Office for National Statistics
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Reliability and Quality Indicators for National Accounts Aggregates

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VOLUME 1: FINAL REPORT

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VOLUME 2: REVISIONS ANALYSIS

INTRODUCTION

Following open, competitive tendering Eurostat commissioned the Office for National Statistics in the United Kingdom to develop a methodology for assessing the reliability of national accounts aggregates, particularly GNP in which the Court of Auditors has a strong interest in the context of budgetary contributions. We are very glad to have had the opportunity to carry out this work.

The methodology which has been developed takes account of the different methods of preparing national accounts among Member States of the European Union. Four Member States, in addition to the United Kingdom, have been selected to cover as fully as possible the wide range of approaches to compiling national accounts found in the European Union. The GNP inventories which have already been provided to Eurostat by Member States' NSIs contain substantial amounts of information about the methods used in each Member State and in particular about balancing procedures, changes to benchmarks and revisions policies. This information was supplemented with information obtained from discussions with the NSIs of each of the five countries selected. We are extremely grateful to the national accountants in those countries for all the help they have provided to us.

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Section 1. SUMMARY

This study, commissioned by Eurostat, is concerned with establishing methods to assess the reliability of the estimates of national accounts aggregates - particularly the estimates of Gross National Product used to determine Member States' contributions to the budgets of the European Union.

Literature Review (Annex A)

The study involved first an examination of the literature relating to assessments of the reliability of national accounts aggregates and related economic statistics. The resulting literature review is included as Annex A to this report. As is apparent from the review, most of the available literature relates to statistical procedures for balancing national accounts estimates in the face of apparent inconsistencies between results compiled using alternative approaches. These statistical procedures derive essentially from a method which was developed in the early 1940s by Stone, Champernowne and Meade – referred to in this report as the SCM method. This method requires estimates of the reliability of the component estimates in the accounts. With these, it is possible to derive (i) statistically the optimal set of balanced accounts and (ii) reliability assessments for the balanced accounts. The literature provides rather less information on how to assess the reliability of the component estimates themselves – a topic on which ISTAT has recently carried out a study for Eurostat.

The literature review also examines work undertaken in a number of countries to analyse revisions to national accounts estimates with a view to assessing the

reliability of the estimates. Methods have been developed particularly to assess the bias in early estimates.

Methods of investigation (Section 2)

As required in the terms of reference for the study, the two different approaches to assessing the reliability of national accounts estimates have been explored further in the course of the study:

(i) analysis of revisions
(ii) procedures based on the SCM method

The methods available, including enhancements of these methods developed during the study, have been applied to the national accounts estimates for five Member States: Finland, France, Italy, Netherlands, and the United Kingdom. These countries were selected to provide coverage of the different approaches to estimating Gross Domestic Product, and hence Gross National Product, followed in the European Union.

As far as possible the statistics required to carry out the analyses in the later part of the study were taken from Eurostat publications and from the GNP returns. But information was also needed from each of the five countries to supplement our understanding of the procedures followed in compiling their accounts, particularly in relation to the balancing of estimates from alternative approaches and in relation to the policies adopted on revisions to the accounts. Information was also sought on any assessments of the reliability of the component estimates. Notes of the discussions with the national accountants in each of the countries are reproduced in Annex B of this report.

Differences in balancing procedures and revisions policies (Section 3)

While there are many similarities in the methods used in the Member States selected, there are also major differences - as expected in view of the way they were selected,. Section 3 identifies the differences which are particularly relevant to this study. In Finland, the estimate of GDP relies entirely on the production approach. The other four countries undertake some form of balancing at component level to arrive at their estimates of GDP and related aggregates. For some - France and the Netherlands – this balancing involves balancing simultaneously both at current and at constant prices. For Italy and the United Kingdom the balancing is carried out in current prices. Balancing in the Italian case is achieved using the SCM method, in the other three countries the adjustments are made judgementally. For the United Kingdom the balancing process covers the income estimates in addition to the expenditure and production estimates, but in the other countries (including France at least in recent years) the income estimates have been less directly involved in determining the level of GDP.

With the exception of the United Kingdom all five countries have a base year to which their accounts relate, though the significance of the base year to the accounts differs from one country to another – as explained in Section 3. The "revisions policies" followed in each country relate closely to the significance of the base year. For the United Kingdom consideration is given each year to the need to revise for earlier years, though revisions for year T will be made after year T+4 if they make a significant difference. In Finland too revisions will be introduced after the "final" estimates are made in year T+2 particularly if they affect estimates of recent growth rates significantly. In the other three countries, once the “final” or “definitive” estimates are made – typically in year T+3 – no further revisions will be made for year T until the base year is changed.

Subjective assessments of the relative reliability of different component estimates are available for Italy, and to some extent for the United Kingdom. For the other three countries only some broad indications of relative reliability are available. There is little information available on the reliability of each component as opposed to the relative reliability of different components. It is the former which is required to establish the reliability of the aggregates. Italy, the Netherlands and the United Kingdom were however able to supply component estimates both before and after balancing. The differences which these show have been used – as described below – as indicators of the relative reliability which the national accounts compilers attach to the estimates involved.

Analysis of revisions (Section 4)

Limitations on the availability of data for sufficiently long runs of years determined largely the choice of component estimates for which revisions could be examined:

Gross domestic product
Compensation of employees
Private final consumption
Gross domestic fixed capital formation

Successive estimates published for each of these variables for the past 20 or more years - and the revisions between successive estimates - are set out in

Volume 2 of this report. However, for the reasons indicated above, the tables show few revisions after the fourth or fifth estimate, and those which did occur arose usually from the major methodological changes associated with a change of base. The analysis has therefore focused on the revisions between the first and fifth annual estimates, excluding those which involve a change of base. The results of the various analyses are set out in Section 4. For each of the components and for some countries, the revisions made to the first estimates imply some significant bias in the early estimates – at least in comparison with the later "final" estimates. These findings suggest some weaknesses in the estimation procedures used for the early estimates during the period covered by the analysis. The Member States involved may wish to examine these further – if they have not already been rectified in the past few years. What the analysis of revisions cannot provide, however, is any indication of the reliability of the estimates after the revisions - that is, of the "final" estimates. The following section appears more promising in this respect.

Estimation of reliability of aggregates based on balancing procedures and reliability of component estimates (Section 5)

The method developed and used in this section derives from the SCM method referred to above. A common matrix framework, similar to that already used in Italy, is adopted to represent the balancing process. This framework can then be used in different ways so as to reflect the procedures actually employed in each country in balancing its accounts, in particular whether estimates at current and constant prices are balanced simultaneously. The method aims first to establish reliability assessments for the national accounts which would have resulted if the statistically optimal SCM method had been employed in balancing them. With reliability assessments for the balanced accounts, the reliability of aggregates such as GDP - and then GNP - can then be derived in the subsequent stage of the calculations.

Use of the SCM method, however, requires information about the reliability of the component estimates before balancing. For some countries, as reported above, some quantitative assessments of relative reliability are available. For some countries there is information available about the adjustments made in balancing the accounts. The report therefore illustrates two different approaches depending on whether:

(a) assessments of the reliability of component estimates are available, or

(b) implicit, subjective assessments of the reliability of the components have to be deduced from the adjustments actually made in the balancing process.

The methodology is applied in turn to the accounts of each of the five countries, adapted as required to reflect the balancing procedures used. In particular, it is possible to explore the extent to which the reliability of the estimate of GDP is improved by balancing simultaneously at current and constant prices while having regard to the deflators implied. It is evident that in certain circumstances the improvement in reliability can be considerable – as illustrated by the analysis of the figures for the Netherlands.

In the case of Finland, since no balancing is involved in settling the level of GDP, the first stage of the methodology is not required. Instead, GDP is derived directly from the (unbalanced) production estimates as opposed to the balanced estimates for the other four countries. In other words, the balanced and unbalanced production estimates can be regarded as being identical for

Finland. So, as for the other countries, reliability of the aggregates (notably GDP) can be derived in the subsequent stage of the methodology – provided assessments of the reliability of component estimates are available.

As a final step, the report illustrates how the methodology can be used to establish the reliability of GNP from the resulting assessment of the reliability of GDP and from assessments of the reliability of the additional series involved.

Concluding remarks

This study has provided a methodology for establishing reliability assessments for national accounts aggregates and has illustrated how the methodology can be used to take account of the balancing procedures employed in different countries - provided that the estimation procedures can be expected to lead to unbiased estimates of the level of GDP and GNP. However, the methodology requires information on the reliability of the component estimates. If the methodology is to be pursued further, a high priority must be given to establishing the reliability of the component estimates. This aspect is the subject of the parallel study undertaken by ISTAT. The idea developed in this study of examining the adjustments made in the balancing process would also merit further examination.

The analysis of revisions can be helpful – and is indeed essential – for some purposes. On the other hand, for reasons referred to above, in assessing the reliability of the “final” GNP estimates it would seem to offer less scope than the alternative methodology developed in the study.

