/or the questionnaire administration of a single survey, is not new in Istat, as it has already been applied in some contexts: the Labour Force survey exploits the joint use of CATI and CAPI, and many business surveys adopt a combination of mail and CATI for follow-ups or reminders. The examples make it clear that these mixed-mode approaches are based on "traditional" techniques applied sequentially. This approach is no longer suitable to face the problems mentioned above.
4. The mixed-mode approach we are advocating in this paper seems a better candidate to tackle these issues. It involves the combined use, either parallel or sequential, of any data collection techniques, including more innovative ones, such as web surveys, as well as of any data collection instruments like mobile phones, smartphones, tablets, etc. Istat is moving towards this approach.

5. The adoption of web data collection is fairly new in Istat, especially for household and population surveys. An exception is represented by business surveys, in that area the prospect of substantial cost reduction made possible by rapid developments in information technology, have led many mail surveys to move to the Web.
6. Some early experiences are:
 - (a) for the household target, the '2011 Population Census' based on the concurrent use of mail and web surveys: 96% of questionnaires have been returned to Istat, of which 32,8% via web;
 - (b) for the population target, the '2009 PHD graduates survey' based on a parallel mixing of CAWI and CATI. Since the phenomenon under study could not be surveyed with only one mode, respondents were administered two different questionnaires: a web questionnaire to collect qualitative information about their scientific publications (title, author, year and other qualitative and open-ended questions); a CATI questionnaire to collect quantitative information about their educational background, occupation and family situation. Some common questions were used in both questionnaires to study mode effect and to reduce the reciprocal non-coverage of the used techniques. Good results in response rates: 70% in CATI and 30% in web surveys (40% of web registrations).
7. The experiences above, although important, represent a "simple" mixed-mode approach. It was "simple" to reach high response rates and "simple" to design the questionnaire for the combined techniques. In fact:
 - (a) the massive advertising campaign for the '2011 Population Census' and the high education level of respondents of the 'PHD graduates survey' were decisive factors to the good level of response rate achieved;
 - (b) the need of designing the questionnaire in a way that reduced the mode effect was totally absent in the 'PHD graduates survey', where two mode-specific questionnaire were administered, and was quite limited in the '2011 Population Census' where the questionnaire design was optimised with respect to the mail mode, as it was the main technique chosen.
8. As for business surveys, mixed-mode experiences have generally followed a simple strategy: a single questionnaire was usually designed and administered in the collection mode adopted as main technique, then other, generally more expensive, auxiliary modes were used to cover the missing strata.
9. Recently CATI surveys respondents without land-line phones have been contacted through their mobile numbers, where available, but experiences are still to be made in combining this method with other techniques. Joint use of new technological platforms and mixed collection modes will imply to address issues like sampling frame, coverage, survey environment (not covered in this paper), but also, in case of mobile phones used in combination with the web, those raised by the imperative to adapt questionnaires layout to smaller screen resolutions. Same problems will arise with the increasing diffusion of other hardware/software platforms (smartphones, tablets, netbooks, etc.).
10. The adoption of web surveys for households and population targets, the use of mobile phones and of other new hardware technologies as methods and instruments to be integrated with the traditional data collection techniques, will be a viable way for Istat to tackle the budget, response rates and land line coverage problems. This choice is supported by the trend of web use among the Italian population as well as the decreasing trend of land line coverage, as illustrated in the picture below (source Istat survey "Aspects of daily life 2011"):

Figure 1: Use of Internet, ownership of land-line and of mobile phone only



Figures are referred to 100% of the Italian households for land- line ownership and to 100% of 6 years and older Italian population for Internet use

11. The picture shows that:

- (a) the use of Internet is increasing: from 27% of 2001 to 51.5% of 2011, with percentage close to 73% among the younger population (aged under 44). This positive trend had a peak in 2008 when it registered 4 percentage points more than the previous year.
- (b) Besides it can be noticed how land line ownership have been decreasing since 2001: from 84.7% of that year to 67.1% of 2011 with stronger fall downs in 2006 and 2007 when it lost 3 percentage points with respect to the years before.

