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EVALUATION AND ANALYSIS OF THE QUALITY OF THE NATIONAL ACCOUNTS AGGREGATES

Final Report

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A. THEORETICAL DEFINITION AND OUTLINE OF THE PROBLEM

1. Introduction

In the past years the issue of quality analysis for National Accounts (NA) estimates is acquiring an increasingly greater importance. What is more it is an issue which is gaining autonomy in the field of data quality, typical of statistical surveys.

The importance of this issue is supported even by the European Audit Court which advanced analyses and indications about the necessity of measuring the quality of the statistical Gross National Product (GNP) determination (Audit Court, 1996).

Two topics are to be dealt with before analysing the quality of NA estimates (Calzaroni, Puggioni, 1995).

The first topic encompasses the connection between methodology used to construct NA estimates and the methodology used to analyse their quality. The second topic encompasses the implementation of a data base required to construct NA estimates. These aspects are of utmost importance in the construction of the model to define methodology and techniques to measure the quality of NA aggregates. In other words, they may be defined as “defining“ topics of the methodology to measure the quality of NA data.

2. Construction of National Accounts estimates: a "Process of Processes"

The economic accounts system can be defined as a complex system. For a long period of time it resulted from a sort of “artisan” process, and now it is changing to an “industrial-like” process (Bracalente, Calzaroni, Pascarella, 1991).

Two conditions are necessary to achieve this change: a complete definition and a “model” of the system to construct economic accounts; the introduction of computer aided techniques which allowed to adopt complex methodologies (meaning even the integrated use of several information sources) and made their standardisation easier.

The process to construct NA estimates can be outlined as a “Process of Processes” composed of the following “macro-steps”:

1. Analysis and standardisation of methodologies to estimate economic aggregates and of the definitions used at national and international level;
2. Construction of an *Integrated Information System* (IIS) including information (data) required to implement methodologies defined in 1;
3. Verification of the accuracy degree of each information source in the system;
4. Verification of the accuracy degree of NA aggregates. The accuracy degree results from the integration analysis of each information source in the system. The adequacy with the NA pattern is checked as well.

3. Standardisation of estimate methodologies and construction of an Integrated Information System

The need for standardisation of methodologies used in the estimate of aggregates required by the accounting model of the NA and the need for an IIS are determined not only by the will to use the highest informative power of existing sources, but also by the need for “repeatable” estimates. Above conditions are deemed necessary so that estimates could be considered part of a methodological model which is clear to users and able to measure statistic effectiveness.

Consequently it must be underlined that: 1) the data base may be implemented and/or established methodologies may be changed due to the "feedback" between the methodology defined to construct NA estimates and the data base available to apply that same methodology; 2) the quality of NA estimates can be analysed by examining the capability of basic variables[1] to meet the information requests of NA models.

To realise the IIS the steps outlined below are to be followed:

1. statistical sources used in NA are to be analysed and classified according to their characteristics and type of use within the national accounts models;
2. data integration (first of all logic integration) and "linkage", whenever possible for micro-data;
3. non Statistical Institute sources should be analysed and integrated into the IIS (for example administrative data).

This system should take into account the limits resulting from the characteristics of each source (target population; adopted definitions and classifications; data collection unit; unit of analysis; interval; source type: administrative, sample, census; error types: sampling, non-sampling; etc.), so that sources could be correctly used to construct basic variables.

4. Selection of the individual sources and verification of their accuracy and reliability

This stage is part of the quality analysis of data for a single survey from the viewpoints of accuracy and reliability, where accuracy indicates the difference between "true" and collected data, reliability means the "stability " of survey quality standards. With a fully operating system, National Accountants should consider the quality analysis output as an input likewise information to be collected. As a matter of fact, within the National Institute of Statistics a tight relation should be established between the producer of data and the first user of data (N.A.). Then the most useful analysis and evaluation tools for both partners could be immediately defined.

The choice of sources to be used among the existing sources for each NA aggregate to be estimated comes before the analysis of accuracy and reliability. As a matter of fact, the choice is based on criteria which are either explicitly or implicitly followed by the researcher. Criteria take into account the following aspects:

relevance, namely compliance with informative needs;

accuracy (this point includes coverage with reference to the other domains of the source, survey error profile aspects are included as well) (see Bailar e Masselli et alias);

adequacy, namely compliance with definitions in the ESA/SNA;

timeliness (availability of information within the expected time).

Nevertheless, it should be underlined that the procedure to construct accounts is not unchangeable, methodologies and sources are interdependent.

5. Verification of the degree of adequacy and accuracy of the NA estimates

NA data quality is to be measured with reference to the cognitive aim of NA. In other words NA economic aggregates and not the original information aims are to be considered to evaluate the adequacy of basic variables included in the IIS. NA economic aggregates are defined by SNA/ESA (UNITED NATIONS, EUROSTAT, IMF, WORLD BANK, 1993) and their use is important to have a correct estimate.

[1]The expression *basic variable* specifies the highest level of aggregation for IIS data for a single source: then it is a variable which can be directly measured or estimated (CSO, 1992).

The statistical comparison among different sources provides a measure for data accuracy when the different sources analyse an event from the same viewpoint (for example, more surveys about enterprises) or from different viewpoints (for example, enterprise surveys, household surveys, administrative acts). Therefore the degree of data accuracy is measured with reference to the target population resulting from the integration of available sources and not taking into account the "true" value of the single source.

Thus two important results are available:

a) data from each information source are to be validated and correct if necessary. Validation and corrections are to be made using any other consistent information (for example using more enterprise surveys, that is with one data collecting unit may lead to the assessment or re-assessment of each single source accuracy);
b) the adequacy validation for NA aggregates which are being estimated.

On the whole, however, the availability of more sources to estimate one NA aggregate complicates the procedure to quantify the accuracy of the same aggregate. In fact the effects resulting from the integration procedure are to be evaluated, since the total error measure is affected as well.

6. Total measure of NA estimate quality

Thus the quality of NA aggregates results from the action and inter-action of the following elements:

1) the accuracy of each single information source used. Accuracy is in terms of Error Profile (EP) related to the process required to realise the survey;
2) the accuracy resulting from comparing and integrating the information sources in the IIS. Accuracy is to be related to basic variables (this step provides useful information about the quality of sources- see Masselli, Signore, Panizon, 1992);
3) the adequacy of NA aggregates estimates with their definitions (however, accuracy of information sources is included within the accuracy which is measured considering the "true" value of NA aggregates), estimates are constructed on basic variables;
4) the compliance with accounting constraints of the national accounts system considered as a whole.

2) and 3) represent the ***Error Profile of National Accounts*** (EPNA).

As for the EP of a survey, the EPNA describes the possible elements leading to errors and evaluates their impact on each NA aggregate. To begin with it seems to be determined by the following elements:

EP of base data (description of error sources attached to every source and quantification of the total error e_{EP} which is obtained as function of the total errors of each source);
Target Population (bias B_P in the estimate of aggregate due to differences between the domain resulting from the integration of sources and the SNA/ESA target population);
Definitions and classifications (bias B_{DC} in the estimate of aggregate due to differences between the SNA/ESA and source definitions and classifications);
Temporariness of available data (bias B_P in the estimate of aggregate since data temporary by construction are provided by one of the sources, whether willing or not, as for example the data of a temporary balance sheet).

Since the elements composing the EPNA can be assumed as non-compatible (non overlapping) by construction, the total error of the aggregate can be defined as sum of the EPNA elements.

Assuming that X^*, estimate of the aggregate X, is equivalent to the expression:

$$X^* = X + e \quad [A1]$$

where *X* is the aggregate "true" value and *e* is the error, the latter will be equivalent to the expression:

$$e_{EPCN} = e_{EP} + B_P + B_{DC} + B_P \quad [A2]$$

Confidence intervals of single aggregates can be constructed from the estimate of e_{EPCN} through the usual statistical inference techniques. The intervals are constructed taking into account the required confidence level (a 90% level can be sufficient).

The EPNA can be described as the matrix shown in fig.A.1 (limited only to two sources of data, however it is still a general example). In the first two lines there is the error contribution of each data source to the error elements of the EPNA. The different elements of the matrix are estimated on the basis of the designing characteristics of each information source, of quality standards for collected data, and on the basis of logical and statistical relation between sources and basic variables.

Fig.A.1 An example of EPNA with two information sources

	E.P.	Target Population	Definitions and Classifications	Provisional Data
Source 1	EP_1	c_1	d_1	p_1
Source 2	EP_2	c_2	d_2	p_2
EPCN	$f(EP_1,EP_2)$	$f(c_1,c_2)$	$f(d_1,d_2)$	$f(p_1,p_2)$

The elements in the last line of the matrix are the EPNA of the examined aggregate. These elements are outcome of an expression which is function of the results of the error element analysis for each source. The integration of sources and methodologies to estimate the aggregate are taken into account. Therefore, if we compare the EP of a single survey with the EPNA, the latter includes an additional element: the analysis of relations between the EPs of each source (in this matrix it is summed up by the expression $f(EP_1,EP_2)$) as well as other elements which result from analysing the differences between the typical characteristics of NA aggregates and the characteristics of basic variables estimated by the IIS.
Thus the total error estimates is given by the following expression:

$$e_{EPCN} = f(EP_1,EP_2) + f(c_1,c_2) + f(d_1,d_2) + f(p_1,p_2)$$

The *Target Population* includes the aggregate exhaustiveness as well. Since exhaustiveness is very important within the European Union criteria, a more detailed description of this concept is given in the next section. The connection between exhaustiveness and quality will be dealt with in details.

In the outline above the estimates are considered before being reconciled. Reconciliation is necessary to guarantee that accounting limits are respected.

Actually, the problem of evaluating the accuracy of NA estimates cannot be divided from balancing or reconciliation the whole set of account systems. From the experience we see that the estimates of NA aggregates are not consistent with the limits, owing to the different level of adequacy and accuracy of the information sources used. Generally speaking, respecting the accounting limits is in itself a tool to define the accuracy of the procedure (Arkhipoff, 1992d).

The outcome of the balancing procedure is an estimate with a total error not greater than the error of the initial estimate and where accountancy limits are respected, if an efficient, from a statistical point of view, mathematical balancing system is used, as the one adopted by ISTAT and suggested by **Stone** (ISTAT, 1990). The total error is not greater than the error of the initial estimate only if estimates of the error are not biased, however this feature is assured by the procedure. Thus the necessity of constructing the EPNA is even more urgent, since the availability of correct estimates guarantees that estimates variances are efficient after balancing with the Stone method. Moreover it should be said that the balancing procedure starts a sort of "virtual cycle" to refine the estimate of economic variables and of the related reliability level. Thus there is a global improvement of the procedure accuracy.

The balanced estimates (called *"post" estimates* while not balanced estimates are called *"pre" estimates*) can be associated with a number indicating their total error, since the Stone method allows to calculate the total error of aggregates after balancing.

7. Connection between Exhaustiveness and Quality of NA estimates

Ensuring that the Member States' GNP estimates are reliable, comparable and exhaustive is a high priority for the European Commission and for Eurostat, the statistical office of the European Commission. This is so because, putting to one side the other requirements for good GNP estimates, a major part of the Union's budgetary income (some X bn ECU in 1997, or Y bn US $) is collected as a charge levied in proportion to each Member State's GNP.

An exhaustive GNP estimate means that the coverage of units which are registered with the public authorities but not covered in statistical data sources, of units which are exempted or otherwise not registered, and of units which mis-report or do not report part of their activities, should all be complete.

In order to define the exhaustiveness of GNP estimates it is necessary to analyse boundaries. Using the System of National Account (SNA93/ESA95), it is useful to stress the main "areas" for which problems of statistical measurement exist. The SNA93/ESA95 uses three different words to describe these "areas": **illegal, underground, informal**. As a convenient summary of these "areas", we will use the term **"non observed economy".**

In the SNA93 we find definitions of the illegal and underground economy, and means by which we can identify the informal sector.

1. Illegal production (SNA93) stands for:

1a. the production of goods and services for wholesale, distribution or possession which is prohibited by law;

1b. all legal productive activities that turn illegal the moment they are carried out by unauthorised personnel.

2. **Underground activity** (SNA 93)stands for all legal production unknown to the public administration for different reasons:

2a. evasion of Value Added Tax (VAT), incomes taxes, etc.;

2b. evasion on social contributions;

2c. the non-observance of standards defined by law: minimum salaries, working hours, equipment for safety on the job, etc.;

2d. the non-compilation of administrative forms and/or statistical questionnaires.

3. To define the **Informal Sector**, SNA93 (chapter 4, ANNEX) includes reference to productive institutional units characterised by:

3a. a low level of organisation,

3b. little or no separation between capital and work

3c. work relations based on kinship and/or social relationships, as opposed to formal contracts.

These units belong to the Household sector and they cannot be associated with other units. In such units, the owner is totally responsible for all financial and non-financial obligations undertaken for the productive activity in question. On the basis of the laws of each country this sector may be identified, for example, on the basis of "size" and/or legislative characteristics which are such that there is no obligation whatsoever to be registered with the public administration.

Having defined the target population for NA estimates and the importance of these topics in assuring that estimates are exhaustive, it is clear that the share of the economic aggregate determined by underground and/or informal economy represents the most important share within the error due to the difference between the survey and NA domains. We already defined this type of error in the EPNA (bias B_P).

When determining the total error the following should be underlined: the total weight, weight of its main elements (underground and informal) and the reliability degree given to these estimates (currently the illegal element is not to be included in the GNP estimates of Member States).

It is now clear that the element resulting from the underground and informal economy are only the quantification and definition of the "exhaustiveness" outcome, already mentioned.[2]

In the synthetic tables described in the next section, exhaustiveness is separated from more statistical elements, whose origins is described above. These two elements together determine the quality of NA estimates, they are to be measured to have "a measure of the total quality of NA estimates".

8. Synthetic tables

A reference model for a systematic approach to the analysis of source quality and integration for the NA estimation is given below:

(a) first, the weight specification of each aggregate is required. The weight is determined with reference to the total Resources and Uses, so that an order is given to the analysis of aggregates;

(b) then, accuracy, adequacy and integration are to be pointed out, with reference to sources used, and the aggregate share estimated for each source;

(c) lastly, as far the aggregates are concerned, it must be specified the adjustments made to improve the exhaustiveness degree and the outcome of data reconciliation procedure.

Table A.1 is suggested for (a): weights as percentage of the total amount of Resources and Use are to be added for the listed aggregates. Weights are calculated at current market price. The total of items is not necessarily equal to 100, since only the main items in the Resources and Use Account are listed.

Reference is to be made to **tables A.2 and A.3** for (b).

Tables A.2 and A.3 should be filled by economic activity branch (classification NACE Rev.1, even though more branches may be joined, the minimum number is seven macro-branches[3]), by aggregate, indicating the release (provisional or definitive) of the reference year. In

[2] For a more detailed discussion see Calzaroni (1998b).

[3] The definition of macro-branches is arbitrary, since it depends on the economic structure of each country; the following could be a classification hypothesis: 1) Agriculture; 2) Fuel and power products; 3) Manufactured products; 4) Buildings and Construction; 5) Trade and Hotels and catering services; 6) Transport and Communications; 7) Other Services.

this way a “NA quality archive” can be constructed, it allows to select information. Only the main sources (with a weight not less than 10% of the aggregate) should be separately recorded into the tables. Any other source is to be recorded under the item *OTHERS*.

A single table is to be filled if different branches have the same sources and information have the same importance. The branches are specified in the heading.

For **table A.2**, we must specify that.

Column (1) (*SOURCE*) records the source name followed by the specification of the producing Body.

Column (2) (*TYPE*) records the type of source, if it is the outcome of a statistical survey (sample or population), or if it is constructed to satisfy administrative or fiscal goals, or for any other reason.

Column (3) (*CHAR..*) records the characteristics of data: that is whether micro-data had been validated by their supplier, whether micro-data are still available, micro-data are being micro-edited by the NA Department, before their use, or, lastly, if only aggregate data are available.

Column (4) (*WEIGHT*) records the percentage of aggregate estimated with the source. The evaluation is to be made for the source domain and not for the aggregate domain. The evaluation should be neglected if it is an integrated source (see table A.3).

Column (5) (*ACCURACY*) for each source a judgement should be recorded using letters (a latter from A to E, indicating the following classification: A-very good, B-good, C-fairly good, D-sufficient, E-not sufficient); A indicates the best condition, that is when there is no actual difference between the source estimated value and the theoretical value; B a difference from 0 to 5%; C from 5 to 10%; D from 10 to 20%; E when difference exceeds 20%[4]. If a quantitative method was applied for the evaluation, the corresponding figure should be recorded. It should be underlined that accuracy includes all those aspects regarding the source coverage of its analysis domain.

Column (6) (*ADEQUACY*) describes the adequacy degree with ESA/SNA definition with the definitions and concepts adopted by the source. Adequacy is defined as “underestimate”, “correct estimate” and “overestimate”, descriptions are quite self-evident and evaluation is referred only to definitions and not to data accuracy. The definition “corrupted estimate” indicates that adequacy cannot be evaluated, even though the estimate is likely to be wrong.

Column (7) (*EVALU.CR.*) records how evaluations on the source were performed.

A description of headings in **table A.3** is given below.

Column (1) (*INTEGRATIONS*) records sources overlapping in the aggregate estimate, thus sources are integrated; source are recorded using codes (1-10) in table A.2 of the same aggregate and branch.

Column (2) (*AIMS*) records one or more aspects that were improved as a result of sources integration. Improvements are: a better coverage, a greater accuracy, a better timeliness (less time required to have informations), a greater plausibility (with reference to a comparative integration), or other aspects.

Column (3) (*INTEGR. METHOD.*) records information about integration procedures. The following cases are considered: micro-data integration through deterministic or probabilistic matching by one or more key variables, or integration at macro-datum level.

Column (4) (*PROCESSING*) records whether statistical models were applied or not to data resulting from source integration. Model were applied for equal distribution and/or interpolation, to estimate the aggregate.

Column (5) (*WEIGHT*) records an evaluation of the percentage of estimated aggregate. The informative basis is obtained from source integration. The aggregate domain is considered.

[4] Evaluations are to be made with reference to a 90% confidence level. This could be an unfavourable level for estimates obtained with quantitative methods, but is fit for “subjective” estimates.

Table A.4 is suggested for all those aspects connected with adjustments of aggregates, with exhaustiveness and balancing of estimates (in general meaning, not necessarily referred to the Stone method), namely (c) of the list at the beginning of this section. The table includes information about values before and after balancing, and other information concerning the incidence of adjustments made to improve estimate exhaustiveness, taking into account informal and underground economy.

Column (1) (*AGGREGATE*) records the name of aggregates (listed in table A.1).

Column (2) (*"PRE" DATA*) records the aggregate amount in the currency or in ECU, at current market price for the aggregate recorded in column (1), before data balancing.

Column (3) (*INTERMED. ADJ.*) records the percentage difference between the first and the last estimate of the aggregate "pre" data. This share is an expression of the incidence of the defining and re-defining procedure for the estimate, before the global balancing procedure, and it contains adjustments due to the incidence of "informal economy" and due to the incidence of "underground economy too.

Column (4) (*EXHAUSTIVENESS*) records the percentage share of "pre" estimate for the aggregate, due to adjustments made to assure the exhaustiveness of estimate. These adjustments are to be made after constructing the estimate.