Section 2. METHODS OF INVESTIGATION

a) *Approaches Adopted*

The study is concerned only with annual estimates at current prices (in the Member State's own currency), and in particular with the procedures for preparing "final" estimates for year T-4 and for handling the subsequent revisions to such estimates. The main issues addressed are the levels of GDP and GNP, but the implications for estimates of growth rates have also been considered. There are two broad strands to the analysis. One focuses on the scale and nature of revisions. The second focuses on the procedures for balancing the national accounts and on assessments of the reliability of the estimates.

<u>(i) Analysis of revisions</u>

This part of the study relies almost entirely on data already supplied to Eurostat. The main source would have been the annual returns to Eurostat under the GNP Directive. However, these were available for only six years and, therefore, statistics published in EUROSTAT publications were used to arrive at the longer time series needed for the analyses. Altogether 20 years of data relating to the individual components of GDP, as well as for the GDP itself, were collected.

In order to obtain consistent interpretation of the time series, the study divides revisions into those due to major methodological changes and other revisions.

The analysis of the revisions is directed towards establishing the scale of the revisions to components and the significance statistically of any bias where the revisions exhibit a noticeable bias. Analysis of revisions does not demonstrate the accuracy of particular estimates, but revisions can be expected in some circumstances to indicate a lower bound to the accuracy of estimates at the appropriate stage of estimation.

(ii) Analysis of balancing procedures and assessments of reliability

The procedures adopted to balance the estimates of GDP vary considerably among Member States. The underlying theoretical approach in this work starts from representing the balancing process which is adopted in a particular Member State as the application of a set of mathematical constraints. With information about the reliability of the components it would then be possible to establish the reliability of the aggregates on the assumption that the balancing procedure was based on a purely statistical approach. (This, it should be added, is not intended to carry the implication that a purely statistical approach to balancing should be adopted, only that this simplifying assumption should be made in examining reliability.)

The method of statistical balancing most widely used is that developed by Stone, Champernowne and Meade (the SCM method). This method is described in mathematical detail in the summary of literature in Annex A to this report. Briefly, the method requires the following inputs:

a. The reliability of each component of the account, expressed as a standard deviation relating to the error in the estimate[1].

b. Information on any correlations between the estimation errors in different components of the account.

c. A set of linear constraints which the account is required to satisfy.

Since in general the initial estimate of the account will not satisfy the specified constraints, the purpose of the balancing method is to distribute any discrepancies over the components of the account in a way which causes as little disturbance as possible. Thus, the objective is to find the balanced account which is nearest to the initial estimate, where "near" is defined in terms of the sum of the squared differences between initial and balanced estimates weighted according to the reliability of the components.

The method of solution of the balancing problem is a form of “constrained least squares” estimation. For fairly small accounts this presents no mathematical problems, but the amount of data to be handled can become unwieldy for large accounts. It can, of course, be difficult to obtain reliable and objective measures of reliability, and it is very rare to find any reliable information on correlations in the estimation errors. It can be shown that the balanced solution is not affected if all the reliability measures are multiplied by a common scaling factor, so that in principle it is necessary to know only the relative reliability of each component. However, unless an absolute reliability measure is available it is not possible to calculate the implied reliability of the balanced account.

[1] If y* is the estimate of the variable whose true value at the relevant time is y, then the “estimation error”, ε, =y*-y. The reliability measure required in the SCM method is σ^2= variance (ε)

The SCM method has been developed considerably since its first presentation in 1942; it is now possible to deal, at least approximately, with accounts involving non-linear constraints and with a sequence of accounts covering successive periods. It has been used experimentally in many countries, but it is not commonly used as a routine part of producing National Accounts.

The main information sought to carry forward this part of the study comprised

(i) a clear understanding of the balancing constraints which are being applied and

(ii) figures, preferably for more than one year, showing the levels of the components, if possible both before and after application of these constraints.

Information was also required about compilers' assessments (whether objective or subjective only) of the reliability - or at least the relative reliability - of different components. Each NSI participating in the study is being given an opportunity to comment on any analysis made of the data relating to the Member State before the report is finalised.

b) Selection of countries for detailed study

The Contract covering this Project requires that the methods recommended should be applied to the national accounts data of at least 5 countries. These countries are to be selected "from those using different measures of GNP and on the basis of the different degree of availability of statistical sources".

The following paragraphs describe the considerations used for the selection of the 5 countries. It is at least implicit in the requirement of the project that countries whose national accounts are to be studied should all be EU Member States; the considerations below therefore concentrate exclusively on the present 15 Member States of the European Union. They also concentrate on the compilation of annual, rather than quarterly, estimates at current prices only.

(i) Approaches to GDP estimation in each Member State

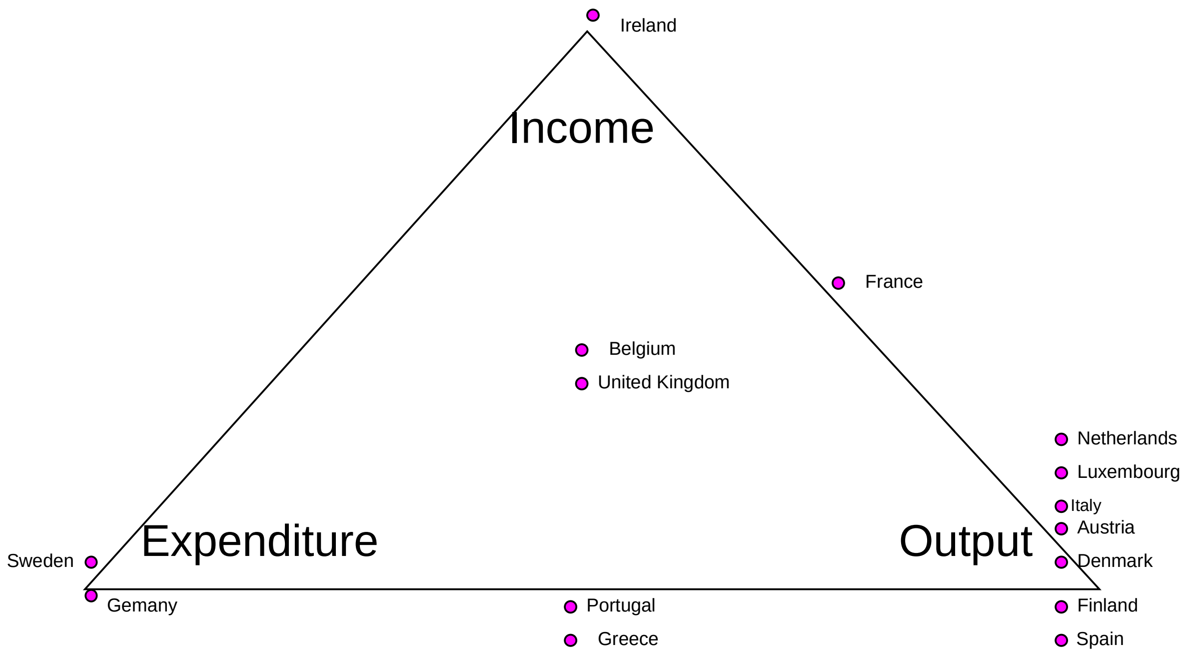
The following table is based on a paper presented by Eurostat to the 25th Meeting of the GNP Committee in October 1996 (Eurostat/B1/CPNB/196) and on additional material from the "GNP Inventories" for each country. Table 1 indicates which of the three approaches can be used in each Member State, by more or less direct aggregation of the relevant components, to derive different estimates of GDP, and indicates in respect of the "final" estimates the dominant approach (if any) and the method of integration. As will be seen from the table, data are available to follow the output and expenditure approaches in nearly all Member States, and in half the Member States the output-based estimates are taken to be the most reliable. In the majority of Member States the estimates from the different approaches are reconciled in a supply-use or commodity-flow framework.

Table 1: Approaches to GDP estimation in each Member State

	output approach	*expenditure approach*	*income approach*	*dominant approach*	*method of integration*
Austria	direct	direct	indirect	output	expenditure adjustment
Belgium	direct	direct	direct	average	not fully integrated
Denmark	direct	direct	indirect	output	commodity flow
Finland	direct	direct	indirect	output	judgement at macro level
France	direct	direct	direct in later estimates	output/ income	in generation of income a/c
Germany	direct	direct	indirect	expenditure	judgement at macro level
Greece	direct	direct	indirect	output/ expenditure	supply/use framework
Ireland	indirect	direct	direct	income	Household spending adjustment
Italy	direct	direct	indirect	output	Extrapolated Supply-use framework
Luxembourg	direct	direct	indirect	output	commodity flow
Netherlands	direct	direct	direct, but not fully reconciled	output	Supply-use framework
Portugal	direct	direct	indirect	output/ expenditure	Input-output
Spain	direct	direct	indirect	output	commodity flow
Sweden	direct	direct	direct but not reconciled	expenditure	commodity flow
UK	direct	direct	direct	none clearly dominant	Supply-use framework

Dominant measure

in methodology applied with ESA 79



<u>(ii) Handling of revisions to National Accounts in each Member State</u>

The procedures for introducing necessary revisions into the national accounts of a Member State are inextricably bound up with the process of benchmarking used in that Member State. Some revisions to recent estimates, or revisions to the methodology used in the estimates for the most recent period, may call for revisions to estimates in earlier years if comparability over time is to be maintained. The earlier years for which the estimates are affected may include the "benchmark" year, for which estimates are not to be revised until the next "benchmarking" exercise. In these circumstances there is then a conflict between accurate estimates of growth rates and accurate estimates of the levels of GDP or GNP. Maintenance of the benchmark may in this manner adversely affect the accuracy of the estimates of the level of GNP, the aspect most important in the context of the GNP Directive.