III. Adoption of a mixed-mode strategy

12. The adoption of a mixed-mode strategy to tackle and solve budget, coverage and response rate problems requires the design of a data collection strategy aimed at containing the portion of non - sampling error due to mode effect.
13. For mode effect it is intended the difference in collected data due to the characteristics of the data collection mode (measurement error) and not to real differences. Mode effect is therefore a component of non-sampling error, in particular of the measurement error (Biemer et al. 2003), always present in the collected data even when a single data collection technique is used. This is because each mode has its own characteristics and peculiarities that can make it not always perfectly suited for survey's needs.
14. The use of mixed mode, therefore, might offer the opportunity to compensate the weakness of each technique (De Leeuw, 2005) with the advantages of each of them, especially of those assisted by computer, paying attention, anyway, not to increase non-sampling error by adding a mix of measurement errors. One way to avoid this is the use of data collection instruments that are mode insensitive (Roberts 2007).
15. As known, a mixed-mode strategy can be designed in many ways that differently influence the design of the survey questionnaire. First of all, mixed-mode strategies can be divided in two groups (De Leeuw 2009):

- (a) mixed-mode strategies consisting of one main mode and the others used as auxiliary or secondary modes. This is the case, for example, of using telephone follow-ups to reduce non response error of the (main) web survey;
 - (b) mixed-mode strategies in which all modes are equally important.
16. The design of survey questionnaire follows different rules and principles according to the two groups above.
 17. The first case, can lead to adopt the *mode-enhancement construction* approach (Dillman 2000): the questionnaire is optimised according to the characteristics of the main technique in order to exploit it at best, thus maximising the data quality. This approach can be used when it is more important to maximise data quality rather than data equivalence between techniques (Betts et al. 2010).
 18. In the second case (all modes equally important) questionnaire design can follow three different approaches:
 - (a) *maximisation method* also known as *mode specific construction*: the questionnaire is optimised for each method. There are two basic assumptions underlying this method. The first is that data collection methods measure the same concepts but with a different level of accuracy and the second is that differences in collected data are due to random error and not to mode effect (De Leeuw 2009).
 - (b) *Uni-mode or unified approach* (Dillman 2000). With this approach the questionnaire is designed as to offer the same stimulus (the same or almost the same question format) in each mode. In this way mode effect is contained since there is less variability among answers from respondents of different modes. This approach indicates nine principles for questionnaire design, which might be hard to respect entirely for some types of modes combination¹. Besides it could not offer a proper solution for problems like social desirability or acquiescence deriving from the presence of interviewer (Dillman et al. 2005).
 - (c) *Generalised mode design* (De Leeuw 2005). The questionnaire is purposely designed to be different for each method, in order to reach the cognitive equivalence of the perceived stimulus. This is because, to state it using de Leeuw's own words, "...the same offered stimulus is not necessarily the same perceived stimulus".
 19. The generalised approach is not an easy approach as its implementation requires that researchers clearly identify the differences among modes that influence the cognitive process of question answering and demonstrate, through cognitive tests, that different question formats elicit equivalent answers (De Leeuw 2005).
 20. Methodological difficulties notwithstanding, this approach seems more suitable for answering Istat needs, since it will allow the combined use of any techniques and instruments, traditional as well as innovative ones.
 21. Fundamental for the implementation of a generalised approach for questionnaire design is the creation of an integrated data collection system, made of generalised functions covering all steps of data collection.

IV. A software solution to support mixed-mode surveys

¹ This is the case, for example, of the principle "avoid questions structure that unfold" that can be hard to implement in a combination of PAPI and a CAI techniques (De Leeuw 2009)