Column (5) (*EXCEPT.*) records whether exhaustiveness adjustments were made after balancing and not before it, as it should be.

Column (6) (*RELIAB.EXHAUS.*) records the reliability level of integration made to assure exhaustiveness of the estimate. A judgement should be recorded using letters (a latter from A to E, indicating the following classification: A-very good, B-good, C-fairly good, D-sufficient, E-not sufficient); A indicates the best condition, that is when there is no actual difference between the estimated value of integration and the theoretical value; B a difference from 0 to 5%; C from 5 to 10%; D from 10 to 20%; E when difference exceeds 20%. If a quantitative method was applied for the evaluation, the corresponding figure should be recorded.

Column (7) (*"POST" DATA*) records the aggregate amount in the currency or in ECU, at current market price for the aggregate recorded in column (1), after data balancing.

Qualitative and quantitative elements to evaluate the EPNA elements are shown in the tables. Needless to say that evaluations based on quantitative methods are more reliable than evaluations based on subjective inferences.

Since the EPNA elements are non compatible, the total error of each aggregate can be calculated from evaluations recorded in the tables, using non complex functions

It's to stress that the estimate of total error relates to the levels of the variables involved; however, if the method used to compile NA for current years (not benchmark one) is based on growth rates, we have to take account of the errors in the benchmark estimates as well as errors on their grow rates for the estimate of total error.

Section D of this report shows an experiment for NA in Italy.

Table A.1 - Weight of Aggregates to the total Resources and Uses (current market prices)

Yearly National Accounts

YEAR : ....

COUNTRY: ....

BRANCH OF ECONOMIC ACTIVITY (NACE - Rev.1): ....

RELEASE: ***provisional |*** **|** ***definitive |*** **|**

		AMOUNT (1)	WEIGHT %
	PRODUCTION		
	INTERMEDIATE CONSUMPTION *VALUE ADDED*		
RESOURCES	IMPORTS		
	TOTAL		

	INTERNAL CONSUMPTION		
	HOUSEHOLD CONSUMPTION *P.A./P.S.I.CONSUMPTION*		
USES	GROSS FIXED CAPITAL FORM. CHANGES IN INVENTORIES EXPORTS		
	TOTAL		

(1) record the aggregate amount in the currency or ECU at current market price

Table A.3 - Integrations of Sources for each Aggregate

Yearly National Accounts

YEAR : ....

COUNTRY: ....

BRANCH/ES OF ECONOMIC ACTIVITY (NACE - Rev.1): ....

AGGREGATE: ....

RELEASE: ***provisional | |*** ***definitive | |***

INTEGRATIONS (1)	AIMS (2)	INTEGR. METHOD (3)	PROCESSING (4)	WEIGHT (5)

(1) codes for sources (1.-10.), described in table A.2, overlapping in the aggregate estimate

(2) record the aspect that was improved through integration (multiple choice is accepted):
(A) coverage, (B) accuracy, (C) timeliness, (D) plausibility - agreement or disagreement with other sources, (E) other

(3) record whether integration was made at micro-data level, through deterministic (A1) or probabilistic (A2) matching, by one or more key variables, or at macrodata level (B)

(4) record (YES/NOT) whether integrated data were applied statistical models or not. Models were applied for equal distribution and/or interpolation, to estimate the aggregate

(5) record an integer (from 1 to 100) to evaluate the aggregate percentage estimated with database given by integration of sources, with reference to aggregate domain

Table A.4 - Adjustments, Exhaustiveness and Balancing

Yearly National Accounts

YEAR : ....

COUNTRY: ....

BRANCH /ES OF ECONOMIC ACTIVITY (NACE - Rev.1): ....

RELEASE: ***provisional | |*** ***definitive | |***

AGGREGATE (1)	"PRE" DATA (2)	INTERM.ADJU. (3)	EXHAUSTIVENESS (4)	EXCEPT. (5)	RELIAB.EXHAUS. (6)	"POST" DATA (7)
A.						
B.						
C.						
D.						
E.						
F.						
G.						
H.						
I.						
L.						

(1) names of aggregates (as in table A.1)

(2) aggregate amount in the currency or in ECU, at current market price for the aggregate recorded in column (1), before balancing

(3) percentage difference between the first and the last "pre" estimate for the aggregate

(4) record the percentage share of "pre" estimate for the aggregate, due to adjustments made to assure exhaustiveness of estimate

(5) record with a tip whether adjustments were made after balancing

(6) record a judgement (A,B,C,D,E) about the reliability level of integration which was made for the exhaustiveness of "pre" estimate (see above)

(7) record the aggregate amount in the currency or in ECU at current market price for the aggregate recorded in column (1), after balancing

B - ANALYSIS AND COMPARISON OF SOME APPROACHES IN THE LITERATURE

1 - Introduction

The national accounts (NA) provide a schematic description of the economy of a country. The model is made up of a system of equations, or more simply of identities, which describe national economic activity as a whole over a period of a year. The identities derive from the application at macro level of the well-known accounting principle of double entry but also represent constraints of various types; besides the balance sheet identity, typically accounting in nature, they may actually describe equalities between estimates of totals and estimates of sums of individual addends, or derive from constraints of other types such as, for example, the availability of quantities by definition not affected by measuring errors.

Based on the double-entry principle, these relationships must be **consistent** with each other, in other words they must be satisfied simultaneously, and be **exhaustive**. As regards these aspects, it should be emphasised that all the accounting identities are defined on the basis of a reference economic model (normally Keynesian or Hicksian). This model is therefore made more realistic through a range of classifying models and methodologies (the "European system of integrated economic accounts", or ESA, in the case of the Italian national accounts), which identify the aggregates in an unambiguous and non-superimposable way, but not, unfortunately, for reasons which we shall see, their estimates[5]. In this section, however, we shall not deal with the issues concerning the exhaustiveness and representativeness of the national accounts model in macro-economic terms. For further explanation of the latter, the reader is referred to the copious existing bibliography (among others, Gnesutta, 1983, and Siesto, 1992). It is assumed, for the sake of simplicity, that this system of identities and constraints is "true", deterministic and accurately verifiable.

The empirical evidence shows that the initial estimates of the aggregates, obtained by the national accountants independently from one another, are not consistent with the system of identities which defines the accounts, due to the nature of the information available, which in practice differs as regards completeness, coherence and reliability, and that it is a complex matter to evaluate their accuracy in statistical terms, that is, expressed in the form of average quadratic error, or even better, of confidence range, whether due to the use of non-statistical sources or to the complexity of the methods of constructing the NA aggregates. We shall see later that this problem is not unambiguously resolved from the theoretical point of view in the literature, and that the data sources and estimating methodologies used to construct the accounts are many and varied.

The discrepancies in the accounts can be eliminated by a balancing operation, or squaring, so that the accounting constraints are met. The possibilities offered by the balancing operation in terms of the interpretation and analysis of the results, in particular by the comparison of the values of the variables before and after squaring, are seen by many authors as a valid tool for analysing the quality of the estimates. This obviously requires sufficient understanding of the problem of balancing from the standpoint both of its analytical formalisation as a problem of optimisation, and of its resolution. The first part of this chapter therefore looks at the question of balancing.

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[5] The methods of constructing and compiling the Italian annual accounting estimates, which were defined when the national economic accounts were overhauled by ISTAT in 1987, for annual sets from 1970, are illustrated in detail in ISTAT (1990).
For the aspects concerning the exhaustiveness of the estimates, refer to another work, edited by the Department of National Accounts and Economic Analysis (ISTAT, 1994), which contains the various integration typologies produced to obtain exhaustive estimates of the gross domestic product.

The methodology used by Stone is the best statistically and shows how the problems of balancing and of evaluating the accuracy of the NA aggregates are closely linked. Arkhipoff (1992d) simply points out that failing to acknowledge one problem means overlooking the other, with the consequence of dangerous oversimplification of the concept of "national economy".

The link between balancing and evaluation of the reliability of the accounts makes it advisable to look first at the balancing problem, both from the theoretical point of view, showing that Stone's solution is the best, and from the practical point of view, describing as an example the procedure currently adopted by ISTAT. We therefore discuss the methods currently used or described in the literature to quantify the margins of error in the accounting system variables (which are decisive in guaranteeing the efficiency of the balancing process) and, among these, in particular, the methodology proposed by Arkhipoff. This focuses on the geometrical and statistical aspects of balancing and also reports the results of an interesting simulation of the model based on the French national accounts and the approach suggested by the *Central Statistical Office* (CSO), now *Office for National Statistics*, based on a "mixed" strategy, which combines, in a general but organised manner, the various proposals previously submitted but which is not explicitly linked to the aspects ensuing from analysis of the balancing process.

2. Divergence and balancing of the national accounts

In mathematical terms, the national accounting system can be represented by the following system of n X_i variables in m equations (see Arkhipoff[6], 1992a and 1992d):

$$a_{11}X_1 + a_{12}X_2 + \dots\dots + a_{1n}X_n = 0$$
$$a_{21}X_1 + a_{22}X_2 + \dots\dots + a_{2n}X_n = 0$$
$$\dots\dots\dots\dots\dots\dots$$
$$a_{m1}X_1 + a_{m2}X_2 + \dots\dots + a_{mn}X_n = 0$$

The X_i variables represent the economic aggregates, while the equations, which describe the accounting constraints of the national accounts, are assumed to be linear and independent. In general, there are many more variables than there are equations (i.e. $m \ll n$).

It will be more convenient, from now onwards, to express this system in terms of a matrix:

$$AX = 0$$

where A is the matrix, assumed to be of the highest rank, of m rows and n columns, of the parameters linking the aggregates, represented by the vector X, of n elements, and 0 is the vector made up of m null values[7].

Geometrically, the vector of the "true" X aggregates is, in the space R^n, a point in the sub-space C defined by the above-mentioned linear system and passing through the origin. The sub-space C consists of *all the admissible, and therefore coherent, values*. In fact, the availability of data sources of various types (statistical, administrative and accounting), which vary in

[6] Oleg Arkhipoff, of the *Institut National de la Statistique et des Etudes Economiques* (INSEE), the author of many works on national accounting, several of which, as we shall see, focus on the problem of evaluating the reliability of the national accounts, has constantly directed attention to the mathematical formalisation and balancing of the system of national accounts.

[7] A vector of known null terms is defined to simplify the expressions in the formula, which nevertheless remain valid, with the appropriate adjustments, even for the system GX = h, where h is the vector of elements which are not all null.

completeness, reliability and coherence, even in concept, the non-availability of information controlled by certain variables, and the use of different methods of recording, estimation and aggregation, imply that the system of accounts as a whole may not be coherent, due to the conflict generated within each equation and between several equations (and, therefore, may not belong to the sub-space C)[8].

The difficulties which arise in finding estimates which respect the constraints of the accounting system, as well as those associated with the analysis and treatment of discrepancies, are linked to the way in which the data are collected in the field, which *does not allow repeated measurements of a given magnitude*. In some cases, using standard techniques, it is possible to estimate the sampling error of statistics extracted from random samples. It is however necessary to take account also of the existence of non-sampling errors and, in the case of non-statistical sources, the error will have to be estimated using other techniques.

The impossibility, in short, of having a Bernoullian sample of observations for each variable makes it advisable, according to Arkhipoff, to set the methods of evaluating the reliability of the national accounts in a conceptual context of the Bayesian type (without, however, wishing to regard this as a limitation).

In general, therefore, the vector X*, the estimate of X, will be non-coherent and outside the sub-space C. The coherence of the national accounting system is however obtained retrospectively by means of a **balancing** operation: the X* estimates (the final ones made by the person who produces these estimates) of the "true", but unknown, X aggregates are adjusted so that the new X** values are coherent; in other words, they satisfy the system of equations, and are also the "best" solutions possible with respect to a defined optimality criterion. Geometrically, X**, a vector passing through the origin, corresponds to the space R^n at a point M**, which belongs to the sub-space C. This adjustment procedure may be seen as an application of R^n to C (Arkhipoff, 1992d):

$$X^{**} = B(X^{*})$$

where B indicates a given mathematical balancing method[9].

Resolution of the matrix equation $AX^{**}=0$ gives a general formula valid for any method of balancing B. This general solution is equal to $X^{**}=(I-A^{-}A)U$ where A^{-} is an inverse generalisation of A (so that $AA^{-}A=I$) and U is an arbitrary vector of R^n, both deriving from the vector of the initial input data.

Arkhipoff (1992d) points out the importance of these balancing methods, known as **projective methods**, which are characterised by an even more immediate solution of the type:

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[8] It should be explained that this coherence will not be guaranteed even by the availability of a set of very accurate estimates, due to the aspects of conformity concerning the same aggregates at the micro-measurement level (this is a problem well known to all statisticians and econometrists). Even in the case of statistical surveys, where control of these factors is better, the units of measurement are often different from the units of analysis used in the ESA. As we shall see shortly, when dealing with the problem of estimating reliability, these factors may even lead to a conflict between coherence and accuracy.
The **discrepancies** within and between the equations of the national accounts system may therefore depend on causes which are not strictly statistical in nature, that is, they are not associated with measurement error. The effects of such causes, however, cannot be completely eliminated.

[9] The operation of balancing the accounts can also be performed manually, by reducing to zero the discrepancies not provided for in the accounts model used, by modifying the values of certain variables one or more times, on the advice of the person constructing the estimates, until the coherence of the system is assured. This approach, which is actually used even more widely, has not been described in this document because, in our view, being very practical and not easily formalised, it is of little use in defining a general and, if possible, statistical/mathematical method of evaluating the reliability of national accounts.

$X^{**}=(I-A^{-}A)X^{*}$.

The projective methods have interesting properties and are so called because they are, in fact, projections of the point M* (which represents X* in the space R^n) to the sub-space C. From this, a particularly simple geometric interpretation is derived, in that it is shown that the sub-space C is none other than the co-domain of the projector B. The projective methods are linear in X* and are equal to $X^{**}=B(X^{*})=X^{*}$ when $AX^{*}=0$. Finally, defining the **deviation vector** with $E=X^{*}-X^{**}$, it is equal to $A^{-}AX^{*}$ and we have:

$$\min N(E)=\min_{A^{-}} N(A^{-}AX^{*})$$

whatever the N distance function used.

If the function is equal to $N(X^{*})=X^{*\prime}GX^{*}$, where G is an *n* order positive defined symmetrical square matrix, the length function becomes a norm defined by an internal product and the existence of a single solution, given by the following expression, is assured:

$$X^{**}=B_G(X^{*})=(I-G^{-1}A'(AG^{-1}A')^{-1}A)X^{*}$$

If G = I, the norm becomes spherical and is none other than the Euclidean length of a vector ($\|X^{*}\|^2=X_1^2+...+X_n^2$). In this case, the solving formula is simplified as:

$$X^{**}=B_I(X^{*})=(I-A'(AA')^{-1}A)X^{*}$$

where $A'(AA')^{-1}$ is the so-called Moore-Penrose inverse (for the properties of this matrix refer to Arkhipoff, 1993a).

If [$G=V^{*-1}$, where $V^{*}=Var(X^{*})=E((X^{*}-E(X^{*}))(X^{*}-E(X^{*}))')$ is the **covariance matrix** of the X* estimates, assumed to be correct, we obtain, through the **balanced vector**, the expression:

$$X^{**}=B_{GM}(X^{*})=(I-V^{*}A'(AV^{*}A')^{-1}A)X^{*} \qquad [1]$$

The solution coincides with that obtained by Stone (1942)[10], and in essence consists of a geometrical application of the least squares method to the system of equations of the national accounts, with C fixed and m less than n.

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[10] Stone's method, which thus belongs to the class of projective methods, was described for the first time in 1942 with the explicit aim of reconciling accounting discrepancies (see Stone, Champernowne, Meade, 1942, an article which is "historic" and also remarkable for the clear, analytical manner in which the logical and statistical limits inherent in the definitions of basic sizes and national accounting aggregates are shown; these fundamental problems, as we shall see, were taken up by the UK Central Statistical Office when tackling the problem of defining a model to evaluate the reliability of the national accounts).
Stone's method, in use for many years after publication of the above-mentioned article, was taken up and developed by other researchers and a substantial number of works have been published on the topic. Among these, we should mention Byron (1978), van der Ploeg (1982), Barker, van der Ploeg, Weale (1984), Keuning, Ruijter (1988).
The heavy computational requirements of the method and the limited availability of efficient algorithms, with the consequent problems of implementation on computers of significantly less power than those available today, prevented immediate application of the method, resulting in the long period of "oblivion".

The variables vector does not however constitute a sample of n observations relating to the same magnitude, but a single n-dimensional observation, the **corrected** estimate of a random vector with an average value of E(X*) and covariance matrix V* (in other words, E(X*) = X, if X is the vector of the "true values"). For these reasons, the method is also known as the **Gauss-Markov balancing method**, applying the well-known Gauss-Markov theorem.

In Arkhipoff (1992d) the **optimal character** of the Stone balancing method from amongst all the projective methods is demonstrated, and it is observed how it satisfies the reasonable and not unimportant principle whereby, having better base statistics, it also improves the quality of the national accounts. Baxter (1992) notes that the Stone method adjusts the variables in proportion to the variances and the constraints. If there were only one constraint with coefficients of + 1 and -1, and no correlation between the variables, the size of the immediate adjustment of each variable would be proportional to its variance. The actual situation is, however, more complex, and different constraints could, overall, tend to modify a variable in opposite directions, with the ultimate consequence of having some variables, in reality estimated inaccurately, not modified in proportion to their variance.

The fact that X* is a random variable allows the "true value" of the aggregates of the national accounts to be defined as the expected value of this vector, belonging to sub-space C. According to Arkhipoff, a definition of "true value" is necessary to address the problem of evaluating the error in the estimates of the aggregates. From the practical point of view, to arrive at quantitative evaluations of the accuracy of these estimates, it is necessary to refer to the problem of the balancing of accounts, a problem which consists of finding the best X** estimator of X = E(X*).

According to Arkhipoff, the random nature of the accounting aggregates justifies speaking of the *average* coherence of the national accounts (see Arkhipoff, 1993b; the document also contains other observations and some criticisms concerning Stone’s ideas regarding representativeness - even in the absence of errors in definition and observation -, coherence and balancing the national accounts, and a complete bibliographic review of these topics).

The formula giving the balanced vector, to be regarded therefore as an estimator in a broad sense, was actually discovered by Stone (1990) in another way, namely in a way which, depending on the constraints of the accounting system, maximised the *a posteriori* probability density function of X, starting from the model X* = X + a, where a is the random vector of the errors, distributed as a normal N(0,V*). Stone assumed, in fact, that X had *a priori* a normal, multivariate distribution and that the matrix of the X* covariances was known. In any case, if the weightings with which V is constructed are correct, the accounts balanced with Stone’s method are the correct linear minimum variance estimates of the "true" accounts[11].

Byron (1978) actually arrived at the same result by resolving the Lagrangian problem of minimising the associated quadratic loss function $1/2(X^{**}-X^{*})'V^{*-1}(X^{**}-X^{*})-\lambda' AX^{**}$ where λ is the Lagrange multipliers vector, with advantages from the computational point of view deriving from the possibility of applying more efficient resolving algorithms, such as the conjugated gradient algorithm (see Antonello, 1990). According to Byron, the introduction of a loss function allows the balancing results to be interpreted more accurately.