Table 2: Benchmarking and national accounts revisions policy in each Member State

	current benchmark	*frequency of up-dates*	*first estimate*	*final estimate*	*comments*
Austria	1988		March T+1	September T+3	
Belgium		every 5 years	July T+1	>T+4	benchmarked to 5 yearly I/O table
Denmark		c.every 10 years	April T+1	November T+3	
Finland	1990	every 5 years	February T+1	July T+2	
France	1977-81	occasionally	June T+1	April T+4	
Germany		c.every 5 years	January T+1	September T+3	
Greece	1988				Tied to first input-output table, re 1998
Ireland	None	not applicable			Continuous revision
Italy	1982	every 10 years	T+1	T+3	Full revision when benchmark is changed
Luxembourg		September T+1	September T+3		Full revision occasionally
Netherlands	1987	every 5 years	February T+1	July T+3	
Portugal	1986		October T+1	October T+2	
Spain	1985		February T+1	June T+4	Full revision occasionally
Sweden			March T+1	November T+2	Full revision occasionally
UK	T-1	annually	March T+1	September T+4	Continuous revisions

Table 2, lists the benchmarking adopted in the accounts of each Member State, and relates the Member State's revisions policy to the nature of the benchmarking adopted.

(iii) Proposed selection of countries

It is clear from Table 1 that all Member States with the exception of Ireland have data to estimate GDP directly from estimates of production and all Member States can derive more or less independent estimates built up from figures of expenditure. Fewer Member States are able to use the income approach to estimate GDP. The countries which can are:

(a) Belgium, France, Ireland, Netherlands, Sweden, United Kingdom.

The use made of the income estimates varies considerably however amongst these Member States, ranging from heavy reliance in the case of Ireland to virtually none in Sweden.

All the other Member States have adequate data to calculate GDP separately on the bases of estimates of output and of expenditure. In some cases these alternative approaches are integrated at a detailed level, but in others any adjustments are made only at the macro level. Member States whose output and expenditure estimates are integrated at a detailed level are:

(b) Denmark, Greece, Italy, Luxembourg, Portugal, Spain

The other Member States, who rely on adjustment at the macro level, are:

(c) Austria, Finland, Germany

The issues which arise in relation to the Member States with a relatively abundant supply of data will embrace most of the technical issues relating to the accuracy for those with fewer data sources. With this in mind, it seemed sensible to select at least two of the five Member States whose accounts were to be studied from group (a) above, with at least one from each of groups (b) and (c).

We knew too that work on the accuracy of national accounts had been undertaken in France, Italy and the Netherlands, as well as in the United Kingdom. Taking account of all these considerations, we put forward the following as our preferred selection:

France, Netherlands, United Kingdom, Italy, and Finland.

We are pleased that the national accountants in each of these countries' NSIs agreed to participate in the study.

Section 3. SUMMARY OF DIFFERENCES IN BALANCING PROCEDURES AND REVISIONS POLICIES

Differences in methodology

The five countries whose accounts are taken as examples in this study exhibit both differences and similarities in the ways their estimates of GNP are derived and the way in which revisions are accommodated. The differences and similarities that are particularly relevant in this study are best considered in relation to (i) the balancing procedures involved in estimating GDP, (ii) the use of a benchmark (or base) year, and (iii) the policy on revisions.

(i) Balancing procedures

While the details of the processes appear somewhat different, conceptually the procedures adopted in reconciling the components involved in the different breakdowns of GDP have a substantial amount in common. In four of the Member States covered there is micro-level balancing between the component estimates following the different approaches to estimating GDP - France, Italy, the Netherlands, and the United Kingdom. In Finland, estimates of value added in each industry, derived by a variety of methods, are combined to estimate Gross Domestic Product. Income and expenditure aggregates are then constrained to this total.

In France, Italy, the Netherlands and the United Kingdom, the balancing process in each case involves looking at the inputs and outputs from each industry and the supply and use of the products involved. There are however also differences between the four methodologies:

(a) Balancing at current and constant prices

In France and the Netherlands the balancing is undertaken simultaneously at current and previous year’s prices. In the United Kingdom and Italy, the balancing is undertaken only at current prices.

(b) Treatment of income estimates

In the United Kingdom the estimates of the income components of GDP feed directly into the balancing framework. In contrast, in Italy and in the Netherlands the value added totals are derived, in effect, from balancing output and expenditure estimates; though in the Netherlands the information on wages in particular is used as a plausibility check on the levels of value added at which the balances are struck. In France, the "final" estimates of value added in each industry are heavily influenced (if not determined completely) by estimates from the income side. The industry and product balances which have been struck are modified to achieve consistency with them. However, in recent years the "final" estimates have not been prepared because of the time consuming and complicated nature of the process. INSEE hope to simplify the process when the new base is introduced next year. At present, the balancing procedures underlying the most reliable estimates of French GDP are similar conceptually to those used in the Netherlands at each stage of estimation.

(c) Level of disaggregation

The Netherlands work with more detail than others - 200 industries and 800 products. (The reason for working with so many products is to achieve consistency between value, volume and price changes.) The levels of detail used in the four countries are:

France	90 industries	500 products
Italy	100 industries	100 products
Netherlands	200 industries	800 products
United Kingdom	123 industries	123 products

Finland works with 100 industries.

(d) Use of statistical balancing methods

Only Italy uses a statistical (or probabilistic) method of balancing with explicit assessments of the relative reliability of different components. Large discrepancies are however investigated to eliminate inconsistencies or mistakes in estimation, e.g. timing differences relating to major items. The other three countries use a judgmental, rather than an automatic, approach to balancing.

(ii) Existence of base year

For the United Kingdom's accounts there is no particular base year for the current price estimates, except in the sense that the very latest figures are extrapolated from the latest fully reconciled estimates of GDP - the 1996 figures have just been reconciled.

For the other four Member States - Finland, France, Italy and the Netherlands - there is a base year, but the significance of the base year in the estimation process differs from one Member State to another:

Finland: the emphasis is on estimating growth accurately in the years since the base year - currently 1990, soon to be 1995.

France: the base refers to a particular set of methodological procedures and assumptions which were developed by very detailed study of the data available for years around the base year - currently 1980, soon to be 1995 using data for 1992-94.

Italy: the recent estimates are derived basically by looking at year to year changes since the base year - currently 1982, soon to be 1992.

Netherlands: the emphasis is on the estimation of year to year changes in current and constant prices, since the last major revision year, when levels were re-assessed - currently 1987, soon to be 1995.

(iii) Revisions policy

The way in which revisions are incorporated into the estimates relates very closely to the significance of base years.

Finland: usually after the "final" estimates are made in July T+2 no further revisions are made until the base is changed. However, if the need for significant revisions becomes evident - particularly those affecting recent growth rates - they will be introduced before the base is changed.

France: after the "final" estimates for year T are published in April T+4, no further revisions are allowed until the base is changed. Moreover the estimates are derived using the same sources and methodology as adopted in the base, even if new data sources have since become available.

Italy: after the final estimates are published in T+3, no further revisions will be made until the base year is introduced.

Netherlands: the "definitive" estimates for year T are prepared in April T+3. No revisions to these are made until the base is changed.

United Kingdom: each year consideration is given to the need to revise figures for earlier years. In practice, the work involved in re-balancing the accounts for more than two years means that revisions to estimates for year T are made after year T+4 only when they make a significant difference to the results.

Most of the data needed for the analysis of revisions were available from Eurostat publications. These provided figures for four of the countries. Because Finland joined the European Union relatively recently, Eurostat publications do not offer a sufficiently long run of data for Finland. Statistics Finland however agreed to extract suitable data from their own databases to fill this gap in the data that were needed. The information gained in the meetings in Member States have provided some insight into the main factors underlying the revisions at various stages.

(iv) Assessments of reliability of data used in preparing the national accounts

No country has objective assessments of the reliability of the source data for their national accounts, though in a few instances sampling errors can be calculated. For Italy and for the United Kingdom, there are subjective assessments of the accuracy of data inputs, based on suppliers' views. In Italy, these are used in the balancing of the output and expenditure components of GDP (as described above), but the assessments relate to relative reliability (which is sufficient for balancing purposes), rather than to the absolute levels.