22. Istat is currently engaged in the definition of the requirements that a data collection system must meet in order to be considered as generalised. The requirements are meant to be applicable to the data collection process as a whole, from management of sample units lists to finalisation of collected data.
23. The need for a software system fully supporting mixed mode strategies arises from the recognition that a further element of risk, brought by the very approach here advocated, is represented by the emerging complexity of the resulting collection process. In other words, when dealing with mixed mode we must take into account the risk of greater non-sampling error, as a result of non-optimal design, but also consider the possibility of increasing survey costs, delays in the delivery of data and measurement errors, due to the duplication of effort in implementing the questionnaire across different modes (Macer, 2003).
24. Whereas the task of reducing non-sampling error in terms of coverage, measurement, frame and non-response errors is accomplished by means of a carefully designed strategy, it is technological facilities that should be expected to decrease complexity, by providing the proper support to the actual implementation of decisions taken at the design stage and, even if IT tools cannot be expected to completely get rid of mode effect, they must not, at any rate, increase the non-sampling error (Macer, 2003).
25. The task of reducing complexity in dealing with mixed-mode collection raises important technological issues:
- (a) *Consolidation.* Integration of the items in the IT toolbox is no longer optional. Mixed mode compels to bring things together. Depending on the scenario, a “Swiss Army Knife” approach can be adopted, where a single all-purpose, tightly integrated system is designed from scratch or, taking the opposite end of the spectrum, the choice can be made of taking advantage of available tools and making them speak common languages, share agreed-upon data representations and meet a clearly defined set of functional standards.
 - (b) *Generalisation.* It is no longer affordable to rely on ad hoc procedures. Although they appear to be immediately effective, especially in comparison with off-the-shelf products, as they are usually tailored for the task at hand, they lack by definition the required flexibility and in the long run are likely to prove highly cost-ineffective in terms of maintenance and reusability.
 - (c) Generalisation should be considered across three main dimensions:
 - *Data collection technique:* systems should be able to handle different modes of questionnaire administration (CATI, CAWI, etc.) and different survey techniques.
 - *Classes of respondents:* systems must adapt to specific features of different survey units (households, enterprises, institutions, individuals).
 - *Software and hardware platforms:* at a minimum, the interposing technological layer should not negatively affect the interaction between user and survey facilities, for example by decreasing response rates or validity of the obtained data, as a result of unequal probability that respondents with different client environments can fill in the same questionnaire form, due to poor cross-platform compatibility. The same applies to back office tools (authoring, management, etc.).
 - (d) *Questionnaire abstraction.* Design tools should enable users to define questionnaires as objects, logically decoupled from their instantiations in any of the collection modes available. At the same time the system should be adaptable enough to allow mode-specific changes to the questionnaire, whenever necessary. This would ensure a higher level of flexibility and is closely entwined with the attainment of items (a) and (b).
26. That said, in our current scenario, being confronted with a set of software developed in different and largely independent contexts, addressed to only partially overlapping domains of application and in the presence of a number of legacy systems to take into account, to achieve these

objectives would hardly be considered as a single-stage procedure. The first objective was set, more realistically, as to collect and analyse the necessary information on which to base the pursuing of the long-term goals. Predictably, the information would not be easily mapped to this three-fold schema. For example, we knew that the abstraction of the questionnaire was not fully attained by any of the tools under analysis and that we should rather look for individual functions that can contribute to achieve this purpose. Then we considered as necessary to assess the possibility to reach the goal by evaluating possible means of enhancing and merging available micro-functions into larger ones, mappable with the three points. In other words we needed to know:

- (a) *what was already there*: i.e. to take an accurate inventory of what is available in order to avoid redundancy and duplication of effort;
 - (b) *what we should require from it*: i.e. to define standards and requirements;
 - (c) *what fully or partially already meet these standards or*
 - (d) *can more easily and cost-effectively be brought into compliance.*
27. In order to fill in the blanks with meaningful data, it was necessary to gather information on the toolbox itself and, running parallel to that, starting to devise the functional requirements by means of which fit this information in an evaluation framework. The two processes were carried out in a feedback loop, to avoid a top-down approach that was considered as too rigid.
28. First step was to conduct an evaluation of the software available in Istat for design and implementation of electronic questionnaires. Meetings have been arranged with the corresponding project managers, in order to gather preliminary data. After these informal sessions and thanks to information collected through them, we proceeded to set up the process in a more structured way. To this purpose a form was designed and sent to the project managers. During the collection the survey managers made themselves available for any clarification about the concepts represented in the form. In addition, feedbacks from the compilers led to changes to the form, where necessary.
29. Then face-to-face interviews with the project managers were conducted, in which data from the returned forms were discussed in detail. The interviews included a demonstration of the software, presented according to the typical workflow of a statistical survey. The information requested in the form worked also as a guide for the demonstrations, to the effect of narrow the range of solutions to a common vocabulary and a shared framework of functions. Data collected from the returned forms and the interviews were finally merged, normalised and table-formatted in order to enhance comparability.