Besides being balanced the estimates extracted using the Stone method are also more accurate than the initial ones, if a corrected covariance matrix is used. In fact, for the covariance matrix of the aggregated estimates, the following result is derived from the properties of the least squares method:

$$V^{**} = (I - V^{*}A'(AV^{*}A')^{-1}A)V^{*}$$

[11] The assumption of normality for the error implies that the estimator X** coincides with that obtained by applying the method of maximum probability.

As $V^*A'(AV^*A')^{-1}AV^*$ is a positive semi-defined matrix, the *ex post* covariance matrix V** is not greater than the *ex ante* one V*. The reduction in the estimate variances produced by the balancing operation is greater the smaller the matrix (AV^*A'), which is none other than the matrix of the discrepancy variances, in turn linked to V*. This result is a major point in favour of the Stone method, which is already important as it provides values which are coherent with each other.

The improvement in the estimates in terms of efficiency is due to the additional information contributed through the observance of accounting constraints by the system variables. However (Weale, 1985), if the uncorrected matrix *V'* is used instead of the corrected covariance matrix V*, the *ex post* variances matrix will actually be equal to:

$$V'' = (I - V'A'(A V'A')^{-1}A)V^*(I - V'A'(A V'A')^{-1}A)'$$

Thus, even with balanced and corrected X** estimates, the *ex post* covariance matrix would not necessarily have elements with lower values than those in the matrix used for the balancing operation. All this confirms how important it is to evaluate as accurately as possible the *ex ante* covariance matrix, this being a decisive factor in guaranteeing the optimal nature of the Stone balancing method.

In any case, the fact that it is possible to get an indication of the accuracy of the NA data is important, as this allows computation of the matrix of balanced value variances, something which is not actually permitted by a manual adjustment of the estimates.

Baxter of the UK Central Statistical Office, in a 1992 article containing the results obtained by the experimental application of the Stone method to the UK national accounts for the period 1988-1991, points out that it is legitimate to expect from the balancing operation a greater modification for the variables estimated with greater uncertainty or for those characterised by deficiencies in the cover, and also that the reduction of the total error, applicable to all the NA model variables, is a consequence of the additional information contributed by imposing the condition that the accounting constraints be satisfied at least once by each variable.

An original "bootstrap" type variant of the Stone method was proposed by Chaumont (1991) (see also Arkhipoff, 1992c, for further explanation and a formal description of the method). In general terms, the method consists of balancing a table of n aggregates and m independent equations (AX*=0) one step at a time, selecting on each pass n-m aggregates as exogenous and without error, and calculating the remaining, unknown aggregates by means of the accounting equations. The number N of possible combinations (there might be no solution, or more than one) is less than or equal to the total number of the combinations of n x m x m elements and is therefore very large, so that, finally, the average of the n solutions is calculated to obtain the balanced value.

The possible solutions are represented in the vectorial space R^n by a cloud of points situated in the linear range of the system of accounting equations. This cloud of points is obtained from a single point, corresponding to the observed values, by means of a procedure which is similar to the *statistical bootstrap* procedure and converts the Bayes problem into a classic statistical one. Among all these points there is, therefore, the point relating to the centre of gravity of the cloud, in other words the average point, to which may be given, by definition, the meaning of "absolute" value.

In fact, the method becomes unmanageable as n becomes large: for this reason, it may be stopped after calculating a limited number of specific combinations, which are deemed more useful because they relate only to a few large aggregates[12].

[12] Chaumont had suggested using the Moore-Penrose pseudo-inverse, to extract an approximate solution directly for the average point without actually constructing the cloud, but without justifying the use of this method (which, according to Arkhipoff, is impossible to do given the complexity of the formulae and the fact that, in general, the existence or uniqueness of the solution is not certain, which leaves open the question of the existence of another method of finding an approximate solution which is simpler than an accurate one).

The Chaumont method is again of the projective type: in particular, it is linear in X* and such that B(X*) = X* whenever AX* = 0.

The adjustment produced by the balancing operations described so far is made using estimates of the aggregates, variances and covariances referred to a given calendar year, and does not therefore take into account the possible dependences existing between estimates relating to different periods (among other things, the Stone method requires that the given measurement errors are not correlated with the true values of the variables). In fact, as shown by Stone himself at a seminar held at ISTAT in September 1988 (Stone, 1990), this simplification is strictly justified only if the auto-correlations in the errors are the same for each variable. Only on the basis of this assumption is it correct to take into account in the balancing operation only the observations made for the reference year.

Nevertheless, when applied to the UK national accounts between 1969 and 1979 (Stone, 1984), the separate treatment of each year produced plausible results, supporting the idea that, in practice, serial correlation might not be a serious problem in adjusting the estimates. For this reason, the assumptions of chance error and temporal independence can be accepted, substantially simplifying the solution of the balancing operation and analysis of the reliability of the national accounts.

Auto-correlation of errors could, in any case, be dealt with by means of econometric models which define the type of connection between the remainders (it is normally sufficient to take into account an auto-correlation of the first order)[13]. The balancing of a system of annual estimates which has "memory", with additional constraints relating to temporal relationships between the variables, could prove useful, from both the statistical and the financial standpoint. It would, in fact, allow the temporal links between certain variables and flows of a financial nature, such as dividends, interest paid and interest rates, to be explicitly considered[14].

Another important and complex problem is that of balancing quantities expressed at **constant prices** (until now, it has been implicitly assumed that the aggregates are evaluated at current prices). For a treatment of the problem, which involves the introduction of non-linear relationships between the variables due to the use of deflators, see Antonello (1990b) and Stone himself (1990). Weale too (1988) proposed a method for solving the problem of the simultaneous adjustment of prices and volume and value data. Briefly, the method consists of defining approximations for the non-linear constraints (in fact, a series of logarithmically derived linearisations of the account components from the point of view of expenditure) to allow application of the Stone technique, and actually designed to balance linear systems. Application of the Weale method requires a numerical estimate of the reliability of the data, in terms of average squared deviations, of the size of the covariances between the data derived from the relationship between

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[13]Among other things, Stone (1990) examines the consequences of adopting assumptions regarding estimate errors which are more complex than the assumption of independence.

[14]A solution to this problem is suggested by M.A.Baxter of the CSO, 1992, in the article cited relating to the application of the Stone method to the UK national accounts for the period 1988-91.
Antonello (1990a), on the other hand, had been interested in the problem of balancing a series of annual economic accounts, with errors characterised by a series of systematic components, independent of time, by a series of components which vary in proportion to the values assumed by certain exogenous variables (for example, error components connected to cycles or trends), and finally, by a series of chance components, assuming however that the various error components are independent of each other, and in the more intractable problem which arises when it is assumed that the errors are also partly generated by auto-regressive processes. Still on the subject of balancing a series of annual economic accounts, a subsequent work, again by Antonello (1994), submitted at the *International Conference in memory of Sir Richard Stone*, Pontignano, 17-20 October 1993, concerned analysis of the theoretical bases of the Stone method and the econometric modelling of national accounting variables, using certain assumptions concerning the distribution of measurement errors.

volumes, values and prices and, finally, of the fraction of volumetric estimates obtained directly without deflating.

Non-linear constraints do not derive solely from the processing of quantities at constant prices, but may also stem from a precise knowledge of the values of certain relationships between the flows which make up the system, such as the aliquots of indirect tax collection, commercial margins, transport margins, and so on.

It should be mentioned, however, that the specification of incorrect accounting constraints introduces distortions into the estimates following the balancing operation. Nevertheless, since the constraints of the model are given by accounting identities, from this point of view, incorrect constraints may be introduced by, for example, mistakenly making the value of some variables equal to zero (Byron, 1978).

For balancing the national accounts at current prices, ISTAT uses the Stone method, while balancing at constant prices is carried out in a second stage, using the balanced estimates at current prices, which are deflated using the appropriate price indices and are therefore corrected to ensure the coherence of the system.

In the case of totals of known system variables having greater accuracy than each addend, a new variable equal to this total is generally added to the system, giving it a low margin of error, and an additional constraint relating to this total. This approach is also suggested by the CSO[15].

Actually, the method used by ISTAT is an adaptation to the Italian model of the one originally proposed by Stone, and consists of a procedure which combines a purely subjective method of finding and correcting errors with a more sophisticated approach which reveals the disequilibria in the accounts by distributing the remainders between the aggregates on the basis of the weighting of the aggregates and of all the available information on the estimate methodologies (for example, degree of cover, use of proxies, etc.), which is summarised by the covariance matrix V in the manner shown below in section 4.3 (for further details refer to Mamberti Pedullà, 1994).

The Stone method was used by ISTAT for the first time in constructing the system of annual national accounts on the occasion of the revision and reconstruction of the national economic accounts, carried out in 1987, for the series from 1980 (cf. ISTAT, 1990), and in 1988, for the years 1970-79. The calculation methods used and the main results obtained from the revision for the years 1970-79, which was in any case coherent with that for the 1980s, are described in the work of Giovannini (1988). In particular, an advanced balancing technique was adopted within an input-output model of the estimates relating to the formation of resources and their use.

The estimates were actually constructed by an iterative process, consisting of the following phases:

- initial estimates;
- assembly of the annual input-output table;
- analysis of the discrepancies;
- revision of the initial estimates (repeated together with the previous phase until it is no longer possible to refine the initial estimates further);
- balancing of the input-output table, with redistribution of the remainders within the whole matrix on the basis of weightings derived as a function of the variances associated with each estimate.

Giovannini’s work shows the deviations introduced by the balancing operation into the initial estimates of the resources and uses account. For the GDP in particular, except in 1971, the corrections turned out to be less than 1%.

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[15]Another method, suggested by the CSO, of representing greater accuracy of the sum of two variables compared with each of them separately, is to add a negative covariance between them in the error covariance matrix. In the event, then, that the uncertainty in both variables is mainly due to a third variable added to one and subtracted from the other, an equal margin of error and a covariance equivalent to a correlation of -1 is assigned to the two variables.

From the balanced estimates of the various components of the input-output table, and then from those of the resources and uses account, the individual evaluations were then deflated. In particular, for calculation of the value added at constant prices, which represents the most complex stage of the deflation process, the so-called "double deflation" method was used: the value added at constant prices is obtained by separate deflation of the estimates of production and costs at current prices[16].

3. Methods for defining the margins of error of the variables

In the previous section we saw how the vector of the balanced estimates is given by a series of products and inversions of matrices, including the variance and covariance matrix V^*. Actually, the expression of the Stone estimator shows that the solution is determined by the relative dimension of the elements of V^* and not by their absolute value and, furthermore, that the result is not changed by multiplying the covariance matrix by a scalar quantity (Weale, 1988).

The matrix V^* becomes diagonal if the economic accounts system is related to a specified time period (normally, a calendar year) and if the estimates of the elements of the economic accounts matrix are independent of each other (see Antonello, 1990a). From the geometrical point of view, V^* is the positive, semi-defined, symmetrical *n* order square matrix, which constitutes the metrics of the space R^n with respect to which a length function, equal to an internal product, is defined.

Estimating the matrix V^* is in fact a major problem in balancing the national accounts. Until now, the Stone method has been applied to the NA real data, with the aim of producing "official" data (as in the case of ISTAT) or of testing and verification (as in the case of the CSO), normally by defining the elements of the matrix V^* on the basis of subjective evaluations of the accuracy of the variables.

In this case, it is correct to speak of margins of error in the estimates rather than variances. These parameters, analogous in significance to average quadratic deviations, may be assumed to be equal to the product of the value of the estimate of the variable and a **coefficient of reliability** r_i^*, between 0 and 1, expressing the evaluation of the quality and reliability of sources used to extract the estimates. Indicating these margins by dx_i^*, we obtain, therefore:

$$dx_i^* = r_i^* X_i^*$$

The margin dx_i^* is intuitively linked to the interval T_i^*, constructed around X_i^* with a size of $\pm dx_i^*$, or, if asymmetric, a maximum size of $2dx_i^*$; this interval contains the "true" value of X_i^*. The margin of error dx_i^*, or **absolute error**, associated with each estimate X_i^*, is a quantity which is always strictly positive, owing to the statistical nature of each measurement.

These margins of error provide information which is only indicative of the accuracy of the estimates, especially in the case of variables distributed asymmetrically.

With these margins, it may be assumed for the variances that:

[16] Refer to Giovannini (1988) for an explanation of how a coherent set of output and input prices was obtained, and to Picozzi (1987) for the way in which the intermediate total costs were deflated.

$v_i^* = dx_i^{*2} = (r_i^* X_i^*)^2$

However, when Stone (1987) compared these variances with the sizes of the adjustments to the initial estimates, equal to $a_j^* = X_j^{**} - X_j^*$ and considered to be of the same order of magnitude as the variances, he found these quantities to be overestimated by the UK national accounts from 1969 to 1979.

The overestimate is corrected by considering a coefficient α which is equal to the sum of the squares of the standardised adjustments (or remainders), divided by the number of the degrees of freedom:

$$\alpha = (n - m - 1)^{-1} \sum_j (a_j^{*2} v_j^{*-1})$$

The assumption of independence of the initial estimates in fact implies, for the sum of the squares of the standardised adjustments, a distribution χ^2 with n-m-1 degrees of freedom. The number of the degrees of freedom therefore constitutes the value having a probability which will not be exceeded by the χ^2 value and therefore represents the appropriate coefficient with which to divide this sum. In this way, the covariance matrix is corrected by:

$$\tilde{V}^* = \alpha V^*$$

and this correction is also valid for the covariance matrix of the final estimates.

The subjective estimate of V^* may be influenced by the arbitrary nature of the method and, among other things, may not allow the attribution of accuracy information to variables not measured directly. In such cases, nevertheless, the variance could be considered as the sum of the variances of the variables used in determining the variable in question. The subjective method bases its validity on the assumption, which is plausible but not demonstrable, that the errors in the margins are less important than the errors in the aggregates and from this standpoint it is preferable to give an estimate, although only indicative and rough, of the margin of error, rather than no indication of the limits of uncertainty.

Applying the Stone method, ISTAT balances the estimates at current prices using a matrix of coefficients of reliability defined subjectively, on the basis of the evaluation of the reliability of the sources of data used (for example, a null coefficient is assigned to data coming from administrative sources and selected for error-free construction).

Furthermore, the matrix is assumed to be diagonal, on the assumption that the estimates of the X variables are independent. To limit the negative effects deriving from possible inaccuracies in these coefficients, the balancing operation is normally repeated several times in the event of implausible results, with revision, where appropriate, of the value previously assigned to the coefficients.

For a quantitative evaluation of the accuracy of the NA estimates another method has also been proposed and used, based on **analysis of the data revisions**, with the NA estimates for a given year being revised for several years (three in the Italian case) before arriving at the final figures, which take into account the maximum informational content, in terms of completeness and reliability, of the sources used. This approach, which offers good qualities of objectivity, constitutes one of the stages of the work programme prepared by the CSO with the aim of producing numerical estimates of the margins of error of the main components of the national accounts (CSO, 1992). We shall look at this programme in detail later.

The advantages of the analysis of the revisions are its applicability to each section of the accounts and its ease of interpretation, in particular when the aim of the analysis is to identify and evaluate the distortion of the initial estimates. Its major defect is that overall it provides a biased view of the errors of the initial estimates. It is, in fact, dangerous to evaluate the size of the total error from the final revision, since the last estimate produced, which represents the definitive estimate of the aggregate, is still affected by measurement errors.

An econometric method, proposed by Weale (1985) for evaluating the reliability of the estimates, is based on analysis of the data revisions (the main theme of the work was actually the relationship between the problem of the balancing operation and verification of linear assumptions for the model of the national accounts). This method can be more accurate than the subjective method, although it is not always entirely satisfactory. Indeed, the fact that some variables are never revised or are revised only to a limited extent, does not necessarily mean that they are accurate, but may depend on the inadequate quantity and/or quality of other sources of information, compared with those used for the provisional estimate[17].

Subsequently, Weale (1992) also proposed a method for extracting the estimate of data affected by measurement errors and subject to linear constraints (as in the case of the national accounts), without it being necessary to know the covariance matrix of the estimates. The proposed estimator can be used by preparing a set of observations; this is in practice calculated from the variances and covariances of the historic series of the non-coherent observations, and has the virtue of coming close to Stone’s in terms of probability. The use of the variance of the historic series is justified by regarding the accounting constraints as capable of removing the "noise" component, relating to measurement error alone, from natural variability (on the assumption, however, that the measurement errors are independent both of the true data and of each other).

In practice, the covariance matrix of the set of non-adjusted data is used as the maximum probability estimate of V. Post-multiplying this matrix by the matrix of constraints, we obtain the covariance matrix of measurement error alone. Thus, even if it is not possible to estimate V directly, an estimate of VA' is sufficient to balance the accounts (for the analytical details and demonstrations of the correctness of the method, which remains valid even in the case of auto-correlation in the errors, refer to Weale’s article).

The applicability of the method, which is characterised by notable statistical and mathematical qualities, is nevertheless, in our opinion, restricted to the availability of series which satisfy the required assumptions.

Another problem which may influence the results of the balancing operation is the presence of a number of unknown variables (that is, for which there is no estimate). This number is normally less than or equal to that of the linearly independent constraints. In this respect, Byron (1978) suggests approximating the solution of the system of economic accounts by assigning a null value

[17] Refer to this article for a description of the method, which, although originally designed for quarterly series, could, at least from the formal point of view, be adapted for annual accounts, but with results to be evaluated with care. As our purpose is to consider the problem of evaluating the quality of the national account estimates by reference to the annual accounts alone, we think it advisable, for the moment, not to mention other interesting methodologies of analysis proposed explicitly for the quarterly accounts. These methodologies are, however, to a considerable extent linked to the analysis of the quarterly historical series of national accounts and in particular to the analysis of the revisions of the estimates, in order to exploit fully the greater quantity of data available compared with the annual series.
In this respect, we should mention, among others, the works of Young (1987) and Hirsch, Mann (1993), of the *Bureau of Economic Analysis*, respectively on the topics of the reliability of the GDP and of the quarterly estimates of international transactions, and those of Pisani and Savio (1993), on the revisions of the ISTAT quarterly GDP from the second half of the 1980s, and of Pisani, Savio and Di Fonzo (1994). In the last mentioned work, the methodology proposed in Pisani and Savio (1993) is extended to analysis of the revisions of the aggregates of the quarterly economic account at current and constant prices and all the occasional revisions of the early 1980s are considered.

and a very high variance to these variables and thus solving the whole system simultaneously for the direct observations and the unknowns.

A more general solution to this problem, suggested by Barker, van der Ploeg, Weale (1984), consists of using some of the accounting constraints to obtain explicit expressions for some of the unknown variables as a function of the known variables. This solution suggests the following identification condition: the number of unknown variables must not exceed the total number of linearly independent constraints, since the identification of each unknown variable requires the elimination of a different accounting constraint. The article includes a formal description of the method, which in practice is an adaptation of the conditional least squares technique proposed by Stone, which takes explicit account of the problem of the non-measured variables. The same authors, nevertheless, admit the heavy computational requirements of the method, and consider the solution proposed by Byron, even if it is not completely accurate, more efficient from the computational point of view.