For Finland, France, and the Netherlands there is general guidance about which figures are thought to be more reliable than others, but no quantification of the absolute or relative levels of accuracy.

As an alternative to assessments of the accuracy of component estimates, we have considered the possibility of examining the magnitude of the adjustments made in the balancing process. These have been examined with a view to reaching conclusions about the views on the accuracy of the components which were implicit in the thinking of those responsible for the balancing. The availability of information to pursue this approach at present is however somewhat limited:

In Finland, the GDP estimates are not based on a balancing process, except in the adjustment of expenditure and income aggregates.

In France, the earlier estimates are over-written as the balancing proceeds, and there is no archiving of earlier estimates. Such data cannot therefore be provided.

For Italy, ISTAT kindly provided matrices before and after balancing for 1993 and 1994. ISTAT also provided the relative error assessments used in the balancing process.

Statistics Netherlands have provided data for 1994 at current and constant prices, before and after balancing.

United Kingdom figures before and after balancing have been provided for 1995 (on the ESA79 basis), together with reliability assessments for some component estimates, and assessments of the reliability of the elements involved in moving from GDP to GNP.

In these circumstances, the work in a later part of this study - described in Section 5 - concentrates on showing how the methodology that is proposed can be applied in the context of the different estimation procedures, and particularly the different balancing procedures, used in the five Member States. These procedures are described in the notes of the meetings in Member States (reproduced in Annex B), and tables were supplied to identify the precise balancing framework involved. However, valid estimates of the reliability of GDP and GNP cannot be derived until reliability measures of the component estimates become available in each Member State - the issue addressed in a study undertaken for Eurostat by ISTAT.

Section 4. ANALYSIS OF REVISIONS

Testing for significance of revisions

The question to be answered in this analysis is whether the mean revision four years after first publication, expressed as a percentage of the initial value, is significantly different from zero. In principle, this may be answered by recording the successive revisions, as shown in the Eurostat publications, and then by calculating the mean and standard deviation and hence the "t value". However, there are three possible complications in such a calculation:

a. In some countries there will have been more opportunities to introduce revisions than in other countries, depending on the policy towards making revisions which each country follows. For example, no more revisions may be allowed after T+2 in some countries, while they are allowed in others until T+4, or later. Thus, the fact that estimates have not been revised at any stage does not necessarily mean that they remain the best available estimates. A decision may have been made to postpone the incorporation of the revisions to a later date, e.g. until there is a change to the benchmark year or the base year, thus leading to more changes at that stage. In such years, in contrast, the revisions therefore include changes due to the adoption of a new benchmark as well as normal revisions. Such revisions should not be confused with "normal" revisions when analysing revisions. Accordingly revisions occurring at the time of a change to the benchmark or base year have been excluded from the calculation of mean revisions and t-values

b. Some revisions reflect one-off methodological changes made between changes to the benchmark or base year. Changes associated with the lifting of "reservations" can fall between benchmark changes. In these circumstances they are not always readily separable from other revisions.

These complications need to be kept in mind in considering the results of the analyses in this section. Successive revisions may also be affected by serial correlation, which will invalidate the conditions for the t test. To deal with this, it is possible to apply modifications to the calculation of the t value which make it possible to use the t test validly. If the first order serial correlation of the revisions is r and the number of observations is n, the following changes to the usual calculation must be made:

i. In calculating the standard error of the mean from the standard deviation, the equivalent number of independent observations is taken to be:

$$n\frac{(1-r)}{(1+r)}.$$

ii. The equivalent number of degrees of freedom for the t test is taken to be:

$$n\frac{(1-r^2)}{(1+r^2)}.$$

With these modifications, the usual t test may be used to test the significance of the mean revision.

This analysis has been carried out for all 5 selected Member States, and the results are shown in the summary tables below. These tables cover the following components: GDP at market prices, compensation of employees, private final consumption and gross domestic fixed capital formation. The headline figures shown for each of the five countries are: number of years covered (after deleting years affected by benchmark changes), the mean revision, the serial correlation of successive revisions, the t value (adjusted as above), the adjusted degrees of freedom and the percentage significance level of the t value. The tables also present the results of the Wilcoxon test which is described below.

As the results in Volume 2 show, there are few revisions after the fifth annual estimates of GDP. The analysis is therefore restricted to revisions up to that stage.

Summary of Revisions Analysis

(Revisions = difference between 5th and the first estimate as percent of first estimate)

I) Gross Domestic Product (GDP)

Country	Years covered	Mean revision	Serial correlation	t-value for bias	Adj. d.f. of t-value	Sig. Level of t (%)	Sig level of Wilcoxon T (%)
Finland	8	1.09	-0.16	1.49	7.60	17.58	not sig.
France	15	0.64	0.38	3.81	11.26	0.29	<1.00
Italy	11	0.41	0.51	1.73	6.42	13.40	<1.00
Netherlands	12	0.89	0.82	1.19	2.40	35.76	<1.00
United Kingdom	19	1.63	0.63	3.43	8.22	0.90	<1.00

It can be seen that only in the case of France is the mean revision significantly different from zero, with a t value well beyond the 1% significance level. The

figure for the United Kingdom is close to the 1% significance level, while those for Italy and the Netherlands are well below significance. In the case of the

Netherlands, the very high serial correlation is the main reason for the lack of significance; a t-test ignoring the serial correlation would be highly significant - as the Wilcoxon test also suggests.

(ii) **Compensation of employees**

Country	Years covered	mean revision	Serial correlation	t-value for bias	Adj. d.f. of t-value	Sig. Level of t (%)	Sig level of Wilcoxon T (%)
Finland	8	0.07	0.48	0.45	5.00	67.04	not sig.
France	15	0.64	0.29	2.92	12.60	1.19	>1.00
Italy	11	-0.13	0.33	0.54	8.78	60.23	not sig.
Netherlands	12	0.59	-0.34	3.83*	11.00	0.28	>1.00
United Kingdom	19	0.46	0.17	2.07	17.97	5.30	10.00

*= t-value is not adjusted when correlation is negative.

The analysis of data for compensation of employees show that the mean revisions in three countries - Netherlands, France and the UK - are significantly different from zero. The respective significance level for t-values being below 1%, 1% and 5%. None of the countries shows high serial correlation in the revisions series.

iii) Private final consumption

Country	Years covered	mean revision	Serial correlation	t-value for bias	Adj. d.f. of t-value	Sig. Level of t (%)	Sig level of Wilcoxon T(%)
Finland	8	0.78	0.36	4.19	6.13	0.57	2.00
France	15	0.36	0.38	1.66	11.28	12.45	not sig.
Italy	11	0.02	0.45	0.05	7.31	96.15	not sig.
Netherlands	9	1.00	0.82	2.80	1.79	10.75	<2.00
United Kingdom	16	1.11	0.53	3.08	8.90	1.31	<1.00

The analysis shows that the mean revision to the estimates of annual private final consumption is significantly different from zero for Finland and the UK - both have significance levels below 2 per cent. A high serial correlation was observed in the revisions for the Netherlands, without which the t-value would have been significant.

(iv) Gross domestic fixed capital formation

Country	Years covered	mean revision	Serial correlation	t-value for bias	Adj. d.f. of t-value	Sig. Level of t (%)	Sig level of Wilcoxon T (%)
Finland	8	1.43	0.14	3.71	7.68	0.60	2.00
France	15	1.52	0.52	3.69	8.57	0.50	>1.00
Italy	11	0.11	0.22	0.37	9.96	72.12	not sig.
Netherlands	12	0.66	0.38	1.42	9.00	19.06	not sig.
United Kingdom	19	2.61	0.23	4.14	17.14	0.07	<1.00

The above results show that the mean revisions were significantly different from zero in three countries, Finland, France and the UK. The significance level of t-tests in these countries were below 1% for Finland and France, and below 0.1% for the UK. The mean revisions were around 1.5 per cent for Finland and France, and 2.6 per cent for the UK.

Wilcoxon test

The validity of the t-test depends on the assumption that the revisions are normally distributed. There is no indication that this assumption is violated for these figures, but, given the fairly small sample sizes, only a very gross violation would be visible. It is worth considering whether some other form of test could be found which does not depend on the normality assumption. The obvious candidate for such a non-parametric test is the Wilcoxon test, which is strictly speaking a test of symmetry of the distribution about zero.

However, the Wilcoxon test depends on the assumption that the observations are independently sampled from the same distribution. Hence, it is not suitable for the case found here, where successive observations often have large serial correlation. There is no modification of the Wilcoxon test, parallel to the modification of the t test shown above, which can take account of serial correlation. Consequently, this test is ruled out for application to the present problem.

To provide reassurance in the face of this difficulty, a Wilcoxon test was applied to each of the cases here and compared with the result of the t test without adjustment for serial correlation. It can be seen from the tables above that in most cases, the Wilcoxon test gives similar level of significance as the t test. Hence we conclude that using the modified t test as above does not involve any serious risk of reaching erroneous conclusions.