V. The evaluation form: criteria

30. The major concern in designing the evaluation form was to take into consideration the different scopes and different levels of maturity of the applications and that they were not directly comparable, as they were developed to handle different data collection techniques, different statistical domains and different classes of respondents. An effort has been made to cover the majority of the topics in the field without privileging one domain over the others, trying to balance a "common minimum" approach with the need for exhaustiveness. We divided the criteria into two categories: the cross-sectional criteria refer to an evaluation of the actual facilities provided by the tools at time t , the longitudinal criteria take into account potential assets in order to assess possible lines of development.

A. Cross-sectional Criteria

(a) Usability

31. The process of authoring the electronic questionnaire should not be too far removed from the context of questionnaire design itself. It is essential that the electronic questionnaire can be implemented directly by statistical researchers. To this end, it is a primary requisite that even non-computer experts are enabled to use authoring tools without the mediation of dedicated IT personnel. The close correlation between technical knowledge of the phenomenon to be surveyed and unmediated use of the software to develop the relevant questionnaire would expectedly result in a significant increase in the quality of the whole process and a further reduction of complexity. Apart from any other consideration, this would reduce, or would help to reduce, both training and support costs. It is therefore required a high level of usability, intended as ease of use and learnability.
32. The two features are obviously correlated, so that we would expect an unfriendly user interface, for instance, to be associated with a steep learning curve. Concepts in the field of Human-Computer Interaction (HCI) are inevitably fuzzy and hard to fit in metrics, but whereas in the present state, the learnability is comparatively more difficult to measure, the ease of use can be tentatively evaluated through some indicators, such as:
- (a) user documentation availability;
 - (b) presence of a user interface;
 - (c) ability to reuse and modify existing objects and data:
 - metadata already defined, such as questions formats, edit checks, variables' items;
 - templates of questionnaire layout.

(b) Flexibility

33. A generalised software should also be evaluated according to flexibility of application, namely to its adaptability to multiple classes of respondents and, relatedly, to multiple data acquisition techniques: CAWI, CATI / CAPI and PAPI data entry.
34. This means that the software must be able to handle structures of questionnaires showing different degrees of complexity in terms of branching rules, edit checks, etc., and different ways of administering questions. Furthermore, it is believed that a huge step forward in flexibility would be to provide the ability to abstract the questionnaire object from the acquisition techniques. As already noted, this would be of key importance as it leads to a considerable reduction of time and costs of development and operation. Also it would make it easier to implement mode-specific versions of the questionnaire, or of chosen subsets of it, without redesign its underlying structure, and to apply adaptive collection techniques (e.g. mode-switching.)
35. Main criteria:
- (a) Completeness of functions (see below);
 - (b) Presence of a metadata-driven architecture: a system that consumes metadata for the definition and configuration of objects is more adaptable to redefinitions of existing classifications and ensures that development work can be reused across projects without recoding;
 - (c) Modularity: breaking down system functions into self-contained modules enhances flexibility and maintainability.

(c) Completeness of functions

36. To be suitable to develop electronic questionnaires for official statistics, applications should meet the following functional requirements:

- (a) To implement all types of question formats provided in a questionnaire for statistical surveys:
 - Single choice questions
 - Multiple choice questions
 - Open-ended questions
 - Matrices
 - Tables
 - Derived variables.
- (b) to implement all types of check rules: consistency and coherence, both as warnings and blocking controls. These should be applied at item (variables) and section level (block of items). They should be implemented both client and server-side;
- (c) to manage question sequences dynamically (smart branching, skip-and-fill, etc.);
- (d) to manage linkage to external archives for look-ups, form pre-fill, cross-referencing, etc.;
- (e) to be able to perform computer-assisted coding through optimised text matching algorithms²;
- (f) to allow the controlled upload of the requested data as files (ASCII, spreadsheet etc.), where the information is already available to the respondent in such format (e.g. master or financial data for enterprises, personal data for institutions, etc.);
- (g) to allow the respondent to export the questionnaire (empty or filled) for reference, printing and/or archiving;
- (h) to allow the respondent or the interviewer to complete the survey in multiple sessions, saving and later retrieving the partially filled questionnaire;
- (i) to enable questionnaire-sharing, i.e. to allow concurrent access by multiple respondents to a single questionnaire or parts of it (e.g. when survey units are large enterprises or institutions and it is likely that the information required to answer the questionnaire is spread across branch offices or independent departments);
- (j) to implement loop functions : i. e. dynamically generate and repeat content, based on input provided by the respondent:
 - **question loops** (e.g. tables whose number of rows is based on user input, as in the case of asking for producer prices by type of goods produced, and the list of goods is known only to the respondent);
 - **page or block loops** (same as above but applied to larger questionnaire items: e.g. the master section of the questionnaire is repeated n times according to the number of family members declared by the respondent);
 - **questionnaire loops**: e.g. a large enterprise should be enabled to complete as many questionnaires as its establishments or branch offices, previously declared in a filter question;
 - **loop-and-merge facilities** : e.g. looping a questionnaire block multiple times, merging in different text each time, all based upon a previous question.
- (k) Multilingualism: textual content should be dynamic to easily allow shift to different languages.

(d) Generalisation of functions

² It is worth noting that in this case the main concern was to evaluate the availability of specific classes of algorithms not the effectiveness of the specific algorithm implementation, which ultimately depends on the type of variables on which it is applied.

37. It is important to note that throughout this paper the word “generalisation” takes two related but slightly different meanings: in the broadest sense we refer to generalisation as the process of widening the scope of an application to encompass a larger domain of objects or environments. For instance we describe an application as generalised with respect to hardware, to simply convey the meaning that the same set of facilities is provided regardless of the physical platform they reside in. In that statement, by the way, nothing is implied about how that feature is actually implemented. As far as we know, such a high-level generalisation may have been achieved through the use of ad hoc, non generalised lower-level components. So basically, when it comes to functions, modules and routines a more strict, technical sense of the term emerges. Classically in the field of software development, the notion of generalisation rests on the concept of abstraction, which is the process of narrowing the description of an object to only those aspects that are relevant to a given context. Taking advantage of that definition, generalisation can be thought of as the process of exploiting properties that are common in a set of abstractions. While abstraction cuts down complexity by screening out irrelevant details, generalisation goes a step further by replacing multiple abstract constructs which perform similar functions with a single object. To provide the necessary flexibility, these objects are in turn fed with quantities whose value varies with the context of application. Those quantities are known as parameters.
38. Thus in a more technical way, we define a generalised software component as one that is enabled to deal with a changing environment by allowing variable data to be introduced in the system through parameterisation. Clearly, the range of user customisations the program may undergo must be considered ahead of time in order to make them high-level choices rather than low-level coding.

(e) Integration with the XML data representation model

39. The system must support data interoperability at three levels:
- (a) data exchange between items in the same data collection toolbox;
 - (b) data exchange with the tools used in other phases of the statistical process;
 - (c) integration with tools for data collection and transmission used at European and international level.
40. The interoperability must also be ensured along two dimensions:
- (a) **Syntactic interoperability:** sharing of formats and transmission protocols for the exchange of data;
 - (b) **Semantic interoperability:** definition and supply of metadata necessary to interpret shared data. Semantic interoperability, which is part of Recommendation 3 of the European Interoperability Framework v.1., must ensure “[...] *that the precise meaning of exchanged information is understandable by any other application that was not initially developed for this purpose. Semantic interoperability enables systems to combine received information with other information resources and to process it in a meaningful manner*” (EIF 2004).
41. For these purposes, it is preferable that the data structure of the questionnaires is represented, or easily representable, in a XML-based language.
42. XML (Extensible Markup Language) is the format of choice for both human- and machine-readable document marking, it allows for easier interpretation of the information represented (metadata, data, checks, rules of administration) and even if data are shared with different tag hierarchies, is always possible to ensure interoperability by extending the metalanguage of interpretation. This would also make easier to comply with future Eurostat standards such as

Eurostat DDI (www.ddialliance.org), SDMX (www.ecollect-x.eu) or X-DIS (<http://ec.europa.eu/idabc/en/document/5385/5637.html>).