4. Connection between coherence, balancing and reliability

Stone's methodology illustrates the connection between the problem of balancing and that of evaluating the accuracy of the NA aggregates. In his work cited above (1992d), Arkhipoff points out directly that failing to acknowledge one problem means overlooking the other, with the consequence of a dangerous oversimplification of the concept of "national economy". The idea, which is both simple and ingenious, from which Arkhipoff started, is that, since the condition of coherence of the national accounts raises the quality of the estimates of the variables, in the same way there is no reason why it should not have a similar effect on the estimates of the margins of error. An example in the field of physics, quoted by Arkhipoff, helps to explain this concept.

The existence of a law $y=f(x)$ implies the use of the formula $dy=fx'dx$ for errors. From the practical point of view, if we have sufficiently accurate measurements for x and y, with margins of error Dx and Dy, the true values sought fall within the intervals x±Dx and y±Dy. Furthermore, Dx and Dy are mutually compatible, in the sense that the relationship $Dy=fx'Dx$ is approximately valid; in other words, the two intervals $f(x)\pm fx'Dx$ and y±Dy are more or less coincident. The interval y±Dy can therefore be calculated from x and Dx through the function f[18].

Arkhipoff appears to have been right, therefore, to consider first of all the problem of the balancing operation and to investigate thoroughly its theoretical and practical aspects, before looking more closely at the problem of reliability, using a logical order which we also wish to follow in this document.

In short, in the process of constructing the national accounts on behalf of INSEE, the balancing operation and the quantitative evaluation of the reliability of the national account aggregates, which are actually regarded as inseparable and interdependent phases of the process, both carry considerable weighting.

Regarding the problem of the reliability of the accounts, Arkhipoff has proposed a **stochastic model**, with which it is possible to define a set of numeric indicators which measure the overall reliability of the national accounts (see Arkhipoff, 1992a, 1992b, 1992d and 1993b).

[18] The comparison with physics should not be surprising when one thinks that physicists were the first to deal with the problem of squaring, in relation to the *problem of establishing coherent values for fundamental constants*, such as the speed of light, Planck's constant, the mass and charge of the electron, and so on (cf. Arkhipoff, ANA, 1993a). It must be said, however, that while accounting constraints are regarded by definition as being true when dealing with accounting identities, physicists do not so view the relationships linking the physical constants.

Let X^{**}=B(X^*) be the vector obtained by applying the given balancing method *B*. Following the squaring operation a mistake will, however, have been made, given in geometric terms by the vector $\vec{\overline{X}M}^{**}$ (it will be remembered that M^* and M^{**} are taken to be the points of the space R^n corresponding, respectively, to X^*, estimates of the aggregates X, and X^{**}), with a length $XM^{**}=N(\vec{\overline{X}M}^{**})$. As X is unknown, this quantity, which measures the distance of the solution from the "true" value X, obviously cannot be calculated, let alone a first immediate total reliability index, given by the relationship/ratio XM^{**}/OM^* (interpretable as relative error of a random variable, if XM^{**} is seen as an absolute error of the variable X^* and O is the origin of the axes).

The triangular inequality $XM^{**} \leq XM^*+M^*M^{**}$, satisfied by hypothesis from N(.), nevertheless allows the following index to be defined:

$$XM^*/OM^*+M^*M^{**}/OM^*$$

This index still gives a measurement of overall reliability, although it is obviously overestimated as compared with the actual error made, XM^{**}/OM^*. The quantity XM^* is still unknown, but with due caution, we can state, by definition, that $XM^*=dM^*$. This is equivalent to supposing that $|x_i^*-x_i^{**}|=dx_i^*$ for each i (in practice, it is assumed that the true value of x is always in the interval $x_i^* \pm dx_i^*$ and, furthermore, that the least favourable case always occurs, that is, that x_i is always at the maximum distance dx_i^* from x_i^*).

We may therefore define the following **index π of the overall reliability of the national accounts**:

$$\pi = dM^*/OM^*+M^*M^{**}/OM^*$$

The addends of π are, in turn, further indices:

$$\rho_0 = dM^*/OM^*$$

is an index which expresses the **"gross" overall accuracy** (that is, before balancing, as it concerns only non-balanced data and the margins of error assigned to them);

$$\rho_1 = M^*M^{**}/OM^*$$

is known as the **model adequacy index**, because it measures the greater or lesser adequacy of the pre-squaring values for the national accounting coherence model (on the assumption that the margins of error have been correctly assigned, ρ_1 contains everything which depends on the system of accounting constraints and which affects both the values of the variables and the margins of error assigned to them).

The relationship between these two indices is known as the **overall refinement index**:

$$\varphi = \rho_1/\rho_0 = M^*M^{**}/ dM^*$$

which is an aggregation of the refinement coefficients of the individual aggregates (we shall presently discuss variables outside the specification limits) and is linked to that of reliability by the following relationship:

$\pi = \rho_0 + \rho_1 = \rho_0 (1 + \varphi)$

The validity of the assumption of coherence of the accounting constraints requires that, in practice, ρ_1 is much smaller than ρ_0, in other words, that φ is much less than unity. If it were, therefore, to result in a value of ρ_1 which is too large with respect to ρ_0, the validity of the actual NA model used would have to be questioned from the point of view of its internal coherence.

The index π meets the usual expectations of increased overall reliability of the national accounts as the accuracy of the basic data increases, and of increased overall accuracy as the coherence of the input vector X^* increases. It should be observed, nevertheless, that the gross accuracy index and the model adequacy index may conflict with each other if a certain value is given for π, namely the sum of the two. The existence, in practice, of a kind of discordance between accuracy and coherence is a fact well known to national accountants. This paradox actually arises out of looking at the estimate errors as the sole causes of the incoherence of the national accounting system. We should not, however, overlook as a potential source of error the use of variables defined inappropriately or non-exhaustively in terms of the requirements of the SNA (the aspect of the exhaustiveness of the estimates is in fact one of the problems of adequacy and is only touched on here, since it requires an in-depth economic and statistical investigation, which is outside the scope of this work). In this case, the balancing operation could lead to disappointing results even with perfect measurements.

For each of the individual aggregates the following **coefficient of refinement** may be defined:

$r_i = |X_i^* - X_i^{**}| / dx_i^*$ for each i=1,2,...,n

If, and only if, this coefficient is strictly greater than 1, X_i is called the **variable outside the limits of specification** or, more briefly, the **OLS variable**. An OLS variable must be regarded as a potentially abnormal estimate, as it is considered that the "true" value falls within the limits of the margin of error.

Geometrically, the fact that one or more variables are outside the limits of specification means that the *n*-dimensional parallelepiped, centred on X^* and with sides of length $2dx_i^*$, has an empty intersection with C, the sub-space of the admissible values, due to inconsistencies between the adjustment made by the balancing operation and the margin of error of the variable.

In practice, these inconsistencies can occur more readily with observations characterised by a high degree of accuracy, as the margin in this case is very narrow, and it is, nevertheless, quite likely that some balanced aggregates will fall outside its specification limits (we may define the number of OLS variables as ν, which clearly must be between 0 and n).

It is clear that, to evaluate any weak points of the process as a whole a thorough analysis will be required of the evaluation of the margins of error and of the adequacy of these variables, as well as of the coherence of the accounting model used. This may lead to a process of readjusting the estimates of the margins of error of the OLS variables, by what Arkhipoff regards as the more immediate and natural process of substituting dx_i^* with dx_i^{**}, and therefore of re-balancing.

Specifying a function of distance N(.), for which the three properties $N(x) \geq 0$, $N(\Theta)=0$, $N(X+Y) \leq N(X)+N(Y)$ are assumed to be satisfied, it is possible to arrive at an explicit expression of the indicators proposed by Arkhipoff (1992d).

A standard way to define this function is to select a norm. For this purpose, Arkhipoff considers it reasonable to use the **Hölder norm**.

This norm is equal to:

$$N_q(X) = \sqrt[q]{|x_1|^q + \ldots + |x_n|^q} \quad (q \geq 1)$$

To arrive at explicit expressions for the reliability indicators defined above, the following weightings are defined:

$$W_q(i) = |x_i^*|^q \ / \ (|x_1^*|^q + \ldots + |x_n^*|^q)$$

$$dW_q(i) = dx_i^{*q} \ / \ (dx_1^{*q} + \ldots + dx_n^{*q}),$$

We find, then,

$$\rho_0 = \sqrt[q]{W_q(1)p_1^q + \ldots + W_q(n)p_n^q}$$

$$\rho_1 = \sqrt[q]{W_q(1)p_1^q r_1^q + \ldots + W_q(n)p_n^q r_n^q}$$

$$\varphi = \sqrt[q]{dW_q(1)r_1^q + \ldots + dW_q(n)r_n^q}$$

Where $p_i = dx_i^* / |x_i^*|$ is the quantity which defines the **relative error** or **accuracy**, assuming, for the sake of simplicity, that all the x_i^* variables are other than zero.

The indicators are therefore equal to weighted averages respectively of the accuracies p_i, of the quantity $p_i r_i$ and of the coefficients of refinement r_i. In the case of q=2, the traditional **Euclidean norm is obtained**. Generally, this norm, or even better the norm corresponding to q=1, is chosen, as the Euclidean norm has the disadvantage of emphasising the importance of the large aggregates, a disadvantage which grows bigger as q increases.

The norm used for calculating the indicators of reliability may not coincide with the one used for the balancing operation. In that case, the balanced vector M^{**} is not necessarily the point nearest to M^*, with respect to the norm used in calculating the indicators. However, it is not always claimed that, given a certain norm, there is a corresponding balancing method (in the case of q=2, the solution is nevertheless the method B_I).

Using the V^* measurement system, a diagonal matrix with σ_i elements, used by the Gauss-Markov method, the indicators assume the following expressions:

$$\|x^*\|^2 = x_1^{*2} / dx_1^{*2} + \ldots + x_n^{*2} / dx_n^{*2}$$

$$\|dx^*\|^2 = n$$

$$\rho_0 = h_2$$

$$\rho_1 = h_2 \varphi_2$$

$$\varphi = \varphi_2$$

where

$$\sigma_i = dx^*{}_i$$

$$n / h_2^2 = (1/p_1^2 + \ldots + 1/p_n^2)$$

$$\varphi_2 = \sqrt{r_1^2 + \ldots + r_n^2}$$

It is assumed, for the sake of simplification, that each x_i^* is other than zero.

As can be seen, these indicators are excessively dependent on the aggregates with a higher level of accuracy. This militates against the use of these measurement systems for calculating the indicators in question, and in favour of the Euclidean (N_2) measurement system, which in this respect offers the best characteristics overall.

The V^* measurement system, which is the best for balancing the accounts, partly because it appears, in general, to provide a limited number of OLS variables compared with other methods, includi ng the B_I method, is not therefore the best for evaluating the quality of the accounts, the Euclidean norm being preferable in this case.

From the operational point of view, if "reliable" estimates of the margins of error are not available, it is advisable, according to Arkhipoff, to assign different values to dX^* and to evaluate the results of the balancing operation case by case, on the basis of the indicators of reliability just defined, with the aim of finally being able to define the margins to be introduced into the final squaring.

Arkhipoff himself (1992a') carried out a series of simulations on the French annual accounts for 1981 to test the various balancing methods and to study the effect of arbitrary (but plausible) margins of error on the margin of error of overall aggregates, in particular that of the GDP, which is conventionally seen as indicative of the reliability of the national accounts. The exercise involved the input-output table, with non-balanced data. The author, incidentally, sees the balancing of the data at gradually increasing levels of aggregation, starting from a greater degree of disaggregation than that of the table itself, as a means of getting round the non-repeatability of the observations, which makes statistical determination of the observation errors difficult. Since each phase requires the margins of error of the aggregates to be defined, in relation to the chosen level of aggregation, the estimate available for these margins is sounder than that obtainable in the case of a single level of aggregation.

Given the nature of the application, a non-recent year was chosen (1981, with base 1971). For that year, the final XD data were examined, the line of "adjustments" was therefore eliminated and, finally, each elementary aggregate of the table was randomly set equal to either the final data or to the provisional XP data. To set the margins, on the other hand, the following methods were used: the standard "revisions" method, with DX=|XD-XP| (ADIF method), and another method based on the Hadamard product DX=|XDxPR|, where PR is the vector of relative accuracies given by random numbers between 1% and a variable higher threshold, set at 1%, 5%, 10%, 15%, 20%, 25%, 50%, 75%, 80%, 85%, 90% and 100%.

The measurement systems used were the ordinary Euclidean (G=I), in combination only with the ADIF method, and that given by the inverse of the matrix of variances and covariances V, with elements set for simplicity at $v_{ij}=\delta_{ij}DX(i)^2$, where δ_{ij} is the Kronecker symbol, in the other 13 possible simulations.

The chosen indicators were m_1 (simple arithmetic mean of DX(i)/ |X(i)|), m_2 (simple quadratic mean of DX(i)/ |X(i)|), h_2 (quadratic harmonic mean of DX(i)/ |X(i)|), and other indicators already described above (ρ_0 - gross overall accuracy; φ - overall refinement index, calculated as the simple quadratic mean of the individual refinements r_i ; ν - number of OLS variables; ρ_1 - adequacy index of the model). The article cited contains a table which gives the values of these indicators and another table which shows, for the main aggregates of the input-output table, the range of values obtained in each simulation. The first of these two tables includes a column for the GDP, which is not an elementary aggregate but a function of the main aggregates of the table.

The data reveal a very small dispersion of the balanced values and the means (arithmetic, quadratic, harmonic, quadratic-harmonic) of the results obtained for the GDP by the fourteen balancing operations are almost coincident to the last three significant figures (the arithmetic mean turns out to be 3 079 billion francs). It should be noted that the PRAL 100% method produced a GDP value equal to the average value.

The mean quadratic deviation was 11 371 million francs, which, compared with the mean, gives a value of 0.37 % , which is comparable in size to the values obtained by ρ_1 and ρ_0 using the Euclidean measurement system with the ADIF method (ρ_0 =0.32 % , ρ_1 =0.29 %) and the V^{-1} system with the PRAL 100% method (ρ_0 =0.57 % , ρ_1 =0.38 %).

5. Problems associated with the estimate of V using the existing and proposed CSO methods

The critical stage of the operation of balancing and evaluating the reliability of the national accounts proves to be the correct estimation of the matrix of covariances V^*. The estimation methods based on subjective evaluations, although acceptable as a first approximate numeric solution of the problem, are so arbitrary as to compromise the level of accuracy required for estimates of V^*. By contrast the methods based on analysis of the revisions of the estimates provide an objective solution to the problem, but the limits mentioned above, which make their use for the annual accounts difficult, must not be underestimated.

However, it appears "hazardous" to provide estimates without any indication of their limits of uncertainty, and it is an advantage, in the opinion of this author, to assign a margin of error to each estimate, even if it is only indicative, as suggested by Stone. The problem is that there is probably no single method of evaluating the reliability of the estimates which is valid for all the components of the national accounts. The solution, then, might be to define a "mixed" strategy, comprising several methods of analysis and evaluation of accuracy, defined in accordance with the methods of constructing the NA aggregates and of the sources used. This is, to a large degree, the approach followed by the CSO[19].

The UK institution, although not officially using the Stone balancing method to produce the official NA data, has paid great attention to the problem of balancing between the various sections

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[19] In fact, other authors have taken the same line in dealing with the problem of evaluating the reliability of the national accounts. As long ago as 1975 Novak, in a well-argued description of the main conceptual and methodological aspects of the problem of analysing the reliability of the national accounts, showed that the use of data of differing quality, which makes it difficult to evaluate overall reliability, was a critically important point. He pays particular attention to the aspects defining the quality of the national accounts, distinguishing the reliability of the basic data from that of the national accounts themselves. The latter actually require definitions which are more appropriate but more difficult to implement.

In the article cited, Novak also deals generally with issues concerning the use of revisions, problems linked to the adequacy of the data and the incoherent nature of sources, the analysis of discrepancies, the problem of the aggregation of errors and the treatment of distortions. According to Novak, it is possible to define only one multiple criterion of evaluation for the overall reliability of the national accounts, since it is difficult to achieve only one aggregation of the possible errors. In practice, this criterion could be given by the number of distortions upwards and downwards, from the size of the sampling errors and from a distribution of non-sampling errors.

Novak's approach was followed in part by Trivellato (1987, in particular Section 1 on the reliability and right timing of the national accounting estimates). Trivellato pays special attention to the aspect of internal coherence, for the analysis of which he suggests the combined use of statistical discrepancies, revisions and subjective indicators of reliability, and to the aspect of the external coherence of the national accounts, for analysis of which he advises, on the other hand, comparison of the national account values with those observed in respect of connected magnitudes.

Lastly, let us mention the work of Bracalente and Viviani (1993), in which they present an analysis having as its objective a detailed survey of the procedures for estimating the national accounting aggregates and of the main potential sources of inaccuracy in the sections "Services to Companies" and "Road Freight Transport". The work of Bracalente and Viviani provides an analysis of the way the estimates relating to these sections are produced and a standard model for quality analysis of the national accounting estimates, focusing on concepts of theoretical importance, accuracy and coherence.

of the national accounts and has been publishing balanced accounts for several years, although only in experimental form[20]. The considerable interest which the CSO has taken in recent years in the problem of the quality of the national accounts is largely derived from the growing discrepancies between the different estimates of GDP and between the economic and financial accounts[21].

For several years now the CSO has been assigning evaluations of accuracy to the main NA aggregates, expressed on the basis of a subjective range of opinions (CSO, 1992). In particular, level *A* is assigned to aggregates with a margin of error considered to be less than 3%, level *B* to those between 3 and 10%, and level *C* to aggregates with a margin of error greater than 10%, these margins being related to a confidence range of approximately 90%. According to the CSO, these evaluations, based on an opinion on the reliability of the sources of data used, are negatively influenced by the subjectivity of the method. Nevertheless, their publication may prove useful to users of the data. In addition, the CSO publishes figures for the discrepancies and for the quantities necessary to balance the accounts (these magnitudes in fact give only an indirect indication of the error and cannot be regarded as explicit measurements of accuracy, although the order of magnitude and, especially, the distribution of a range of these values, may give pointers as to the overall error).

The CSO is studying a mixed methodology based on the use of several methods (CSO, 1992), with the objective of evaluating correctly the margins of error of the main components of the national accounts. The first method (A) consists of the subjective assignment of a level of reliability to each NA aggregate, and not just to the main ones as hitherto, requiring the persons responsible for constructing the estimates to perform a numerical evaluation of the margins of error of the aggregates, based on considerations and opinions of a qualitative nature[22]. This method, although better mixed than that previously used by the CSO, suffers generally from the limits peculiar to evaluations of an exclusively subjective nature.

The second method proposed by the CSO (B) is based on an analysis of the data sources and the methods of constructing the estimates, and uses an appropriate combination of objective and subjective evaluations to identify and quantify the possible sources of error. In practice, it benefits from a series of analytical studies aimed, in particular, at monitoring and studying non-sampling errors and its use at a very fine level of detail could probably make significant improvements to knowledge of the "true" level of error. For these reasons, we consider that this method is the one which deserves further investigation and formalisation.

The third CSO proposal (C) is based on an analysis of the statistical properties of the revisions made to the initial estimates (revision here means the difference between the error made in the first estimate and the error in the revised estimate). Through this analysis it is possible to evaluate, in particular, the existence of distortions and other systematic effects, the variability and

[20]An article by P.B. Kenny (1991) describes experimental application of the Stone method separately for the years 1985-87, restricted in the case of GDP to a value equal to the average already published, at current prices (only for 1987 was a variant considered in which this restriction was not applied, leading to a result fairly close to the official one).
The problems of implementing the Stone method were overcome by using the technique of *partition balancing* which allows the processing of very large models, even over several years, without too much computational work, but at the cost of a certain complexity in the structure of the model (refer to the appendix of Kenny's article for a detailed description of the method, which rearranges the restrictions and variables involved in the computational simplification of the Stone method).