Summary of Analysis of Revisions

The analysis of revisions does not provide information on the reliability of the "final estimates". What it does provide is some indication of the reliability of the first estimates. In particular it suggests that first estimates of the following variable have shown significant indication of bias in comparison with the final estimates:

GDP

France
United Kingdom

Compensation of employees

France
Netherlands
United Kingdom

Private final consumption

Finland
United Kingdom

Gross domestic fixed capital formation

Finland
France

United Kingdom

The main recommendation to which these findings point is the need to identify more precisely the sub-components contributing to this bias in the first estimates, and to find ways of improving the basis of the first estimates accordingly.

Section 5. ESTIMATION OF RELIABILITY OF NATIONAL ACCOUNTS AGGREGATES BASED ON BALANCING PROCEDURES AND RELIABILITY OF COMPONENTS

In this section, we illustrate how estimates of the accuracy of national accounts, in particular of GDP, can be obtained for the five selected member countries. Since the quantity of information available varies from country to country, it is not possible to use a uniform approach. Instead, a common framework has been developed which can be used in different ways depending on the availability of information and the balancing procedures used in the country's accounts. After a discussion of the general problem, we introduce each country with a description of the available information, explain the method and assumptions used and then give illustrations of the calculations involved to estimate the accuracy of GDP. Applications to the accounts for each country are presented starting with Italy and the Netherlands. The application to these two countries illustrates the full methodology. The application of the methodology to the accounts of the other three countries whose accounts we have studied - Finland, France and the United Kingdom - then follows in the subsequent sections.

What is to be calculated?

The calculations will be set out in the standard framework used by the method of Stone, Champernowne and Meade (SCM) for balancing the accounts. In this system, the account is represented as a column vector x, and is subject to a set of linear constraints represented by a constraint matrix A. The variance of the elements of the account is given by the square matrix V, which will generally be very sparse, usually diagonal. In this framework, we can write the constraints as:

$$Ax = 0,$$

the balanced account as:

$$x^{*} = x - VA'(AVA')^{-1}Ax$$

and the variance matrix of the balanced account as:

$$V^{*} = V - VA'(AVA')^{-1}AV.$$

As a new step going beyond SCM balancing, we assume that the main focus of interest is not on the individual elements of the account, but rather on selected linear combinations such as GDP. For convenience, we focus here on just one combination, which we represent using the coefficient vector *c*, so that the aggregate can be written as $c'x$. We can see that the variance of $c'x$ after balancing can be written in the form:

$$\mathrm{var}(c'x) = c'V^{*}c,$$

which after substitution has the form:

$$\mathrm{var}(c'x) = c'Vc - c'VA'(AVA')^{-1}AVc.$$

It can be shown that, in most cases, it is more efficient to calculate the variance of the aggregate directly using the latter formula, rather than to calculate the balanced variance matrix *V**. This is because in most cases the matrix *V** is not at all sparse, every element being different from zero although many of them are extremely small. In a simple but realistic case, such as balancing in an 11 by 11 input output framework, the number of variables in the supply matrix and use matrix together is about 350, while the number of constraints is 44. In this case, we would find that the coefficient vector representing GDP would have about 50 non-zero elements if we use the expenditure definition - a much smaller number of items than the 350 in the balanced matrices.

The most difficult part of the calculation is the inverse matrix $(AVA')^{-1}$, whose dimensions are 44 by 44 in the example quoted above. However, this matrix is common to all the aggregates based on this account, and would need to be calculated only once for all of them. The other components of the calculation are $c'Vc$, which is not too complicated because V is sparse, even though it is 350 by 350, and $c'VA$, which again is not difficult because $c'V$ is a 350 element vector which has already been calculated in forming $c'Vc$. Consequently, we can calculate the variance of any chosen aggregate without ever having to store any non-sparse matrix as big as 350 by 350.

The numbers may not seem too intimidating in this example, but we should bear in mind that, if we were handling an input output framework with 121 rows and columns, the number of variables could reach over 30,000. On the same basis, the number of constraints would be 484, and the number of non-zero elements in the coefficient vector defining GDP would be about 500. In such a framework, trying to calculate V^* directly would overwhelm any computer, while the calculation of variances of aggregates by the method outlined above would remain (just) feasible.

How to define the calculation?

The outline given above presupposes that the account has been converted into a vector form and the constraints have been expressed as a matrix. In practice, this is tedious, difficult and error prone, and in any practical software it is essential to make the process as automatic as possible. To achieve this, a convenient starting point is the presentation of the accounts as a square matrix, incorporating both the supply and use matrices. An example of this formulation is presented in the GNP inventory for Italy. With this formulation, the balancing constraints are simply that the sum of each row shall equal the sum of the corresponding column. In the Italian case, this presentation is used only for current price accounts, but it is easy to extend this to handle current and constant price data simultaneously in a matrix which has twice as many rows and columns. It is more difficult, however, to take account of the relationship between current price estimates, constant price estimates and price indices, but procedures for doing so are presented.

(i) availability of accuracy assessments for components

Although the algebraic formulation is clear enough, it is not easy to obtain all the required information. Countries can supply the final balanced account, but very few also have any information about the accuracy of the components. However, several countries can provide information about the unbalanced account, although the definition of the starting point can be ambiguous. For example, the initial estimate of the account may contain gross errors due to mistakes in data processing, such as entering the wrong quantity. It would not be right to confuse such errors with the "normal" measurement errors which are meant to be handled by the SCM process.

In the absence of either objective or subjective assessments of the accuracy of each of the component estimates, the information available about balancing adjustments, that is to say the differences between unbalanced and balanced estimates, may be used to provide some information about the reliability of components of the accounts. In effect, in following this approach we assume that countries have balanced their accounts by using an informal equivalent of the SCM process, and we try to find the set of standard errors which, when used in the SCM formula, give adjustments as close as possible to those actually used.

We therefore illustrate, in the following sections, calculations based on the two different bases for establishing the variance matrix V:

(a) where V is based on objective or subjective assessments of the accuracy of component estimates before balancing

(b) where V is based on the adjustments made in the balancing process

Even where information on the reliability of components is available, it may be given in the form of numbers which are merely proportional to the variances, implying that there may be an unknown scaling factor. Such a situation presents no problem for SCM balancing, since the balanced figures are not affected; however, if we require the variance of the balanced figures, as in the present exercise, we must have an estimate of the scaling factor. To deal with this problem, we use Stone's suggestion of scaling variances by the ratio of the Mahalanobis criterion to its degrees of freedom - as described in the Literature Review (Annex A).

(ii) use of different balancing frameworks

Although the principal objective of this study is the accuracy of current price accounts, it is necessary to take account of the balancing processes used by member countries, which often depend on simultaneous balancing in current and constant prices. It is clearly the intention that this process will give greater accuracy than balancing in current prices only; in this work, we shall attempt to quantify this effect.

The process of simultaneous balancing is handled by an extension of the SCM method, involving additional constraints which represent the relationship between current prices, constant prices and deflators. This multiplicative relationship is made linear by using a linear approximation to the logarithms of the variables, as described in the Literature Review (Annex A). In order to use this approach, it is necessary to have some information about the accuracy of the deflators; this is deduced from the difference between the balanced and unbalanced deflators, in the same way as for the other variables.

Analysis of data for Finland

In the case of Finland, no input output balancing is carried out in the course of producing the accounts. The only assessments of reliability of the components are approximate groupings into three categories of more or less reliable figures. In this situation, it is not possible to make any definitive statement about the reliability of GDP estimates for Finland. We can say, purely for illustration, how we could calculate the standard error of GDP if estimates of the standard errors of the components were available.

For example, if the most reliable category (government services) has a standard error of 0.5%, the intermediate category (manufacturing, utilities, agriculture) a standard error of 1% and the least reliable category (construction, services etc) a standard error of 2%, then the calculated standard error of GDP is 0.45%. The method of calculation is simple and direct; for each category, a standard error in monetary terms is calculated from the given percentage, these figures are squared and added and the square root of the sum is expressed as a percentage of GDP.

The figure quoted above is purely illustrative. If actual assessments of reliability for components were available, a meaningful estimate of the standard error of GDP would be produced by this method.

Analysis of data for France

The data available for France consisted of 37 by 37 input-output tables, at current and constant prices, for 1994. The tables had been balanced, but no details of the balancing adjustments were available. There were no quantitative assessments of the reliability of components, so that it is not possible to produce any realistic
assessment of the reliability of the balanced GDP. However, it is possible to illustrate the methodology we propose by constructing some artificial data on reliability.

As a first step, the balanced input-output tables were combined into a single square matrix, for current and constant prices separately, using the same approach as for the other countries already dealt with. In this case, the combined matrix is of size 84 by 84, and is shown in summary form in the table below. (It should be noted that, in the French data, the traditional form of supply table or "make matrix" does not appear, since the analysis uses homogeneous production units and hence the supply matrix is diagonal by definition. Nevertheless, to maintain a uniform approach, a diagonal supply matrix was constructed and inserted. In the combined matrix, the four categories of “final use” are consumption, capital formation, stocks and exports. The four categories of “other supply” are transfers, imports, taxes and margins. “Other inputs” form a single category of value added.)