43. At a further level, the adoption of XML to define the syntactic/semantic structure of the questionnaire would be a key step in the direction of its abstraction.

(f) Independence from proprietary systems

44. The choice of non-proprietary technologies has several advantages: lower costs of acquisition and management and greater independence from suppliers. In principle, this choice would ensure not only a greater control over the code, thus avoiding the need to modify it in relation to changes in the instrument adopted, but it would enhance his flexibility as well. Finally, adopting open technologies allows to share solutions with the developer community of other NSIs.

(g) Cross-browser compatibility

45. The software should ensure that the layout and functionality of the web questionnaire do not vary as different browsers are used to access it. A cross-browser application ensures the smooth running of the compilation process even when the specifications of respondent's client environment are unknown or not directly controllable, like in business or households/population surveys.

(h) Platform compatibility

46. In an ever-changing technological landscape and with the progressive widening of the range of users adopting emerging technologies, platform compatibility becomes an essential requirement: users must be able to easily fill in electronic questionnaire even on devices such as PDAs, netbooks, laptops, smart-phones, tablets, MID, UMPC.

B. Longitudinal Criteria

47. The survey was not limited to take a snapshot of the available tools in their current stages of development, but also to evaluate the potential for future development towards a fully-fledged generalised software. According to some basic metrics:
- (a) Generalisability of available ad hoc functions³.
 - (b) Modularity of functions (generalisation and modularisation are normally used together to provide greater utility).
 - (c) Logical and semantic abstraction: separation between logic and data, between data and metadata.
 - (d) Compliance with recognised standards of description of data and metadata.

C. Results and Future Directions

³For all intents and purposes we will consider here the outcome of the process of parameterising a specialised, hard-coded component as an ipso facto generalised component. No special reference is made to more complex criteria and any evaluation is carried out without taking into account factors such as degree of generalisation or other fine-grained distinctions involving lower-level analysis of software architecture. By the same token, any reference made to the related concept of modularisation is intentionally left without further elaboration (e.g. measurement of dependency, cohesion etc.) These factors would be key to a thorough assessment at a later stage of software development, but in our opinion somehow premature and hardly pertinent to our current purposes. Considering the bottom-up design approach largely employed by the projects under survey, a choice was made to adopt looser engineering criteria, to avoid forcing the tools under evaluation to fit into too strong requirements. On the other hand, much stronger specifications are being proposed on a functional level, where the software is expected to meet inescapable statistical standards. We thought that this would be a reasonable trade-off between accuracy and the growing need (in our NSI) for mapping and managing a largely uncharted, rapidly developing field.

48. As expected, none of the surveyed software tools was found fully compliant with all the proposed requirements. But the resulting data together with the functional framework proposed represent a solid foundation to build upon towards a wider and deeper analysis of the toolbox.
49. Currently the results of the evaluation survey are being taken as a starting point in a recently formed workgroup for the definition of the enterprise architecture standards for data collection in Istat. A major study is underway to evaluate the entire process of data collection according to these main functions (in addition to those directly related to the implementation of the electronic questionnaire):
- (a) **Survey units management:** available tools for managing the information required to contact the respondent and to logically define it as a user in the system: name, address, phone, e-mail, username and password etc.
 - (b) **Data collection management:** available real-time administrative tools for conducting and monitoring the data collection process: management of user grants, first validation tools, questionnaire tracking systems, reporting tools etc.
 - (c) **Communication facilities:** available tools for exchanging information with survey respondents: helpdesk system, content management system, automatic reminders management, etc.
50. This wider assessment of data collection facilities fall within the scope of “Stat2015” project, which envisages the standardisation and industrialisation of the entire cycle of ISTAT statistical processes, according to a model based on a metadata-driven and service oriented architecture.

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