[21]The first step carried out in the attempt to explain these discrepancies consisted of looking for possible distortions in the sources of data used, with the objective of reducing the discrepancies to the level of an apparently random error of negligible size.

[22]The application of the Stone balancing algorithm to the years 1988-1991 (Baxter, 1992), required, for example, a confidence range of 90% for each variable and the margin of error was set at half the width of this range, with the instruction, in the case of asymmetric distribution, to take into account the central value of this range, in order to reduce the distortion of the precise estimate provided.

the serial correlation, all properties which can be used as instruments to evaluate the consistency of error estimates obtained by the application of other techniques (the analogies with the approach followed by Trivellato, 1987, are obvious).

We have already pointed out the advantages of the analysis of revisions, namely the possibility of performing it on each section of the accounts and of interpreting it easily, in particular when an indication of the distortion of the initial estimates is required. The main drawback of this analysis is, as already mentioned, that it provides a partial view overall of the errors in the initial estimates. In fact, it appears risky to estimate the size of the total error from the final revision, since the last estimate produced is still affected by measurement errors.

For the time being, the CSO has performed the analysis of revisions only on certain variables chosen from among those officially studied by the CSO to evaluate the efficiency of the successive revisions to the economic accounts (cf. 'Agency Framework Document', CSO, 1991), but the intention is to extend the analysis to more variables. These variables are not expressed in absolute values, but as percentage variation ratios, magnitudes which are compared with the GDP or other appropriate denominators, so that they are comparable independently of changes in the size of the economy over time.

As a further tool for analysing the quality of the national accounts (D), the CSO is proposing analysis of the accounting discrepancies and of the account balancing variables. Such analysis constitutes, first of all, a means of evaluating the consistency of the margins of error estimated using the other methods. In particular, an analysis is made of the statistical properties of the discrepancies and of the balancing variables, which come directly from the statistical properties of the errors in measuring the variables.

Through an appropriate combination of these methods, the CSO intends to arrive at a definition of a well-structured model for estimating measurement errors in the national accounts. In practice, this will start from subjective estimates of the margins of error (method A), which are then integrated and corrected with the results of the analyses of the revisions of the provisional data and of the discrepancies and balancing variables (proposals C and D). The next step consists of any required validation or correction or in other words completion of the estimates through a series of analytical studies, of the type described in method B[23].

The second stage of the CSO programme shows several analogies with the methodology of the *error profile*, whose usefulness in the qualitative and quantitative analysis of non-sampling errors is widely recognised today. Referring to Bailar (1982) and Bracalente, Calzaroni, Pascarella (1991) for a more complete description of the method, the *error profile* consists, briefly, of a description of the phases of an estimate production process with the aim of identifying the main sources of non-sampling error, the levels of control of the process and, when possible, of quantifying the individual components of the error. This methodology takes on very particular aspects in national accounting, although, in view of the difficulty, which has been emphasised

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[23] Regarding this last point, some pilot studies have been prepared, and in part completed, in the sector of rubber and plastics production, for which the main source is the monthly survey of sales (carried out by mail on a sample selection of companies), and expenditure by domestic consumers (*consumers' expenditure on household and domestic services*), for whose estimation the main source is the survey of domestic consumption (carried out by direct interview).
The choice of these fields of analysis stems from the desire to process sets of data derived from sources internal to the CSO itself, and thus of a statistical nature, including at the same time a survey on households and one on companies regarding different components of the GDP, in respect of which they might, however, have a similar weighting.
These analyses, concentrating mainly on the estimate of non-sampling errors, with approaches clearly linked to the methods of planning and carrying out the surveys, are designed to make an initial evaluation of the adaptability of the methods proposed, using an actual case, the possibility of applying the same methods to other national accounting series and aggregates and, lastly, the size of the resources required (some results from these analyses are described in the *contributed paper* submitted by S.Penneck of the CSO at the 'Quality Control of Statistics' seminar, Eurostat, Athens, January 1993).

several times, of arriving at an error model which allows evaluation of the reliability of all the components of the national accounts, one should not consider obtaining **partial** results to be unimportant[24].

One problem associated with the use of the various approaches suggested by the CSO is the integration of the results obtained in very different ways into a unitary and coherent context. In this respect, the approach of the CSO is to define a model which describes the process of constructing the national accounts, is very flexible and includes at the same time the "basic" input variables (for a definition of which see the appendix) and the final aggregates of the process, and which also indicates the point of introduction, at each level, of the estimates of the errors, which require regular systematic updating, through the advancement and completion of new studies. The introduction of all the required information into the model therefore allows construction of the **margins of error** needed to define the reliability of the national accounts. Comparison with the information extracted from the revisions and with that obtained from the discrepancies finally allows the coherence of the results to be evaluated, suggesting the possibility of further surveys for the most important components of the economic accounts.

6. Comments on the various proposals

Evaluation of the reliability of the NA estimates, although dependent on the methodology adopted for constructing the estimates themselves, may find a solution which is correct and generally valid in a "mixed" approach, like the one proposed by the CSO. Effective quantification of the error requires, however, the solution of a number of problems which must be confronted and somehow resolved. In this author's opinion, the most important of these problems concerns evaluation of the reliability of the base data and its conversion into the correct estimate of the accuracy of the NA data, which is necessary for a correct and efficient operation of balancing the accounting system. This means looking for other evaluations derived from objective procedures, or at least using them in support of the subjective evaluations. The procedure is objective when it is characterised by those criteria of transparency, repeatability and knowledge of the basic assumptions which are the special properties of the statistical method. Only in this way can one think of changing from a phase which is basically "craftsman" in nature to one which is more properly "industrial", both in evaluation of the quality and representativeness of the NA data and in construction, on the understanding that, even if accuracy evaluation may be of assistance in improving the quality of the estimates, the quality of the national accounts will in any event depend on the availability of increasingly complete and reliable surveys.

The national accounting system may, in fact, be, compared to a *"process of integrated and co-ordinated partial production processes,* based on a specially designed and constructed system of economic statistics", which is analogous to what happens in an industrial production process (see Bracalente, Calzaroni, Pascarella, 1991). The more the empirical base of the accounts is an integrated information system, the more the partial production processes are coordinated between each other. The integration of the economic statistics system therefore constitutes the essential prerequisite for defining the "production" of the NA estimates as a process of processes.

Bracalente, Calzaroni and Pascarella have also observed that at present the statistically most developed countries are nevertheless in an intermediate position between the "craftsman" process and the perfectly integrated and coordinated process of processes. The statistical information systems actually established and which may be established in support of the national accounting system actually reveal fairly wide gaps in terms of completeness and operational integration. These

[24] Quintano et al. (1987) applied the method to one of the most important statistical sources for the Italian national accounts, the survey of the gross product of companies with at least 20 employees.

gaps impose indirect criteria in the estimating of certain aggregates or sub-aggregates and are, therefore, the source of a substantial number of the problems concerning the quality of the information produced and the measurement of this quality (cf. Esenwein, Rothe, 1973).

It must be pointed out, however, that the fundamental condition for approximating the process of producing the estimates to an industrial production process is the standardisation of definitions, classifications and procedures, in particular the procedures for estimating aggregates. The result of this process should be repeatable, with the same value being obtained for the aggregate estimated from the same information base.

A structured analysis of quality which is as "objectivised" as possible represents a valid tool for verifying the bases of data used, the estimates produced from these statistical and other sources, and the actual process of constructing the aggregates. This analysis provides important elements of analysis and control to all parties affected by this process at all levels (survey managers, organisations and institutions in possession of administrative archives, persons responsible for the estimates of each NA aggregate, users of the data). One thinks, in this sense, of the usefulness of having accuracy measurements for the NA aggregates (explicit for example in the familiar expression of a range of confidence), for example in the evaluations of economic policy, with the ability to base decisions both on precise estimates and on the probable upper and lower limits of a given magnitude. An accurate and articulate evaluation of the quality of the national accounts may also prove to be very useful to ISTAT itself for defining actions and investment in the most critical areas, in the light of the results obtained before and after the balancing of the accounts.

Taking the line suggested by the CSO, a series of studies and researches must first be initiated to determine the "best" estimates of the elements of the covariance matrix V^*, whose importance in the data balancing operation has been mentioned earlier, from the aggregates having more weight in relative terms in the determination of the GDP. As we have seen, the estimates are generally based on a subjective evaluation of the range of variation of the variables and quantified using numeric coefficients between 0 and 1 (assigned respectively to the cases of absence of error and presence of an error with an order of magnitude equal to that of the value of the estimate itself). The evaluations are derived, obviously, from the degree of confidence in the various sources used and do not, therefore, guarantee the correctness of the estimates.

In particular, to arrive at the estimate of the *total error* of each variable included in the national accounting system model, great attention must be paid to a study of statistical methods designed to estimate the *non-sampling error*.

Regarding the *balancing procedure*, it is considered advantageous from the theoretical, practical and computational viewpoints, to use the Stone methodology. The statistical and mathematical qualities of the method, such as the correctness and efficiency of the estimates, and the direct geometrical interpretation, have been mentioned earlier. Above all, guaranteeing continuity in the application of a balancing procedure allows the selection and evaluation in a homogeneous manner of any modifications made to the estimate production process, as well as any changes made to the elements of V^* through new estimating methods, changes in the quality of the information base or information coming from the balancing operation itself (one thinks of the indices proposed by Arkhipoff), guaranteeing at the same time the continuity, objectivity, transparency and credibility of the national accounts.

The use of the Stone method is also further supported by the availability of a computer program which performs the balancing operation easily and, therefore, by the possibility of comparing the results produced by new research and simulations with the data already certified and published. At the same time, the geometric and algorithmic aspects of the method may be further investigated, with a view to improving the control and analysis of the balancing operation, with the result of providing an easier and more accurate interpretation of the results produced.

C - DEFINITION OF THE STATISTICAL TOOLS FOR MEASURING THE QUALITY OF THE NATIONAL ACCOUNTS. THE ITALIAN SITUATION

1. Error profile and integration of sources for estimates of current years

For a description of the steps relating to this procedure, refer to the section on application in part D.

2. Analysis of discrepancies in the account balancing operation

In the first compilation of the accounts, the equations which constitute the national accounting system generally reveal discrepancies, since the information sources used have differing degrees of exhaustiveness and accuracy. This means that the system variables[25] are affected by errors (not only statistical errors, but also errors of classification or definition, or connected with timing, except for cases where the errors in the variables are considered null by construction, for example, the data of the Public Administration).

The discrepancies, when they are not of worrying size, are actually a valuable source of information on estimate measurement errors and not merely a nuisance factor to be eliminated by using a balancing technique.

In particular, the discrepancies can be used as a "check" to evaluate the coherence of the accounts and to assign or modify the error associated with the system variables[26]. The analysis of the discrepancies may also be useful for checking process errors caused by the process of assembling the accounts.

In this respect, the Central Statistical Office (CSO) proposed (1992) calculating a statistical criterion (*Criterion C*) from the economic accounts; this is constructed from the variances and covariances of the discrepancies, and provides pointers as to the correctness and appropriateness of the margins of error of the variables.

A second way of improving the correctness of the estimates of the margins of error of the variables, logically following the analysis of the accounting discrepancies, was suggested by Stone (1990) and is based on analysis of the values of the variables after the balancing operation. The statistic α suggested by Stone, constructed from the differences *before* and *after* balancing, allows the extraction of margins which are probably more correct than the initial ones, because they are "nearer" the size of the differences found in the values of the variables following the balancing of the system accounts. The procedure was applied to the same year of economic accounts, 1993, as the one chosen for the *C* criterion (Puggioni, 1998).

[25]The variables which are measured from this information are called *basic variables* (CSO, 1992) when they represent the greatest aggregation obtainable from an individual source of data. The basic variables do not normally coincide with the aggregates of the NA system; in these cases the aggregates are extracted by a function of these variables.

[26]The errors in the variables of the NA system are not currently evaluated explicitly and fully by the national statistics institutions, except for countries (including Italy) which use, as will be mentioned shortly, balancing methods which expressly require this. It must be said, however, that any method used to redistribute the accounting discrepancies in some way takes account of the reliability associated with each estimate.

2.1. Analytical modelling of the national economic accounts and of the Stone balancing method

As shown above in section B, the system of national accounts can be represented as a system of n X_i variables in m equations (see Arkhipoff, 1992, Puggioni, 1996):

$$a_{11}X_1 + a_{12}X_2 + \dots\dots + a_{1n}X_n = 0$$
$$a_{21}X_1 + a_{22}X_2 + \dots\dots + a_{2n}X_n = 0$$
$$\dots\dots\dots\dots\dots\dots\dots\dots$$
$$a_{m1}X_1 + a_{m2}X_2 + \dots\dots + a_{mn}X_n = 0$$

The X_i variables represent the economic aggregates, while the equations, describing the accounting constraints of the national accounts, are assumed to be linear and independent. Normally, there are many more variables than equations (that is, $m \ll n$).

In terms of matrices, the system becomes:

$$AX = 0$$

where A is the matrix, assumed to be of the highest rank, of m rows and n columns, of the parameters which connect the aggregates, represented by the vector X, of n elements, and 0 is the vector consisting of m null values[27].

Actually, the availability of sources of data of different types (statistical, administrative and accounting), constructed in different ways and therefore having a different degree of completeness, reliability and coherence, the absence of direct information for certain variables and the use of different methods of estimating the NA aggregates, mean that the system of accounts as a whole is not coherent, due to the conflict arising within each equation and between several equations.

The balancing method with the best statistical and mathematical properties is that proposed by Stone (Stone et al., 1942).

If $V^*=Var(X^*)=E((X^*-E(X^*))(X^*-E(X^*))')$ is the **covariance matrix** of the X^* estimates, which are assumed to be correct, the **balanced vector** is given by the expression:

$$X^{**}=(I-V^*A'(AV^*A')^{-1}A)X^*$$

The method takes into account the different reliabilities of the sources used, by specification of the matrix V^*.

The formula which gives the balanced vector was obtained by Stone (1990) in such a manner that the function of *a posteriori* probability density of X, starting from the model $X^* = X + a$, was maximised, subject to the constraints imposed by the accounting system, a being a random vector of the errors distributed as a normal $N(0,V^*)$. Stone assumed in fact that X had *a priori* a normal multivariate distribution and that the matrix of the covariances of X^* was known.

The estimates extracted with the Stone method are, besides being balanced, more accurate than the initial estimates, if a covariances matrix corrected from the statistical point of view is used.

[27] A vector of known terms which are all null is assumed, to simplify the expressions of the formulae, which however remain valid, with the proper adjustments, including for the system GX = h, where h is the vector of elements which are not all null.

Application of the valid results by the method of least squares gives the following expression for the matrix of covariances of the balanced estimates:

$$V^{**} = (I - V^{*}A'(AV^{*}A')^{-1}A)V^{*}$$

As $V^{*}A'(AV^{*}A')^{-1}AV^{*}$ is a positive semi-defined matrix, the matrix of the covariances *after* V^{**} is not greater than that *before* V^{*} and this expression constitutes the reduction in the variance produced by the balancing operation.

The improvement in the estimates in terms of efficiency is due to the additional information contributed through the observance of accounting constraints by the system variables. However (Weale, 1985), if the uncorrected matrix *V'* is used instead of the corrected covariance matrix V*, the matrix of variances *after V''* will actually be equal to:

$$V'' = (I - V'A'(A\,V'A')^{-1}A)V^{*}(I - V'A'(A\,V'A')^{-1}A)'$$

Thus, even in the presence of balanced and corrected X** estimates, the *ex post* covariance matrix would not necessarily have elements with lower values than those in the matrix used for the balancing operation. This fact confirms how important it is to evaluate as accurately as possible the error covariance matrix, so as to guarantee the optimal nature of the Stone balancing method and to obtain a correct estimate of the V** variances and covariances (a fundamental requirement for obtaining an evaluation of the accuracy of the "official" NA estimates).

2.2. The Italian national accounting system

The method used by ISTAT is an adaptation to the Italian model of the one originally proposed by Stone, and consists of a procedure which combines a purely subjective method of finding and correcting errors with a more sophisticated approach which reveals the disequilibria in the accounts by distributing the remainders among the aggregates on the basis of the weighting of the aggregates and of all the available information on the methods of estimating (for example, degree of cover, use of proxies, etc.), which is summarised by the covariance matrix V (for further details refer to Mamberti Pedullà, 1994).

The Stone method was used for the first time by ISTAT in constructing the system of annual national accounts, when the national economic accounts were revised and reconstructed in 1987, for the series from 1980 (cf. ISTAT, 1990), and in 1988, for the years 1970-79. The calculation methods used and the main results obtained from the revision of the years 1970-79, which was in fact coherent with that for the 1980s, are described in the work of Giovannini (1988). In particular, an advanced balancing technique was adopted within an input-output model of the estimates relating to the formation and use of resources.

As said in part B, the construction of the estimates was actually the result of an iterative process, comprising the following phases:

- initial estimates;
- assembly of the annual input-output table;
- analysis of the discrepancies;
- revision of the initial estimates (repeated together with the previous phase until the initial estimates cannot be further refined);
- balancing of the input-output table, with redistribution of the remainders within the whole matrix on the basis of weightings derived as a function of the variances associated with each estimate.

Giovannini's work shows the deviations introduced by the balancing operation into the initial estimates of the resources and uses account. For the GDP, in particular, except in 1971, the corrections turned out to be less than 1%.

The Stone method was recently used to revise the annual set of national economic accounts for the years 1970-94, with reference to the aggregates at current and constant prices (Picozzi, Agostinelli, 1997 - cf. Part I, section 1, and Appendix). In fact, one of the reasons leading to a complete re-processing of the accounts by branch of economic activity was the opportunity to balance the new estimates for resources and uses separately, using, for each of the years considered, the adapted Stone method described above, in view of the good results produced by it in terms of reliability and soundness. However, a different methodology was used for balancing the years 1970 to 1981, with a reduced accounting model compared with the one normally used (described further on in this section)[28].

Actually, the expression of the Stone estimator shows that the solution is determined by the relative dimension of the elements of V^* and not by their absolute value and, furthermore, that the result is not changed by multiplying the covariance matrix by a scalar quantity (Weale, 1988). These are important properties, since they show that the objective is first and foremost to identify margins of error in the variables in the correct proportion between them, although knowledge of the correct margins of error in absolute terms, at least for the more important aggregates (the most important being GDP), is of considerable interest both for the balancing operation and for the producers and actual users of the data.

Estimating the matrix V^* is in fact a major problem in balancing the national accounts. Until now, the Stone method has been applied to the NA real data, with the aim of producing "official" data (as in the case of ISTAT) and of testing and verification (as in the case of the CSO for example), by defining the elements of the matrix V^* on the basis of subjective evaluations of the accuracy of the variables. In particular, a **coefficient of reliability** r_i^* is assigned to each accounts system variable; this coefficient, having a value between 0 and 1, is an inversely proportional expression of the level of quality and reliability of the base data used to estimate the variables.