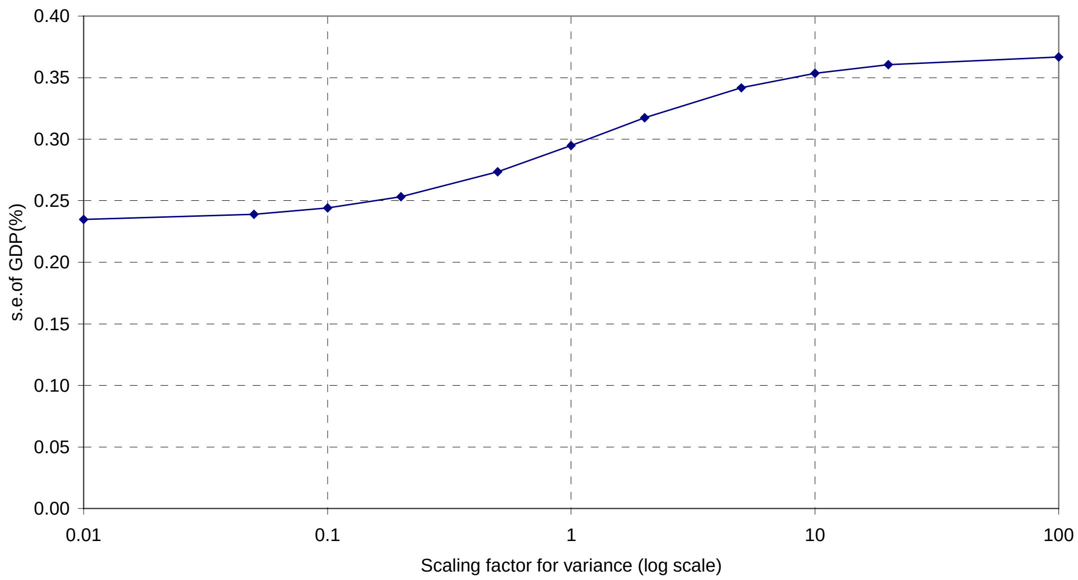
Summary form of French matrix (84x84)

(nos. of rows and columns of sub-matrices in brackets)

	Int. Use (37x37)	Final Use (37x4)			
Domestic Supply (37x37)					
					Final Use Totals (4x1)
Other Supply (4x37)					
	Other Inputs (1x37)				
			Oth. Supply Totals (1x4)	Other Input Total (1x1)	

In order to be able to demonstrate the methodology, a corresponding set of unbalanced matrices was constructed by adding to each cell of the balanced matrices a random disturbance in the range +5% to -5%. The differences between the unbalanced and balanced figures were used to provide estimates of the variances, in the same way as for the Netherlands - that is using basis (a) described above. As for the Netherlands, the relationship between current and constant price data was represented by ratio constraints involving the deflators for the five major components of the expenditure definition of GDP. By scaling the variances of the deflators, it was possible to vary the standard error of GDP between 0.37% and 0.23%, as illustrated in the graph below.

FR: Effect of changing variance of deflators



The figures here are purely for illustration, and do not necessarily represent the true accuracy of the French data. They are in the same range as those found for the Netherlands, since the range of the random disturbances was chosen to make them so. They do serve to illustrate two points about the methods used here. Firstly, the effect of introducing tighter constraints on the deflators is to reduce markedly the standard error of balanced GDP, exactly as for the Netherlands. This is therefore likely to be a general feature of balancing. Secondly, the SCM balancing adjustments are very close to the random disturbances, the correlation being greater than 97%. This result too is consistent with the hypothesis that SCM balancing, with variances estimated as described, can provide a close approximation to the informal balancing used by statistical offices. In this case also, it has to be remembered, however, that only one year's data have been analysed.

Analysis of data for Italy

In Italy, the published balanced account is produced using the SCM method. Consequently, estimates of the variances of the measurement errors for each component are available - basis (a) described above. In fact, the available figures are relative errors, ranging between 0 and 1, which have to be multiplied by the values of the variables to obtain variance estimates.

The available data for Italy consist of balanced and unbalanced current price data, together with the variance factors mentioned above, for 1993 and 1994, presented as a set of 188 by 188 matrices. However, these factors were not used exactly as provided by ISTAT, because in some ways they seemed unrealistic. In particular, the variance factors for some of the major components of GDP were set to zero, although the lower level components from which these were aggregated had non-zero variances. This had the effect that components such as total exports and total imports could not be changed in balancing, although the total could be allocated differently between products and industries. This seemed unreasonable, in the present context, since clearly these totals must be subject to some degree of uncertainty. They were therefore given non-zero variance factors for the purposes of this study.

A calculation was done for 1993 and 1994 separately, using the methods described above. The results were that for 1993 GDP had a relative standard error of 0.24%, while for 1994 the relative error was 0.32%. Despite the changes to the variance factors mentioned above, the calculated balancing adjustments had a high correlation with the actual adjustments.

Analysis of data for the Netherlands

Data for the Netherlands consisted of balanced and unbalanced data, at current and constant prices, for 1994, but with no variance estimates. It was therefore assumed that the variances of the components were proportional to the square of the differences between balanced and unbalanced figures - basis (b) described above. The data were presented as the traditional supply and use tables. As a first step, the supply and use tables, at current and at constant prices, were combined into square matrices as used by Italy; in the Netherlands case the matrices were of size 106 by 106. The table below shows the matrix in a summary form.

Summary form of Netherlands matrix (106x106)

(nos. of rows and columns of sub-matrices in brackets)

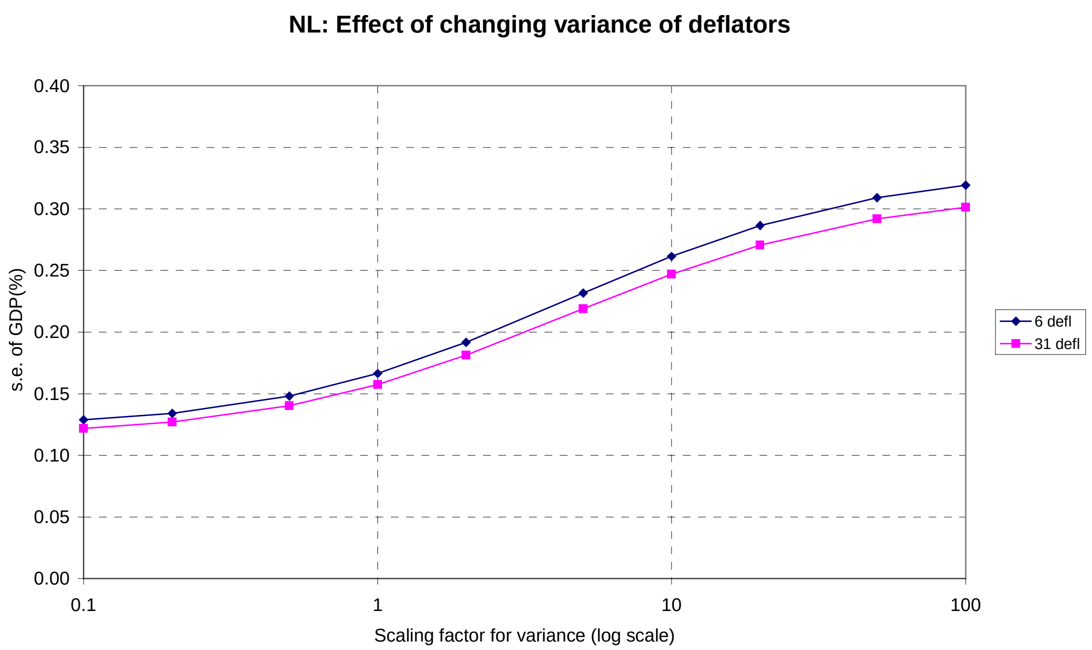
	Int. Use (56x25)	Banking (56x1)	Final Use (56x7)				
Domestic Supply (25x56)						Trade etc Margins (25x1)	
							Banking Total (1x1)
							Final Use Totals (7x1)
Other Supply (4x56)						Trade etc Margins (4x1)	
	Other Inputs (11x25)						
							Total T&T Margins (1x1)
				Oth. Supply Totals (1x4)	Other Input Totals (1x11)		

(In interpreting this table, it should be noted that the Netherlands input-output system uses 25 industries and 56 products. The seven categories of "final use" are exports, household consumption, government consumption, capital formation, stock changes, VAT and consumption of households overseas. The four categories of “other supply” are imports, trade margins, taxes on products and subsidies on products. The 11 categories of “other inputs” include wages and salaries, gross operating surplus and taxes minus subsidies.)

As a first step, the standard error of GDP at current prices, based on a balance of current price data only, was calculated in the same way as for Italy. The result was a relative standard error of 0.35%. Next, a simultaneous balance of current and constant price data, but ignoring the constraint linking current and constant prices, gave a relative standard error of 0.34%.