The **margins of error** may then be assumed to be equal to the product of the value of the estimate of the variable and the corresponding coefficient of reliability. Indicating these margins by dx_i^*, the following expression therefore holds good for the known relationship between margin of error and standard deviation:

$$dx_i^* = r_i^* X_i^* = t\sigma_i^*$$

where σ_i^* is the standard deviation of the error and t is a parameter dependent on the type of distribution of the error and the chosen level of confidence.

With these margins, the following holds good for the **variances**:

$$v_i^* t^2 = (t\sigma_i^*)^2 = dx_i^{*2} = (r_i^* X_i^*)^2$$

from which

$$v_i^* = (r_i^* X_i^*)^2 / t^2$$

[28] The aggregates are balanced in two stages: in the first stage, the whole structure of aggregates is balanced using their initial estimates, then the consumption by function and the bridge matrices are balanced to adjust their initial estimates to the values of consumption by branch balanced in the first stage of the squaring operation.

Using the Stone method, the estimates at current prices are balanced by ISTAT with the aid of a matrix of coefficients of reliability defined subjectively, on the basis of the evaluation of the reliability of the sources of data used (for example, a null coefficient is assigned to data coming from public administration budgets, which are selected for error-free construction). Furthermore, the matrix is assumed to be diagonal, on the assumption that the estimates of the X variables are independent. To limit the negative effects deriving from possible inaccuracies in the values assigned to these coefficients, the balancing operation is normally repeated several times in the case of implausible results, revising, where appropriate, the value previously assigned to the coefficients.

The current Italian standard accounting model (see Figure C.1, taken from Picozzi, Agostinelli, 1997) is a 188 x 188 element square matrix (cf. Borgioli, 1996), similar to an input-output table, and the accounting constraints, which are linear, are defined by the equality of the total of rows and columns for each i=1, 188, that is, by the equality of resources and uses.

The coefficients of reliability used for constructing the final estimates for the 1993 accounts vary from 0 (estimates constructed from administrative and accounting data for example, and therefore not subject to modifications to redistribute accounting discrepancies) to 1 (a value to be interpreted not so much as expressing the reliability of the estimate in a statistical sense, but rather on the basis that the balancing operation has the possibility of freely modifying the value of the estimate, which in any case is considered unreliable)[29].

Figure C.1 **- Standard accounting model**

	C 44×44	**DSRMC** 44×44			**I** 44×5				
DSCC 44×44									
			MC 44×40						
				SCMC 40×1					
									SMC 1×1
									SCAS 5×1
R 5×44									
RM 2×44									
MAR 2×44									
						SRR 1×5	**SRM** 1×2	**SRMAR** 1×2	

[29] It is observed that the application of the tests as described in the following paragraphs, on the variances calculated in a different way from these margins (first setting the variance equal directly to the margin of error, and then equal to the margin squared, without dividing by t^2) leads to implausible conclusions, strengthening the correctness of the proposed transformation between variance and margin.

where:

C	matrix of the intermediate flows
DSRMC	diagonal matrix of private consumption by branch
I	matrix of the components of end uses (excluding private consumption)
DSCC	diagonal matrix of total costs by branch
MC	bridge matrix of consumption
SCMC	vector of consumption by consumption function
SMC	total domestic consumption
SCAS	vector of totals of components of end uses
R	matrix of the components of value added
RM	matrix of imports and associated duties
MAR	matrix of total commercial margins and transport by branch
SRR	vector of totals of the components of value added
SRM	vector of totals of imports and associated duties
SRMAR	vector of total commercial and transport margins

2.3 The diagnostic criterion *C*

The **diagnostic criterion *C***, proposed by the CSO, is given by the expression:

$$\mathbf{C = (AX^{*})'(AV^{*}A')^{-1}AX^{*}}$$

The matrix product AX^{*} represents the vector of the discrepancies, while $AV^{*}A'$ is the matrix of the covariances of these discrepancies. The criterion *C*, which in fact is a **Mahalanobis distance** (Baxter, 1992), allows evaluation of whether the discrepancies are significantly greater than those expected, given the order of magnitude assigned to the margins of error.

On the assumption that the measurement errors are distributed normally with a zero mean value, the distribution of the discrepancies will also be normal and, for a known property of the calculation of probability, the criterion *C*, being equal to a summation of standardised quadratic deviations with the respective variances, will have a chi-squared distribution. The degrees of freedom are equal to the number of the accounting constraints not satisfied by the data, which is equal to that of the balancing variables relating to these discrepancies (*m* in the case of the standard model shown in Figure C.1). If the initial computation is constructed so that *k* of these variables are certainly equal to zero, the number of the degrees of freedom is, however, reduced by *k*, since they do not make any contribution to *C*. The number of degrees of freedom is the value expected for the criterion on the assumption of coherence in the data, and higher values are observed with a gradually declining probability of occurring solely according to case, strengthening the assumption of incoherence.

The criterion allows testing of the effectiveness of global fitting of the accounts, representing a measurement of the coherence of the data, with respect to the defined margins of error, before the balancing operation. If this criterion has a significantly high value when tested against the appropriate chi-squared distribution, the established assumptions could have been infringed. This could be due to one or more of the following causes:

– measurement error variances greater than those defined;
– measurement errors with non-null mean values, due to the presence of distortions in the unknown data;
– non-normal distribution of the measurement errors;
– existence of unknown correlations in the data.

A significant value for the criterion *C* says nothing about which of these causes may have had an effect. However, what is of greater interest is to know which sections of the accounts are contributing more than others to the value of *C*, and why the information inherent in the constraints of the national accounting model is not sufficient to identify with certainty the variables affected by any of the problems mentioned above.

2.4. The Stone coefficient α

The other route taken for analysing the correctness of the margins of error is based on an analysis of the differences between the values of the variables before and after the balancing operation. In fact, the relative differences between the values before and after balancing indicate values which are generally much smaller than the margins used for the balancing operation (Table C.1 shows, as an example, the percentage differences referred to the diagonal matrix of the total costs by branch) and, although this difference is not necessarily of the same order of magnitude as the true margin of error, because it is in turn dependent on the margins introduced into the balancing operation and the accounting relationships existing between the variables, it nevertheless provides valuable information in this regard.

This subject is dealt with by research carried out by Stone (1990). When comparing the size of the adjustments made to the balancing with the order of magnitude of the variances in the UK national accounts from 1969 to 1979, he realised that the variances were overestimated.

The overestimate was corrected by considering a coefficient α which is equal to the sum of the squares of the standardised adjustments (or remainders), divided by the number of the degrees of freedom:

$$\alpha = (n - m - 1)^{-1} \sum_j (a_j^{*2} v_j^{*-1})$$

The assumption of independence of the initial estimates implies, in fact, for the sum of the squares of the standardised adjustments, a χ^2 distribution with n-m-1 degrees of freedom. The number of the degrees of freedom therefore constitutes the value having a probability which will not be exceeded by the χ^2 value and therefore represents the appropriate coefficient with which to divide this sum. In this way, the covariance matrix is corrected by:

$$\tilde{V}^* = \alpha V^*$$

and this correction is also valid for the covariance matrix of the balanced estimates.

Table C.1 - Percentage differences between the values
before and after the balancing operation (1993).
Diagonal matrix of the total costs by branch

BRANCH	(X**-X*)/X*%
01-Agriculture	0,00%
03-Coal and lignite	0,00%
05-Coking	0,10%
07-Petroleum and natural gas	0,00%
09-Electricity, gas and water	0,00%
11-Nuclear fuel	0,00%
13-Ferrous & non-ferrous metals	-0,80%
15-Non-mettaliferous minerals	-0,30%
17-Chemicals, pharmaceuticals	-0,10%
19-Metal goods	0,50%
21-Agric.& indus. mach.	0,40%
23-Office equipment	1,40%
25-Electrical goods	-0,30%
27-Motor vehicles and engines	0,60%
29-Other means of transport	0,40%
31-Meat	0,90%
33-Milk and dairy produce	0,70%
35-Other foodstuffs	-0,20%
37-Beverages	1,40%
39-Processed tobacco	0,40%
41-Clothing and textiles	0,30%
43-Leather, skins, footwear	1,00%
45-Wood, wooden furniture	0,00%
47-Paper, printing, publishing	-0,10%
49-Rubber, plastics	-0,40%
51-Misc.manufactered goods	2,10%
53-Building and construction	0,00%
55-Salvage and repair	0,80%
57-Commerce	-0,10%
59-Hotels and catering	-0,60%
61-Internal tspt, oil pipelines	0,00%
63-Sea/air transport	1,00%
65-Auxiliary transport	0,40%
67-Communications	0,40%
69-Lending, insurance	-0,50%
71-Services to businesses	-0,10%
73-Leasing of buildings	0,00%
75-Private research	1,30%
77-Private health	-0,10%
79-Recreation and culture	0,40%
81-PA	0,00%
85-Public education	0,00%
89-Public health	0,00%
93-Domestic and ISP	0,00%

D - IMPLEMENTATION OF THE MODEL TO THE ITALIAN SITUATION FOR THE ESTIMATES OF CURRENT YEARS

This section shows two applications of methods described in sections A and C to Italian National Accounts.

In particular, D.1 shows an application based on the Error Profile of National Accounts, while D.2 illustrates an application of criteria based on discrepancies and values of aggregates, calculated before and after balancing. The criteria in section D.2 were suggested, respectively, by CSO and by Stone.

D.1 An approach based on the Error Profile of National Accounts

The most important aggregates included in the account Resources and Uses were examined, namely Value Added (VA), Consumption and Gross Fixed Capital Formation (see table D.1). It must be stressed that the measurements are only an exercise aiming to verify if the proposed method can be applied to evaluate the EPNA components identified in chapter 1.

Economic activities, which are part of Manufacturing Industries (MI), were examined to guarantee homogeneity. Nevertheless the expounded methodology can be applied to every economic activity branch for which required basic data are available. The aim is to define the EPNA of specified aggregates.

The different types of error are analysed below. Errors are examined according to the classes in section A (EP of sources, Target population, Definitions and Classifications, Provisional Data). If not otherwise specified, figures are referred to 1992. The rationale to construct and use the EPNA requires that the most recent error evaluations should be assigned to aggregates estimated for the following years as well, if information required to estimate the several factors composing error is not available. Above conditions are to be applied unless remarkable variations occurred in the sources or in estimate methodologies.

Chapter 1 outlines the ISTAT method to estimate the aggregates in the Resources and Uses account examined in this paper (Value Added, Consumption, and Gross Fixed Capital Formation). This method is based on the estimate of Units of Labour (UL) and of aggregate per capita values. In the current estimates yearly variations in per capita values related to economic aggregates are applied to the per capita levels established for the last input-output matrix. In this way it is possible to determine the per capita figures for the year to be estimated. Then the NA employment (UL) estimates are used as expansion factor to obtain an estimate of aggregate level (ISTAT, 1990).

Chapter 2 describes the methodology to estimate UL and its EPNA is evaluated, with reference to MI sector; VA is examined in chapter 3; Consumption and Gross Fixed Capital Formation are examined in chapter 4; chapter 5 includes comments and reflections about the EPNA approach.

Table D.1.1 - Weight of Aggregates to the total Resources and Uses (current market prices)

Yearly National Accounts

YEAR : 1992

COUNTRY: ITALY

BRANCH OF ECONOMIC ACTIVITY (NACE - Rev.1): ALL

RELEASE: ***provisional |*** | ***definitive |*** ***X*** |

		AMOUNT (1)	WEIGHT %
RESOURCES	PRODUCTION		85,8
	INTERMEDIATE CONSUMPTION		*40,8*
	VALUE ADDED		*45,0*
	IMPORTS		9,1
	TOTAL		94,9

USES	INTERNAL CONSUMPTION		40,1
	HOUSEHOLD CONSUMPTION		*31,2*
	P.A./P.S.I.CONSUMPTION		*8,9*
	GROSS FIXED CAPITAL FORM.		8,4
	CHANGES IN INVENTORIES		0,0
	EXPORTS		10,6
	TOTAL		59,1

(1) record the aggregate amount in the currency or ECU at current market price

1. The ISTAT method

The Italian economy is characterised by a strong presence of small productive units, often unrecorded, and a high rate of irregular employment in the labour market. In order to ensure coverage of these two problem areas in GDP estimates, the Italian national accountants have developed in the 1980s the "Input of Labour Approach", which is an original method first adopted by ISTAT in 1987.

In this report we describe briefly the ISTAT method (ISTAT, 1990) only to describe how to measure the quality of estimates. The ISTAT method requires a large database (regarding employment first of all, but also enterprise and household budgets, as well as specific aspects of final consumption for particular kinds of services). This type of methodology contains advantages such as organic unity and the systematic nature with which the problem of the exhaustiveness is treated, as well as the replicability resulting from its standardisation. It developed from the characteristics of the Italian statistical system and observation of the structural connotation of the organisation of production in Italy.

The techniques used for estimating the production and value added are diversified by branch of economic activity, on the basis of the best results obtainable in exhaustiveness terms:

A. estimates "quantity × price", this technique is used for estimating the activities of the agricultural and energy sectors and part of construction;
B. estimates through expenditure (part of constructions, rents and private services for education and research, health, entertainment and leisure);
C. estimates through direct collecting of costs and earnings from balance sheets (credit, insurance and some branches mostly belonging to public enterprises);
D. estimates through distributed incomes (non-market services);
E. estimates through expansion of per capita values for units of labour, after having estimated the overall labour underlying the product and after having corrected the per capita values for possible underreporting (technique "input of labour × average per capita values", used for estimating all other branches).

These criteria show the fundamental role played by employment in methods which estimate the product from the point of view of formation and approximately 70% of the value added is estimated with the E technique ("input of labour × average per capita values"). For the MI, E technique is used at 100%.

To sum up, Italian accountants consider the utilisation of irregular labour within the productive process and underdeclaration of the production obtained by means of regular labour the two major aspects that characterise the Italian underground reality.

As far as other branches of economic activities are concerned, particularly those in which the proportion realised by very small units is very important, special sample surveys on final consumption (different from household budget survey) are carried out with the aim of uncovering aspects of underground economy.

The whole range of the above described methodologies enables us to integrate the data on underground activities with the data which make up the statistical base used to estimate the various economic and financial flows which describe the different phases of the income circuit.

The final balancing of economic accounts makes the system coherent, and in addition it lets us uncover other activities not symmetrically registered.

The procedure for estimating the aggregates of national accounts (such as production, value added, compensation of employees and capital formation) analysed by branch of economic activity can be summarised with the following formula:

$$Y = \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} \cdot UL_{ij} + \sum_{i=m+1}^{n} Y_i$$

where:

Y = overall estimate of the aggregate (for example: production)

i = indicator of the branch of economic activity (101 branches)

j = indicator of the size of the enterprise (1-5, 6-9, 10-14, 15-19, 20-49, 50-99, 100-249, 250 and more employees)

x = average per capita value of the aggregate (for example: production per employed)

UL = unit of labour

$\sum^{n} Y_i$ = part of the aggregate not estimated through the units of labour technique i=m+1

Input of labour estimates are obtained with the same methodology for all branches of economic activity. In those branches where the technique “input of labour × average per capita values” is not used, input of labour estimates are applied for coherence controls.

2. Units of Labour

2.1 Methodology to construct the Units of Labour

As regards MI, if enterprises with 20 employees and more are examined, UL estimate results from the application of yearly variation to benchmark levels, estimated from censuses. Variations are estimated from survey on Labour Force (LF), for the total, and from surveys on enterprises (which is dealt with in the next chapters) and from the Business Register[30], for more detailed levels. The estimate of yearly variations is characterised by extreme accuracy as available information is accurate and the share of non regular economy is negligible.

With reference to benchmark levels of UL, the associated error component may be neglected. In fact the non-sampling error associated with each census should be cancelled or reduced by a number of comparisons made to estimate the levels of Uls: comparisons and integration of different censuses (Population, Industry and Services, Agriculture), as well as of administrative sources (Ministry of Finance, Social Security, etc.). Therefore, it is assumed that the error associated with UL estimates of big enterprises may be neglected.

On the contrary, as far as enterprises with less than 20 employees are concerned, the significant presence of non regular economy affects the reliability of the yearly variations in the number of employees estimated by the survey. Benchmark levels are updated using other sources, which allow to have a more exhaustive recording of real employment levels on the “Supply” side.

The Survey on LF is the main source of this type (LF).

The remarks in this paper about enterprises with 1 to 19 employees were obtained from the LF survey error profile. Remarks were filtered using the ULs estimate methodology.

2.2 Error Profile

2.2.1 Sampling error

The LF survey is a quarterly collecting through direct interviews with households. The annual total for collected variables are given by adding the totals obtained from the four quarterly surveys and by dividing the resulting figure by four. The survey sampling design has more than one stage. The first stage is stratified with sample selection based on different probabilities and with no re-entry of primary units, and on equal probabilities and no re-entry of secondary units (P.D. Falorsi, S. Falorsi, 1994). Due to the complexity of the design, the sampling error estimate is achieved trough a rather complex procedure. This procedure, described in the paper mentioned above, is based on linearization and interpolation methods. The sampling error of an estimate can be obtained from the model if the estimate value is known.

In 1992, the number of ULs in the 1-19 class was 2,091,000 units (equal to 41% of total ULs of MI). The associate sampling error resulting from the application of this model was about *0.30%*.

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[30] The Register of Companies is used to check the number of employees declared by enterprises and to get information on the state of activity (useful to accept or not outliers).

Error is very low since the total of MI was considered. If single branches are considered, there is higher and more varied error.

2.2.2 Non-sampling error

Some ISTAT researches evaluated that non-sampling error is about 50% of sampling error (Masselli, 1991).

Thus *0.15%* is the value obtained for UL in 1992.

2.3 Target population

The survey concerns employment defined by ULs as “regular”, “non regular” and “the non employed with part-time job”, that is about 95% of all ULs of MI. Other sources estimate ULs concerning “moonlight job” (equal to about 2% of all ULs in the 1-19 class) and non regular foreigners.

A 5% difference is recorded between the LF survey and NA estimates. This share was estimated using other sources. The accuracy level of these sources is expected to be *E* (a 20% error at least). Therefore *1%* represents the error for this part (this value results from the application of the 20% error to the share not covered by the survey, which is 5%).

2.4 Definitions and Classifications

There are no differences between definitions and classifications used in survey on LF and in the other sources used and UL’s.

2.5 Provisional nature of available data

Needless to say that answers not subject to this type of error.

3. Value added

Statistical surveys on enterprises are the main data sources to estimate the Value Added (VA) aggregate. Analysis relating to MI was made by employee size classes: 1 to 20 employees and more than 20 employees, as there are different surveys for the two classes.

Different types of error defined in section A are analysed below for VA (EP of sources, Target population, Definitions and Classifications, Provisional data).

3.1. Methodology to construct the Value Added aggregate

3.1.1 Enterprises with 20 employees and over

The main sources to construct the VA estimate of MI enterprises with more than 20 employees are: the *Survey on Business Accounting System* (BAS), the survey on the *Provisional Estimate of Gross Product* (Rapid), taking into consideration only the main items of the economic account of big enterprises (with more than 200 employees until 1994, with more than 150 employees from ‘94), it is available from the year after the accounting period examined, and lastly the *SK survey*, designed to update the Business Register. The VA estimate is the result of two operations: the evaluation of per capita VA, the estimate of level, using the Units of Labour (ULs) as expansion factor (ISTAT, 1990). The EP of VA estimate for enterprises with 20 employees and over only depends on above surveys, used to estimate the per capita values. In fact for this class, the number of ULs is considered very accurate (see par.2.1) and it is assumed that for this employee size class all workers are regularly in the wages book.

In this field, attention will be given to calculating the error in true values and in the yearly variations of per capita values (in NA estimates, these variations are the parameter to relate to the reference year the per capita values constructed for the "benchmark" year).

3.1.2 Enterprises with less than 20 employees

The *Survey on Small Enterprises* and the *SK Survey* were used as main sources to construct the VA estimate of MI enterprises with less than 20 employees. The VA estimate is the result of two operations: the evaluation of per capita VA, the estimate of level, using the Units of Labour (ULs) as expansion factor (ISTAT, 1990). The error (sampling and non-sampling) in sources used to estimate ULs is to be calculated in order to evaluate the EP of VA, since the number of people without regular employment is rather high and considered that the number of ULs for enterprises with less than 20 employees is given by regular employees plus non regular employees, which are only partly examined by statistical surveys (they are determined by statistical and economic underground – see section A). These aspects were dealt with in the previous section, in which the methodology currently used to construct ULs was analysed.

3.2. Error Profile of sources

3.2.1. Sampling error

3.2.1.1 Enterprises with 20 employees and over

VA per capita values are estimated from the BAS and Rapid surveys. The corrections made in NA are connected to the quality of data from the surveys and to problems resulting from the updating of the Business Register, since they are total surveys for each observation domain (≥ 20 employees and ≥ 200 employees). In both cases these errors are non-sampling errors.

3.2.1.2 Enterprises with less than 20 employees

VA per capita values were estimated from data provided by Small Enterprises survey.

It is a sample survey via form in the mail, enterprise population is stratified by economic activity (first two digits of ATECO 91, classification of economic activities proposed by ISTAT for '91 census with the same classes of NACE Rev.1 up to the fourth digit), by size of enterprises (1 employee enterprises, 2 employees enterprises, with 3-5 employees, with 6-9 employees, with 10-14 employees and with 15-19 employees) and by geographical areas (5 geographical areas). Enterprises are the examined units.

With reference to data published for 1994 (ISTAT, 1997), about enterprises with 1-9 employees, 0.9 % is the error at Italian level. It is calculated on the basis of five variables (gross fixed capital formation, goods and services purchase, personnel expenditure, turnover and value added) and economic activities on the whole. In particular, value added recorded a 0.7% figure (these errors were calculated using a sort of empirical model, described in the same paper).

For enterprises with 10-19 employees, the relative error is 2.1% at Italian level. In particular, for value added it was 2.9%.

The relative error of examined variables is within 10% for the majority of economic activities and for both classes, even though for the 10-19 it is higher on the average.

As sampling error is higher for Services economic activities, on the average, values obtained for all economic activities can be prudentially assumed as valid even for the MI sector (to compensate for the increase in error values owing to the decreased number of enterprises in the sample section concerning MI).

For the 1-19 class, the error is represented by the weighted average of the two sampling errors using VA weights of the two classes. The final result is *1.6%*.

3.2.2. Non-sampling error

3.2.2.1 Enterprises with 20 employees and over

Non-sampling error is one of the main items of the error profile of surveys. Usually, different types of errors are referred to, but no standard classification has been made insofar. However the following types have been described in literature: a) observation errors; b) non observation errors; c) process errors (Quintano et others, 1987, Penneck, 1995).

Some remarks about non-sampling errors were made on the basis of the “feedback” from IIS to the NA quality analysis; they concerned data collecting, editing and correction.

These remarks resulted first from cross and longitudinal comparisons between BAS and Rapid surveys. Therefore, for a specific reference year, a panel of enterprises included in the two surveys and with “definitive” data can be used. Then data referred to the same enterprises should coincide. As a matter of fact, this condition is not always proved. Two reasons were found to explain these differences: first the respondent behaviour, because he gives different information with no reason, secondly the process to produce data (from data entry to ultimate validation) since error elements can added to supplied data.

The most correct ways to construct both the panel and the estimator most suitable to record the error from these causes are being studied, even though several tests revealed an order of magnitude, which can be neglected[31]. This is a useful parameter to evaluate data accuracy and to check the reliability of information resulting from the integration of the two sources. It is still to be evaluated which of the two sources and conditions can provide the most accurate measure of the phenomenon. In this way bias can be estimated using the same method applied in the re-interview with reconciliation of statistical surveys.

Bias in the estimate of per capita values resulting from *nonresponse* is another part of EP, which can be calculated through the IIS. Bias due to nonresponse is the difference between the per capita values arising from actually collected data and those from the BAS target population. Data about the enterprise target population are needed to estimate this bias. The enterprise target population variables are estimated calculating per capita values from data collected and stratified by geographical area, size and economic activity (according to variables, which are assumed not to be correlated with the reasons for nonresponse) and multiplying for the employees number of the target population, obtained from the integration of BAS and SK surveys; in other words the most up-to-date target population of the IIS is used[32].

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[31] Enterprises which were discorporated or merged are the main problem. In these cases, enterprise tends to give different answers to the same questions included in the two surveys. In fact data are supplied at different times and in a number of cases enterprises take-over and transfers are differently considered.

[32] As a matter of fact the ISTAT department who has in charge the BAS survey gives integrations for nonresponse. Nevertheless it is not used for reasons of timeliness.

Bias resulting from *nonresponse* was calculated using the procedure below. A sample (*sample A*) was selected from data collected by the BAS survey (*population A*) (about 35,000 enterprises). The selected sample should represent the average answer rates of the last years, according to the stratification described above. The suggested estimate method was applied to this enterprise sample, thus the 35,000 enterprises population was estimated (*population B*). The three per capita values were compared, that is the sample of enterprises (*sample A*) (about 16,000), the estimated population in the survey (*population B*) and the actual collected population (*population A*). If data collected were not integrated then the resulting error would be represented by the absolute difference between the per capita values of the collected target population (*population A*) and those of the sample (*sample A*) (3.5% of per capita average value). The same difference between the estimated collected population (*population B*) and the actual population (*population A*) is the error, which is made owing to the difference between estimated and actual data (*2.5%*). It is an estimate of the error due to nonresponse, assuming that the bias resulting from the difference between the sample and the actual collected population (35,000 enterprises) is the same difference between the latter and the actual population (about 55,000 enterprises). The effectiveness of the adopted estimate method is shown by the error decrease resulting from the integration of nonresponse (from 3.5% to 2.5%). However the resulting improvement in NA estimates cannot cancel bias due to nonresponse. We just want to hint that data stratification was defined so that the method correction effect could be maximised.

3.2.2.2 Enterprises with less than 20 employees

As to non-sampling error, useful indications can be found in the appendix to the volume with 1994 data about small enterprises, in which 58,085 enterprises were examined (ISTAT, 1997).

Some aspects should be underlined, namely the outcome of deterministic automated checks applied to quantitative data using the “logic operator mode” or the “monitoring function” (e.g. the “addition” function). These checks consider all types of error in the questionnaire. Corrections are made first of all on non-basic variables according to the adopted criteria, thus non-basic variables are less accurate.

The most interesting incompatibilities analysed in this context are the partial nonresponse about the following variables: costs, employees (but the wage variable is not missing) and wages (but the employee variable is not missing). For these variables, the average intervention rate (for which only the interactive correction can be made by the sector economic expert, after a further questionnaire editing) was respectively 0.3%, 1.1% 0.8%. Editing (that is errors automatic corrections can be made on the basis of known distributions and of basic variables included in the questionnaire and considered correct) were made only for the employees (3.1%) and wages (2.4%).

A good proxy for non-sampling error of VA is the one defined for wages and it is equal to *0.8%,* as it is supposed that the average intervention rate for partial nonresponse is a good estimate of other components of nonsampling error.

3.3 Target population

3.3.1 Enterprises with 20 employees and over

The errors described in this paragraph results from the difference between observation domain resulting from IIS and the observation domain required in ESA.

The analysis of planning specifications for each source allows to evaluate the coverage of the NA aggregate. However, source coverage is seldom equal to theoretical coverage since sources are defined on incomplete lists and because there is nonresponse (these problems are included among nonsamplig errors).

Theoretically, the BAS domain is the same domain required by NA. Thus the error connected with this factor is null (the absence of non-regular economy for this size class was already hypothesised). A biased estimate for per capita VA is supplied by the Rapid survey, because it surveys only enterprises with more than 200 employees. Bias in per capita variations can be estimated as the difference between variations calculated for this domain and variations resulting from the total number of enterprises with 20 employees and over.

For 1991 and 1992, this difference, that is the error made in the VA estimate was 0.6 %.

This parameter can be used as correction factor for data from the Rapid at a more detailed level, for example for branch of economic activity (if the error from the production process is the same for both the examined sets of data).

The actual error that is made results from a comparison between per capita variations (variations resulting from the Rapid) and variations resulting from collected data including enterprises with less than 200 employees, after two years.

In 1991, the error of BAS can be considered *null*, as data from BAS were used. Then the estimated error is about the provisional NA estimate for the year t made at t+90 days.

3.3.2 Enterprises with less than 20 employees

As far as small enterprises are concerned, the errors dealt result from the difference between the IIS observation domain and the ESA one.

The analysis domain of the survey on small enterprises does not include non-regular economy.

In the Italian case, non-regular employment can be calculated with an acceptable reliability level (see chapter2). The value added for "non regular" per capita is estimated in the same way as the one from other surveys. There are no current available and sufficient informations to calculate the error resulting from this procedure.

As the ratio of non-regular employees to total employees is equal to 23% and assigning to the difference between the value added for “non regular” per capita and the one for “regular” per capita a level within 5% and 10%, the error is about *1.7%*.

3.4 Definitions and Classifications

3.4.1 Enterprises with 20 employees and over

We consider the possible different definitions and classifications used for data sources and by ESA. Thus error and accuracy of data are not examined. In fact errors will not be made in the estimates of NA aggregate if sources use the same definitions and classifications adopted for NA.

In the surveys examined in this paper, differences are due to the fact that data are available by enterprise and not by functional unit (FU), for the provisional estimate period. In turn FU is a proxy variable of the Unit of Local Economic Activity (ULEA), that is the unit of analysis for NA estimates (Calzaroni, Pascarella, 1998). Then error is the sum of two elements: the bias between FU and ULEA data, and the bias between the estimate by enterprise and FU.

The difference between percentage variations of per capita values by enterprise (enterprises are classified by main economic activity) and by FU represents the bias introduced by this second element.

For MI, in 1994 the per capita values variation by FU is +8.6% and by enterprise is +10.4%. The FU variation can be estimated using a methodology based on data collected by enterprise. Thus

FU data can be estimated, and the last available structure allows to link the enterprise population with FU population, then the resulting value is +8.9%, and error is reduced by 1.5 %. The difference between the FU estimated data and "true" data by FU represents an estimate of bias which will be made in the following years, if data by FU are not available.

An approximate evaluation of the first element (difference between ULEA and FU data) can be made examining differences in the distribution of employees by FU and ULEA. Distributions are provided by the 1991 Industry and Services Census. A detailed description of the procedure for this evaluation is in the methodological note on the estimate for Units of Labour (Calzaroni, 1998a).

At the level of the MI sector, the error due to this component can be neglected, since the employee redistribution for all the ULs is equal to 0.8%, for the first two ATECO 91 digits.

The error resulting from this element is considered *null* for the definitive years.

3.4.2 Enterprises with less than 20 employees

Should the assumption that small enterprises have a single location and a single function prove true then the error element examined here would be null. Current researches aiming at a general revision of yearly accounts from 1988 show that this assumption is not always true. Therefore this type of bias can be considered *null* till the results of this research are available, because evaluations examined here are about the total MI economic activities.

3.5 Provisional nature of available data

3.5.1 Enterprises with more than 20 employees

The term provisional means that the respondent does not have definitive data. Thus the error is the difference from this datum and the definitive one subsequently supplied by the respondent. In any case it does not depend on errors due to data production process (thus, the difference does not depend on the respondent will – for example provisional balance data supplied by an enterprise).

3.6. Error calculation for the Value Added aggregate

Table D.1.2 shows EPNA errors for MI Value Added with reference to used sources. The figures include the errors attached to the benchmark levels.

Tab. D.1.2 EPNA Value Added – Industrial Transformation

	E.P.	*Target Population*	*Definitions and Classification*	*Provisional Data*
BAS	2,5%	0,0%	0,0%	0,0%
SE	2,4%	1,7%	0,0%	0,0%
LF	0,4%	1,0%	0,0%	0,0%

Error components from ULs estimates (estimated from the LF survey) should be added to the ones for the 1-19 employees enterprises, since an addition synthesis function is used (as the two components are indipendent).

The error of the examined aggregate is a function of the errors in the table.

4. Consumption and Gross Fixed Capital Formation

4.1 ISTAT method to estimate Consumption and Gross Fixed Capital Formation

This section describes **Consumption** and **Gross Fixed Capital Formation** aggregates.

Survey on Household Budgets (HB), BAS survey and survey on Industrial Production (SIP) are the main sources.

Survey on HB is carried out by EUROSTAT Partners, however its realisation and use in terms of NA varies in the different Countries (see Borgioli, Cainelli, Costanzo, Mantegazza, 1998, used in this paper as reference in constructing error profile of Consumption estimates as far as demand is concerned). In particular, data on consumption and output for own final use are used within estimates of NA single item.

HB data are considered reliable in estimating household Consumption of durable and semidurable goods and expenses for particular kind of services, such as dwellings. As regards durable Consumption and Consumption of products from manufacturing industries transformation on the whole, estimate of apparent Consumption is updated through supply method[33].

Actually, HB survey and supply method provide non sufficient information for the estimate of household Consumption. Services record the wider information gap, but different sources and methods (Di Leo, Corea, Massari, 1998) should be used even for some other goods. However, other sources and methods are not taken into consideration here.

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[33] Supply method estimates good or service quantities potentially supplied to domestic consumption subtracting quantities appropriated for other uses from overall resources of every good class, by the expression:

$$C = P + (M-E) + (G1-G2) - U$$

where C is domestic consumption of good taken into consideration, P domestic production, M imports, E exports, G1 total changes in inventories at the beginning, G2 total changes in inventories at the end and U other uses (ISTAT, 1990, chapter 6, by N. Bernardi). Imports and exports are not considered as they are “official data” drawn from Balance of Payments and consequently exact.

Informations stated on HB survey are valid until 1997. In this year, in fact, a new questionnaire model, with a classification compatible with NA, was adopted. An ISTAT committee is analysing the new survey, comparing error between old and new collecting. It is also realising a statistic model to define sampling error. The direct use of the survey implies lower levels of the final NA aggregate (in Italy, ratio between the two levels is 63%). One of the reasons for this underestimate is the different target population: some changes in basic data processing are required to allow for differences in concepts and definitions particularly concerning target population. Yearly frequency survey permits to use it not on the basis of levels but on the basis of variations without outliers, as expenditure level is available through one year of benchmark. Even though actually only few products are concerned, analysis of time series data allows analysing compatibility with other available sources.

IPA is carried out on enterprises with 20 employees and over every year. BAS and IPA surveys allow to estimate the total production rate and use allocation (in reality, the same product mix estimated for this size class is applied to enterprises with 1-19 employees; the error attached is not possible to estimate with the available information).

However, the supply method is used in estimating benchmark levels, while annual variations are examined to estimate the current years, as from mentioned sources.

A supply method, similar to the one used to estimate household consumption, is used to estimate benchmark levels of Gross Fixed Capital Formation, while the method described before for estimating VA is used to estimate Gross Fixed Capital Formation in the current years as well. In particular, gross fixed capital formation item coming from BAS survey is used to estimate Gross Fixed Capital Formation by Owner Branch while turnover items coming from BAS survey are used to estimate Gross Fixed Capital Formation by Productive Branch (the net exports are added, too). A comparison between estimates is made for obtaining an estimate more accurate than the first one that is used in Account balancing.

4.2 Source Error Profile

As far as BAS is concerned, reference is made to the previous section. Evaluations of VA error components in the above section are still valid. Nevertheless, estimated figures for the EP component have been corrected as the variance of the Gross Fixed Capital Formation variable is nearly twice as much as the variance of other variables estimated through BAS. As regards items used in the supply method (different turnover items requested from enterprises), the same evaluations for VA are used (obviously, those relative to MI).

Error profile is not reported for IPA, but error equal to *C* (between 5% and 10%) is expected from this survey concerning the figures estimated.

4.2.1 Sampling Error

Every year, survey on Household Budgets has a sample of some 39,000 households; it is based on a sample divided into two stages. The former is composed of about 550 Communes divided into two groups: on one hand, provincial Capitals and Communes with more than 50,000 inhabitants and on the other hand, remaining Communes. The latter includes sample households whose name is drawn out from the register office of the Communes previously identified.

Simple random sampling was examined in order to simplify; then as regards consumption function, estimate of standard error in household expenditures (absolute) is given by:

$$\sqrt{N(N-n)}\sqrt{\frac{\sum_i (x_i-\mu)^2}{n(n-1)}}$$

where x_i are the quarterly expenses of the i-th household (i=1,2,...,n), μ the average expenditures of n sample households and N population size.

Means of coefficients of variation were calculated for the following expenditure classes with reference to 1987.1-1994.4 period and the two sub-periods 1987.1-1989.4 and 1990.1-1994.4 (table D.1.3).

Table D.1.3 - Coefficients of variation (%) for consumers'expenditure

	87.1-89.4	90.1-94.4	87.1-94.4
Non durable goods	0,64	0,62	0,63
Semidurable goods	1,62	1,50	1,55
Durable goods	5,02	4,91	4,95
Services	1,42	1,08	1,21
Food and drink products	0,64	0,63	0,63
Non-food products	1,18	1,02	1,08
Total	**0,96**	**0,85**	**0,89**

These coefficients (divided by 100) have to be multiplied by the respective total amount for obtaining values of total error. With reference to 1992, the relative error is *0.9%* if total coefficient of variation (0.85) for 90.1-94.4 period is taken into consideration.

4.2.2 Non-sampling error

Non-sampling errors are due to operative difficulties arising in collecting and processing data (complete or partial nonresponse, errors in compiling, recording and codifying questionnaires).

In '92, participation rate of households was 87%, but just over 80% supplied information, which could be used.

As precise estimates of this kind of error are not available, non-sampling error value calculated through survey on Labour Force is used as proxy variable. Furthermore, this is the reference survey as design of survey on Household Budgets is mainly based on it. However, since HB survey is more complex than the LF one, non-sampling error is expected to be twice to and not 50% of sampling error, as for LF.

Therefore, error is equal to *1.8*%.

4.3 Target Population

HB survey population is the resident population, whereas population present in our national territory at a fixed time is used in NA estimates. Moreover, the survey takes into consideration households, while NA estimates both household and cohabitation consumer expenditures. Survey level adjustment was required. Therefore, estimates from different sources about foreign tourist consumption were added to basic data and per capita expenditure collected was assumed for that part of population, which was not covered by survey.

Underestimate value is 4% on the average (Cainelli, Costanzo, Di Leo, Semprini, 1996). As a precaution, accuracy level for this evaluation is expected equal to *E*, considering survey complexity.