Finally, an attempt was made to represent the effect of the relationship between current and constant prices. To do this at the level of individual figures in the account would have increased the size of the calculation to an unmanageable extent. The simultaneous balance of current and constant prices involves 194 constraints, this being the total number of rows and columns in the current and constant price matrices after excluding those in which all variables have zero variances. To include a ratio constraint for every component would have added a further 1991 constraints, this being the total number of non-zero entries in each matrix. To reduce the problem to a manageable size, it was decided first to include ratio constraints only for the six major expenditure components of GDP. As mentioned above, the variance estimates for the six deflators were obtained from the square of the differences between balanced and unbalanced deflators. With this definition, the relative standard error of GDP was reduced to 0.17%.

The fact that the standard error is reduced by as much as 50% by the inclusion of the ratio constraints between current and constant price data is at first sight surprising. As a check, the figures were modified by changing the standard errors of the deflators - clearly, if the standard errors of the deflators are large enough, the ratio constraints will have no effect on the balance. The graph below shows the effect of multiplying the estimated variances of all six deflators by a common scaling factor between 0.1 and 100. It is clear that, as the scaling factor increases, the calculated standard error of GDP increases towards the value of 0.34% found when no ratio constraints are present. A factor of 100, meaning that the standard errors of the deflators are multiplied by 10, is sufficient to get almost to the limiting value. At the other extreme, a factor of 0.1 brings the standard error close to a lower limit of about 0.12%. It is clear that the results quoted above, with and without ratio constraints, are fully consistent.



As a further illustration of the methodology, additional ratio constraints were introduced on the output side of the accounts. In each of the 25 industries in the supply table, the product with the largest output was selected. Ratio constraints were included for each of the 25 cells so defined. Thus, these calculations had altogether 31 ratio constraints. The effect of these additional constraints is to reduce the standard error of GDP slightly - from 0.17% to 0.15%. An additional curve showing the effect of varying the deflator variance in this model is shown in the graph above. Clearly, the effect of the additional constraints is small; the six original constraints have captured all the main effect of linking current and constant price data.

It should be mentioned that, in carrying out these calculations, the variance estimates have been scaled the using the Mahalanobis criterion in the way described above. However, the effect of the scaling was not very large; the value of the criterion was typically about 185 with 200 degrees of freedom. This means that the apparently crude method of assuming that the variance may be estimated by the square of the revision in fact seems to work quite well. In addition, the correlation between the calculated balancing adjustments and the actual revisions was always greater than 90%. Hence it seems possible to represent the actual balancing procedure as an approximation to SCM balancing with variances estimated in this way - though it has to be remembered that data for only one year have been analysed.

Apart from its significance in the present exercise, two general results may be deduced from the effect of the ratio constraints as shown in the graph above. Firstly, there is clearly a substantial benefit to be obtained from balancing the accounts in current and constant prices simultaneously. Secondly, it is necessary to have reliable estimates of the deflators in order to obtain this potential benefit of simultaneous balancing.

Analysis of data for the United Kingdom

The data for the UK used in this exercise were taken from 11 by 11 input output tables. Data were available for 1995 at current prices only, showing the balanced supply and use tables and the adjustments made in balancing. As a first step, the supply and use tables were combined into a square matrix, of size 35 by 35, in a similar way to that used for the Netherlands. The table below shows a summary form of this matrix.

Summary form of UK matrix (35x35)

(nos. of rows and columns of sub-matrices in brackets)

	Int. Use (11x11)	FSA (11x1)	Final Use (11x5)			
Domestic Supply (11x11)						
						FSA Total (1x1)
						Final Use Totals (5x1)
Other Supply (3x11)						
	Other Inputs (3x11)	FSA (3x1)	Other Inputs (3x5)			
				Oth. Supply Totals (1x3)	Other Input Totals (1x3)	

(In this table, there are of course 11 products and 11 industries. The five categories of "final use" are consumers' expenditure, government consumption, capital formation, stock changes and exports. The three categories of "other supply" are imports, margins and taxes. The three categories of "other inputs" are sales by final demand, taxes on expenditure less subsidies and total value added.)

As in the case of the Netherlands, the variances of the components were estimated as the squares of the balancing adjustments – basis (b) above. After calculating in the same way as before, the estimated standard error of GDP is 0.05%. Again, the calculated SCM balancing adjustments had a correlation of over 90% with the actual adjustments.

To a limited extent, it is possible to analyse the UK figures using subjective assessments of the reliability of components - basis (a) above. Annual accounts in a simple form were balanced using SCM methods for some years, starting from assessments of accuracy provided by the compilers of the individual data series. The components used in that analysis are not as detailed as those used in the present exercise; in fact, the only components of the 35 by 35 matrix for which reliability assessments are available are the six components of the expenditure definition of GDP, together with total value added. As an experiment, the calculation mentioned in the previous paragraph was re-run using these assessments in place of the variances calculated from balancing adjustments - of course, this could only be done for the few components mentioned. The result of this calculation was a standard error of GDP of 0.14%. The increase, compared with 0.05% found previously, is due to the fact that the balancing adjustments of these components were much smaller than the estimated standard errors - typically less than a quarter.

Since the annual balancing exercise mentioned above has all the necessary subjective assessments of reliability, it is possible to use it to estimate the reliability of GDP wholly using basis (a). Of course, that exercise uses a completely different framework from that of input output balancing ; the data relate to all the activities of sectors of the economy (personal, industrial, financial, etc), and the constraint is that, within each sector, income minus expenditure shall be equal to net financial transactions. Nevertheless, it is worth while to see what the estimated reliability will be using a consistent approach. This was done using data from 1994, and the estimated standard error of GDP was 0.49%. The difference between this and the figure of 0.05% given above emphasises again that the balancing adjustments in the input output exercise are much smaller than might be expected given the subjective assessments of reliability of the components.

The transition from GDP to GNP

All the calculations described above relate to the standard error of GDP. However, the definition of the project refers to the accuracy of GNP. It is therefore necessary to consider how to modify the standard error of GDP to obtain a standard error for GNP. The main components which are in GNP but not GDP are "property and entrepreneurial income received from the rest of the world" and "property and entrepreneurial income paid to the rest of the world"; the other components, relating to compensation of employees, are small enough to be neglected for this purpose.

For most countries in the exercise, there is no information available on the accuracy of these two property income components. However, for the United Kingdom, there are estimates of the reliability of these components prepared in the context of the annual balancing exercise mentioned above. If we assume that measurement errors in the property income components are independent of each other and of GDP, we may calculate the sampling variance of GNP by simply summing the sampling variances of GDP and the property income components. Following this procedure, we find that the standard error of GNP is 0.50%, compared with 0.49% for GDP. We cannot say, of course, whether these results for the UK are typical, but if they are then we may work with standard errors for GDP as though they related to GNP.

The calculation of confidence intervals

The project definition refers to the measurement of reliability through confidence intervals. All the discussion above has related to the estimation of the standard error of GDP or GNP. If we are willing to assume that measurement errors in GDP are purely random and normally distributed, we may define a 95% confidence interval as being a range of two standard errors either side of the estimate. Of course, there may well be biases in the estimation of GDP, due to deficiencies in the coverage of the data or other systematic causes. However, such deficiencies by definition cannot be quantified, since if they could they could also be eliminated. Consequently, the symmetric confidence interval based on normal theory seems the best summary statistic to represent the magnitude of measurement errors in GDP or GNP.

Annex A: REVIEW OF THE LITERATURE

Introduction

The purpose of this note is to review the literature on methods of assessing accuracy and reliability of national accounts and to discuss their relevance to the current Eurostat project. It should be mentioned that much of the literature is devoted to the question of balancing the accounts, that is to say of producing the best consistent set of data given the initially inconsistent estimates. In most cases, these methods assume that the accuracy of the components of the accounts is known. They provide, therefore, a useful way of summarising the error information in the form of error margins for the major aggregates such as GDP. Most papers on balancing do not, however, help with the question of obtaining error margins for the components. Other papers are more helpful for this purpose. The note will discuss first the literature on balancing, then other work on measuring accuracy and finally the implications of this work for measurement of accuracy of the national accounts.

Balanced accounts

The application of balancing methods to national accounts has a history running from 1942, although essentially the same methods have been used in the reconciliation of experimental data from the time of Gauss. This section reviews the literature in roughly chronological order. Each section is identified by the name of the relevant authors, followed by an outline of the methods used by the authors and a brief discussion of their significance.