Therefore, error is about *0.8%*.

4.4 Definitions and Classifications

From a concept and definition standpoint, significant differences exist between HB survey and NA estimates. This is the reason why survey outcomes can be used by selection making required adjustments.

Principal differences can be divided into:

1. different processing by expenditure items examined in both consumers' expenditure definitions (output for own final use, rents, insurance, pension funds, health charges, state lottery, lotteries, soccer pools and others);
2. types of expenditure recorded in the survey but not in NA and vice versa (money given to children, social contributions in kind, incomes in kind, second-hand good buying).

19% is the average adjustment incidence to overall survey level, 8% is attributable to rents (Cainelli, Costanzo, Di Leo, Semprini, 1996). Accuracy level equal to *E* is assigned to this evaluation, considering previous paragraph remarks.

Thus, error is about *4%*.

4.5 Provisional nature of available data

Answers given by households interviewed are not subject to this type of error.

4.6 Calculation of error in Gross Fixed Capital Formation

As described in paragraph 4.2, the EP component influences error of Gross Fixed Capital Formation estimate from BAS survey more than the error of VA. Error in Turnover estimate is the same as VA. Total error level is a function of these components and it is expected between the two bounds, as estimate of NA Gross Fixed Capital Formation is given by comparison between the two estimates (a more precise calculation of error has to consider individual economic activities).

As far as IPA is concerned in the benchmark estimates, survey is expected to have an error level equal to *C* (between 5% and 10%).

4.7 Calculation of error in Consumption

Table D.1.4 shows EPNA of non-durable and semidurable Consumption drawn from HB survey. An other source of error comes from BAS turnover items, used to estimate other kinds of Consumption. Also for the Consumption, total error level is a function of these components.

Table D.1.4 EPNA of non-durable and semidurable Consumption

	E.P.	*Target Population*	*Definitions and Classification*	*Provisional Data*
HB	2.7%	0.8%	4.0%	0.0%

It is to stress that the error coming from the EP will grow much more than the other components for the estimates concernig more detailed sectors (for example, see table D.1.3).

So the gap between errors for estimates coming from Supply side (VA) surveys and for estimates coming fron Uses side (Consumption) will grow for each branch of economic activity.

Therefore, the figures here described (considered by balancing process) are only an example to verify if this approach can measure each component of the EPNA.

4. *Conclusions from EPNA approach*

For each NA aggregate, different errors aggregation to have an estimation of total error cannot be standardized, but it depends on type of basic variables and on aggregate construction process (the aim is of estimating incompatible errors, so that an addition function can be used).

However, this paper shows that almost all error factors in estimating the considered aggregates (VA, Consumption and Gross Fixed Capital Formation) can be identified and measured.

In conclusion, double “output” from EPNA is to be outlined:

- Identification and measurement of errors in NA aggregates, as from those in Resources and Uses Account, required for the correct application of Stone balancing method (used in ISTAT);
- Definitions of correction methods, to harmonize estimates with SNA/ESA requirements and namely to reduce errors in estimates on the basis of data from EPNA.

D.2 An approach based on the analysis of discrepancies

1. Application of the C and α criteria to the Italian economic accounts for 1993

The first objective of the test was to evaluate whether the margins of error attributed to each system variable in the final annual accounts for 1993 were coherent with the value assumed by criterion *C*. The analysis was carried out on the equations of the system relating to the 44 branches of economic activity (as the matrix V^* is diagonal, the value of *C* applicable to the whole system is simply given by the sum of the values calculated with respect to each equation) (Puggioni, 1998).

In the case of an individual equation, the number of the degrees of freedom is equal to 1. Setting a significance level of 5% the test is therefore significant when the value of *C* is greater than 7.9[34].

The change from margins to variance, as required by the criterion, was made by setting a level of confidence of 90% (a reasonable value considering the subjective character of the evaluations) and thus t=1.645. To guarantee the reversibility of the matrices a non-zero but negligible value (equal to 0.000001) was set for the margins set at zero.

Table D.2.1 shows, for each equation, the value of the discrepancy (AX^*), of its standard error, $MSQ(AX^*)$, and of the criterion *C*, and the total, in millions of Liras, of uses and resources. None of the equations (referring to the first 44 equations of the system, in other words, the matrices marked **C**, **DSRMC**, **I**, **DSCC**, **R**, **RM**, **MAR** in Figure C.1 in section C) showed significant values, with the value of *C* always turning out to be practically nil, and, as the criterion is additive, the same obviously applies overall for the table of the 44 branches. The reason for this can be seen in the values attributed to the margins; for the sake of caution, these values were generally high enough to reduce the ratio which defines *C*. On the one hand, the margins are coherent with the discrepancies, but on the other, they do not, in themselves, indicate the true reliability of the aggregates.

At this point, again on the basis that the balancing operation was accurate, since the margins of error were homogeneously over-estimated, it was decided to proceed with the analysis in order to evaluate whether, using this approach, coefficients which were more accurate and indicative than those used could be defined.

The variances were reduced therefore, by taking into account a percentage of the values attributed to the margins of error, in steps of 0.1% (up to 1%), of 1% (up to 10%) and of 10% (from 10% upwards), and calculating the corresponding value of *C*. The percentage for the step immediately preceding the one providing a significant result for the test was chosen as being the one closest to the value which guaranteed, for each branch, a coherence of the margins with respect to the discrepancies, without nevertheless "flattening" the value of C excessively.

The result obtained is certainly not the best estimate of the margin of error, but constitutes a value which is probably closer to the "true" value, and in any case is useful as a reference for the estimate of the same margins obtained more directly (for the problems concerning evaluation of the accuracy of the NA aggregates, refer to section D.1).

Table D.2.2 shows that the percentage share lies between 7% and 0.1%, and that the average is 1%, given that for the percentage immediately below (0.9%), half the 44 branches are significant (for the relationship between variance and margin, in fact, a figure of p^2 % for v corresponds to one of p% for dx).

[34] Baxter's work (1992) shows that the contribution to criterion C, attributable to a "grouping", is approximately equal to the square of the ratio between discrepancy and standard deviation; on the assumption that it is normal, this quantity is distributed as a chi-square with 1 degree of freedom.

Table D.2.1 - Criterion C calculated on the variances used for balancing (1993) (mill.liras)

BRANCH	AX*	MSQ(AX*)	CRIT. C	USES	RESOURCES	USES-RES.	SIGN.
01-Agriculture	340161	17132523	0,00	133762074	133421913	340161	NO
03-Coal and lignite	-5682	0	0,00	1387805	1393487	-5682	NO
05-Coking	45732	392371	0,01	912807	867075	45732	NO
07-Petroleum and natural gas	1783505	15241629	0,01	129500485	127716980	1783505	NO
09-Electricity, gas and water	458676	11922766	0,00	54628401	54169725	458676	NO
11-Nuclear fuel	-39343	0	0,00	23657	63000	-39343	NO
13-Ferrous & non-ferrous metals	-2917762	26123264	0,01	78112010	81029772	-2917762	NO
15-Non-mettaliferous minerals	-912917	18868095	0,00	67888510	68801427	-912917	NO
17-Chemicals, pharmaceuticals	-906610	39080761	0,00	153866707	154773317	-906610	NO
19-Metal goods	120668	23920937	0,00	82590600	82469932	120668	NO
21-Agric.& indus. mach.	454149	30358515	0,00	106615393	106161244	454149	NO
23-Office equipment	1023192	5546664	0,03	35066289	34043097	1023192	NO
25-Electrical goods	-1849298	23920178	0,01	101164738	103014036	-1849298	NO
27-Motor vehicles and engines	429331	14479911	0,00	72742530	72313199	429331	NO
29-Other means of transport	80760	6619886	0,00	26215337	26134577	80760	NO
31-Meat	1361385	9284125	0,02	63223090	61861705	1361385	NO
33-Milk and dairy produce	545257	7470516	0,01	32132142	31586884	545258	NO
35-Other foodstuffs	-695801	29480573	0,00	95383907	96079707	-695800	NO
37-Beverages	646702	4112412	0,02	18630236	17983533	646703	NO
39-Processed tobacco	34676	0	0,00	16057871	16023195	34676	NO
41-Clothing and textiles	1189765	36497834	0,00	147881522	146691758	1189764	NO
43-Leather, skins, footwear	1230191	10621736	0,01	47456174	46225982	1230192	NO
45-Wood, wooden furniture	-132321	16984912	0,00	61720820	61853141	-132321	NO
47-Paper, printing, publishing	-345423	19917942	0,00	74187073	74532495	-345422	NO
49-Rubber, plastics	-991361	14227613	0,00	50234126	51225486	-991360	NO
51-Misc.manufactered goods	857599	4386267	0,04	36281904	35424305	857599	NO
53-Building and construction	-980827	52285430	0,00	180660665	181641492	-980827	NO
55-Salvage and repair	1176898	15118242	0,01	56075325	54898426	1176899	NO
57-Commerce	-2077791	54508670	0,00	49008185	51085976	-2077791	NO
59-Hotels and catering	-837625	0	0,00	108161243	108998868	-837625	NO
61-Internal tspt, oil pipelines	202245	22966065	0,00	34116833	33914588	202245	NO
63-Sea/air transport	623338	0	0,00	29011810	28388472	623338	NO
65-Auxiliary transport	296122	5776781	0,00	35476579	35180456	296123	NO
67-Communications	399873	4275115	0,01	35340587	34940714	399873	NO
69-Lending, insurance	-3674973	31883504	0,01	138236752	141911725	-3674973	NO
71-Services to businesses	457361	17613670	0,00	138468531	138011170	457361	NO
73-Leasing of buildings	-468175	0	0,00	146869437	147337612	-468175	NO
75-Private research	298899	0	0,00	12346420	12047521	298899	NO
77-Private health	-155569	0	0,00	41959815	42115384	-155569	NO
79-Recreation and culture	496690	9879233	0,00	78800310	78303620	496690	NO
81-PA	1556	0	0,00	142043350	142041794	1556	NO
85-Public education	2807	0	0,00	74905326	74902519	2807	NO
89-Public health	9657	0	0,00	56872697	56863040	9657	NO
93-Domestic and ISP	0	0	0,00	17192000	17192000	0	NO

Table D.2.2 - Minimum sizes of variance with values of C still not significant (1993)

BRANCH	AX*	MARGIN SIZE	MSQ(AX*)	CRITERION C
01-Agriculture	340161	0,8%	137060	6,16
03-Coal and lignite	-5682	0,1%	0	0,00
05-Coking	45732	5,0%	19619	5,43
07-Petroleum and natural gas	1783505	5,0%	762081	5,48
09-Electricity, gas and water	458676	2,0%	238455	3,70
11-Nuclear fuel	-39343	0,1%	0	0,00
13-Ferrous & non-ferrous metals	-2917762	4,0%	1044931	7,80
15-Non-mettaliferous minerals	-912917	2,0%	377362	5,85
17-Chemicals, pharmaceuticals	-906610	1,0%	390808	5,38
19-Metal goods	120668	0,2%	47842	6,36
21-Agric.& indus. mach.	454149	0,6%	182151	6,22
23-Office equipment	1023192	7,0%	388266	6,94
25-Electrical goods	-1849298	3,0%	717605	6,64
27-Motor vehicles and engines	429331	2,0%	289598	2,20
29-Other means of transport	80760	0,5%	33099	5,95
31-Meat	1361385	6,0%	557048	5,97
33-Milk and dairy produce	545257	3,0%	224115	5,92
35-Other foodstuffs	-695801	0,9%	265325	6,88
37-Beverages	646702	6,0%	246745	6,87
39-Processed tobacco	34676	0,1%	0	0,00
41-Clothing and textiles	1189765	2,0%	729957	2,66
43-Leather, skins, footwear	1230191	5,0%	10621736	5,37
45-Wood, wooden furniture	-132321	0,3%	50955	6,74
47-Paper, printing, publishing	-345423	0,7%	139426	6,14
49-Rubber, plastics	-991361	3,0%	426828	5,39
51-Misc.manufactered goods	857599	7,0%	307039	7,80
53-Building and construction	-980827	0,7%	365998	7,18
55-Salvage and repair	1176898	3,0%	453547	6,73
57-Commerce	-2077791	2,0%	1090173	3,63
59-Hotels and catering	-837625	0,1%	0	0,00
61-Internal tspt, oil pipelines	202245	0,4%	91864	4,85
63-Sea/air transport	623338	0,1%	0	0,00
65-Auxiliary transport	296122	2,0%	115536	6,57
67-Communications	399873	4,0%	171005	5,47
69-Lending, insurance	-3674973	5,0%	1594175	5,31
71-Services to businesses	457361	1,0%	176137	6,74
73-Leasing of buildings	-468175	0,1%	0	0,00
75-Private research	298899	0,1%	0	0,00
77-Private health	-155569	0,1%	0	0,00
79-Recreation and culture	496690	2,0%	197585	6,32
81-PA	1556	0,1%	0	0,00
85-Public education	2807	0,1%	0	0,00
89-Public health	9657	0,1%	0	0,00
93-Domestic and ISP	0	0,1%	0	0,00

Overall, considering that the threshold of significance of the test for 44 degrees of freedom is 71.9 (with significance level always equal to 5%), the figure immediately above the one giving a significant value for the test is 6%.

The use of the criterion *C*, which in practice is equal to the sum of the squares of the standardised residuals, is also proposed, therefore, as a tool for extracting reasonable values which are coherent with the data for the values of the margins of error of the estimates. In the case under consideration, a value equal to about 6% of the initial value should be assigned overall to the margins of reliability attributed to the variables.

In the case of the Italian economic accounts for 1993, application of the methodology proposed by Stone produced a value of 0.003 for the coefficient α, and of 0.059 for $\alpha^{1/2}$ (factor to be applied to the margins of error, for the relationship between variance and margin).

The result practically coincides with that obtained by applying the criterion *C*. From the computational point of view, it should be noted that ratios with a zero denominator were excluded from the calculation of α (ratios relating to variables to which a null margin was attributed, but for which, in some cases, a change was in fact observed after the balancing operation). On the other hand, although a very small value was assigned to the nil variances, this would have "inflated" the standardised adjustments incorrectly.

The value extracted for α taking the system as a whole appears too general and should be evaluated, in the authors' opinion, with reference to the individual equations (Table D.2.3 shows, for each of the first 44 equations, the percentage values of α and of its square root).

As already pointed out regarding criterion *C*, it is plausible that the result of the balancing operation using the Stone method, starting with a variances matrix equal to α% of the one actually used, is not markedly different from the current one, although the advantage of having more accurate estimates for the elements of V is undeniable[35].

The results should however differ if the variances are modified in a non-homogeneous manner (this observation must be taken into consideration if more accurate estimates are available for some elements of the system only: in that case, the variances of the other aggregates should be at least readjusted in accordance with the relationship which exists mid-way between the "new" and "old" values of the margins).

[35] In fact, the application of the balancing operation using the Stone method to the economic accounts for 1993 with predefined shares of the initial margins (10%, 1%), and actually intended to verify Stone's views, did not introduce differences into the balanced values of the estimates.

Table D.2.3 - Percentage values of alpha by branch (1993)

BRANCH	alpha %	sqrt(alpha)%
01-Agriculture	0,1%	2,6%
03-Coal and lignite	0,3%	5,6%
05-Coking	0,2%	4,0%
07-Petroleum and natural gas	0,2%	3,9%
09-Electricity, gas and water	0,1%	2,8%
11-Nuclear fuel	56,5%	75,2%
13-Ferrous & non-ferrous metals	0,6%	7,9%
15-Non-mettaliferous minerals	0,2%	4,1%
17-Chemicals, pharmaceuticals	0,1%	2,6%
19-Metal goods	0,0%	2,2%
21-Agric.& indus. mach.	0,0%	2,2%
23-Office equipment	0,8%	9,1%
25-Electrical goods	0,3%	5,0%
27-Motor vehicles and engines	0,1%	2,8%
29-Other means of transport	0,1%	2,6%
31-Meat	0,4%	6,1%
33-Milk and dairy produce	0,3%	5,7%
35-Other foodstuffs	0,1%	2,6%
37-Beverages	0,4%	6,7%
39-Processed tobacco	0,0%	1,8%
41-Clothing and textiles	0,2%	4,3%
43-Leather, skins, footwear	0,9%	9,7%
45-Wood, wooden furniture	0,1%	2,4%
47-Paper, printing, publishing	0,1%	2,5%
49-Rubber, plastics	0,2%	4,1%
51-Misc.manufactered goods	0,5%	7,4%
53-Building and construction	0,1%	2,9%
55-Salvage and repair	0,2%	4,0%
57-Commerce	0,1%	2,5%
59-Hotels and catering	0,1%	2,4%
61-Internal tspt, oil pipelines	0,0%	2,2%
63-Sea/air transport	0,5%	7,2%
65-Auxiliary transport	0,1%	2,9%
67-Communications	0,1%	2,6%
69-Lending, insurance	1,0%	10,1%
71-Services to businesses	0,1%	2,2%
73-Leasing of buildings	0,1%	2,7%
75-Private research	0,5%	6,8%
77-Private health	0,0%	1,4%
79-Recreation and culture	0,1%	2,8%
81-PA	0,1%	2,3%
85-Public education	0,3%	5,1%
89-Public health	5,8%	24,1%
93-Domestic and ISP	0,0%	0,0%

2. Comments

Even with all the limits mentioned above, criterion *C* has proved to be very useful for the overall analysis of the coherence of the margins of error attributed to the system variables in the national annual accounts. In particular, the criterion has revealed that for 1993, the margins were apparently substantially overestimated (it is in fact sufficient to be able to allow for a figure of not more than 7% for the margins of reliability in order to have values for *C* which are still not significant).

It should be borne in mind, however, that the diagonal structure of the matrix V (which initially, however, is acceptable) simplifies implementation of criterion *C* from both the interpretative and the computational points of view.

Although not yet tested here, the criterion could provide valid indications on the estimate of the margins and on the soundness of the actual process of construction of the aggregates if it is calculated and compared, for individual equations as well as for the total, for various reference years, or for a given year, at the time when the provisional and final data are compared (in short, the criterion could provide a useful indication as to the conformity of the process with the established standards; any differences might, for example, depend on quantitative or qualitative deficiencies of the available sources of information).

Perhaps even more useful and specific, for the various aspects of the analysis of the coherence and fitting of the accounting system, is an analysis of the differences *before* and *after* balancing, both as a basis for comparing the margins of reliability used in the balancing operation and in order to evaluate the size of any over- or underestimate, through the calculation of α as suggested by Stone, which, moreover, provides indications very close to those obtained for *C*.

Arkhipoff (1992, 1993) also uses the differences in the values of the variables before and after balancing to arrive at indicators of reliability of the economic accounts. In the author’s opinion, these indicators could be evaluated from the results produced by the present research, and could also provide indications on the adequacy of the estimates of the variables.

From the interpretative point of view, obtaining estimates of the margins of error "closer" to the "true values" is a an important result, given that it allows these values to be used not just as "weights" for the balancing operation but also as more accurate measurements, in themselves, of the reliability of the aggregates.

This is another important step forward on the road to obtaining the best estimate of the margins of error of the NA aggregates, on the understanding that the most accurate and efficient evaluation requires an approach based on analysis of the information sources and on the methods of constructing the aggregates (cf. Calzaroni, Puggioni, 1996, and Penneck, 1995).

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