Stone, Champernowne and Meade (1942)

The original reference on balanced accounts methods is Stone, Champernowne and Meade (1942). The outline of the method of this paper is as follows:

It is assumed that the observations on the components of the account may be represented as a vector x which consists of the true values x_0 together with measurement errors:

$$x = x_0 + \varepsilon. \qquad (1)$$

The measurement errors ε are assumed to be distributed with zero mean and known variance-covariance matrix V. It is assumed that the true values satisfy a set of linear constraints which may be represented by the matrix A:

$$Ax_0 = c. \qquad (2)$$

With these assumptions, it is easy to show that the optimal estimate $x*$ for the true values x_0 which satisfies the constraints is given by the solution to the problem of minimising the quantity:

$$\left(x^* - x\right)' V^{-1} \left(x^* - x\right) \qquad (3)$$

subject to the constraint:

$$Ax^* = c; \tag{4}$$

this is given by:

$$x^* = x - VA'(AVA')^{-1}(Ax - c). \tag{5}$$

Here, "optimal" may be interpreted as meaning either that the balanced estimate is a minimum variance unbiased estimate, with no assumption about the distribution of the measurement errors, or that the balanced estimate is a maximum likelihood estimate, where it is assumed that the errors are normally distributed. These two interpretations may be used interchangeably according to the assumptions considered appropriate.

Equation (5) has a simple intuitive interpretation. The term in the final brackets, $(Ax - c)$ represents the vector of balancing items, that is to say the amounts by which the constraints fail to be satisfied in the initial estimates. The expression by which this is multiplied, $VA'(AVA')^{-1}$, is a matrix which converts the vector of balancing items into a vector of adjustments to the initial estimates. In simple terms, therefore, the process allocates the balancing items over the initial estimates as a function of their reliabilities.

It is worth noting that, in the special case when the matrix V is diagonal, that is when all the errors of measurement are independent, the quantity (3) can be written in the form:

$$\sum_i \frac{(x_i^* - x_i)^2}{\sigma_i^2}, \tag{6}$$

where the sum is over all the elements of the vector x and the σ_i^2 are the diagonal elements of V. Thus, the quantity to be minimised can be regarded as a weighted sum of squares of the differences between the balanced and unbalanced values, where the weights are inversely related to the reliability of the figures. In this sense, the balanced account chosen is the one which is nearest, in terms of this weighted sum, to the original unbalanced account.

It can also be shown that the balanced values have a variance-covariance matrix given by the equation:

$$V^* = V - VA'(AVA')^{-1} AV. \qquad (7)$$

It can be seen from the equation for the modified variance that the balancing process has reduced the variance of every component (except in the special case when the initial estimates x satisfy all the constraints, when of course the balancing produces no change and the variances are also unchanged). In this sense, balancing can be said to have improved the accuracy of the account.

One feature of this method which is worth noting is that the solution does not depend upon the actual magnitudes of the variances and covariances, but simply on their relative magnitudes. It is clearly possible to multiply all the elements of the matrix V by a common scaling factor without having any effect on the solution of equation (5), although of course the variance matrix of the balanced values in equation (7) would be changed by the same scaling factor. Stone et al do not discuss in detail how to obtain the values of the variances. The authors applied the method to a small artificial balancing problem, in which the variances were all obtained from judgements rather than from actual data. At the time, of course, computational restrictions prevented the solution of any large problem by this method.

Byron (1978)

The first major extension of this method was by Byron (1978), who added two features to the method. Firstly, he considered the problem of balancing a very large account, for which the matrix multiplication and inversion of equations (5) and (7) would be very time consuming. He considered the problem of minimising the quantity (3) subject to the constraint (4) by direct numerical methods, rather than by the analytical solution of equation (5). He showed that a conjugate gradient method (see Ralston and Wilf, 1960) would provide an efficient solution to large balancing problems. Of course, this method does not provide the modified variance matrix given by equation (7), so that in this sense we are obtaining less information. Nevertheless, if the primary interest is in the balanced account rather than in the error margins, the results are well worth having.

The second improvement introduced by Byron deals with the problem of accounts containing elements which are not measured directly, and about which nothing is known except that they enable the account to balance. For example, in analysing net acquisition of financial assets by sector, the acquisitions of the personal sector can usually not be measured directly; all that is known is that net acquisitions for all sectors must sum to zero. These residual items make it impossible to obtain a solution using the standard approach described in paragraphs 3-8, since for these items we know neither the value of the unbalanced x nor the corresponding elements of the variance matrix V. Byron shows that we can deal with this problem in two ways.

One way is to express the residual items as a function of others which are measured directly; for example, in the case of financial assets mentioned above, the acquisitions of the personal sector would be replaced by minus the sum of the other sectors wherever it appears in a constraint. By this means, the account is balanced in terms of quantities which are known, with no reference to the residual items. These residual items are then inserted after balancing by using the equations which were used for their substitution.

In more complex cases, however, Byron shows that the process of substitution can be difficult and time consuming. Alternatively, he deals with the problem by allowing these items to have a variance which is effectively infinite; strictly speaking, he shows that the solution is obtained by letting the variance tend to infinity. As well as having a mathematical justification, this method is intuitively appealing; if we know nothing directly about the value of an item in the accounts, it seems natural to express this ignorance by giving the item an infinite variance.

By using these two modifications, Byron was able to balance a moderately large social accounting matrix (46 x 46 elements) in a reasonable computing time (less 15 seconds CPU time).

Arkhipoff (1977)

According to Stone (in the discussion on van der Ploeg (1982)) Byron's work was the first practical use of the method since his 1942 paper. In fact this was not true, since Arkhipoff had independently rediscovered the method of Stone et al and had applied it to reconciling the national accounts of the Cameroon. The essentials of the method are given in Arkhipoff (1977), which shows that his solution is essentially the same as that of Stone et al. In this and other papers (e.g. Arkhipoff, 1992) he has extended and generalised the approach in an axiomatic framework, and he has considered in particular alternative balancing criteria in place of the least squares method used by Stone et al.

Nevertheless, he appears to conclude that the Stone approach is the most appropriate.

Van der Ploeg (1982)

Van der Ploeg (1982) extends the model further by considering the simultaneous balancing of a sequence of accounts, for example the National Accounts for several successive years. Drawing on an unpublished note by Stone (1980), he considers the possibility that errors in successive accounts are serially correlated, or alternatively that some errors persist from one year to other. He sets up a general model, which involves solving a system of equations similar to those set out in (3) to (7) above but covering all the years simultaneously. Such a model is likely to be very large and unwieldy, and he therefore considers a number of simpler special cases.

The first case considered is one in which errors in all variables follow the same pattern of serial correlation. Quoting a result by Stone (1980), van der Ploeg shows that in this case balancing is not affected by the presence of such correlation. The argument to demonstrate this is very similar to that used by Cochrane and Orcutt for their regression method. To take a simple case, if there is only first order serial correlation, so that the errors have the correlation pattern:

$$\varepsilon_t = \rho\varepsilon_{t-1} + \upsilon_t$$

for every variable, then it is clear that the transformation:

$$z_t = x_t - \rho x_{t-1}$$

will give a set of variables z which have no serial correlation. It is also clear that the variance matrix of the errors in the z variables will differ only by the scaling factor $(1-\rho)^2$ from the variance of the x variables. Consequently, the process for balancing the z variables will also balance the x variables, and hence common serial correlation may be ignored in obtaining the balanced account. A similar argument applies in cases of higher order correlation.

A more complex modification of the method involves error components which are common to all the years. Van der Ploeg, following Stone (1980), who in turn is following an earlier unpublished paper by Fisher and Durbin (1953), assumes that two kinds of error can affect all values of a variable. One of these, referred to as a systematic error, is treated as constant for all years. The other, called a proportional error, is a constant multiple of the value of some variable. Consequently, the full error model can be expressed in the form:

$$x_t = x_t^o + \varepsilon_t^x + \varepsilon^{sys} + \varepsilon^{prop} y_t ,$$

where the three error terms are referred to respectively as the spot, systematic and proportional errors; it is of course possible that y is the same as x. With this kind of model, it is necessary to assume that each of the error terms has its own variance matrix, which is known, and that the three error terms are uncorrelated. It should be noted that the systematic and proportional error terms are regarded as random variables, not as fixed bias terms.

Van der Ploeg provides formulae for solving this problem in the most general case. He shows that the most difficult part of the problem is dealing with the proportional error. In a practical example, dealing with the United Kingdom Production Accounts, he considers the case where only spot and systematic errors are present. He derives an estimate of the error variance of the systematic component from the mean balancing error of the sequence of accounts. With these assumptions, he is able to produce a balanced set of production accounts for six consecutive years. Given his simplifying assumptions, the procedure reduces to estimating the systematic error component by balancing the sum of the six separate accounts, then removing the estimated systematic error from each annual account and balancing the account so adjusted.

Van der Ploeg considers the balancing of several years primarily because treating the years individually would give a less accurate balanced account. However, it is necessary in any case to consider such models in the context of estimating, or providing error margins for, year to year growth rates.

It is of course well known that measuring year to year changes can be affected by the presence of serial correlation or systematic errors. It is easily shown that, if successive measurement errors have a positive correlation greater than 0.5, the standard error of the year to year change will be less than the standard error of an individual observation. If the focus of interest is on growth rates rather than levels, and if error margins are required, it is clearly possible to obtain such margins provided that the serial correlation coefficient is known.

If the model is not that of serial correlation but rather the systematic error model, it will also be found that the error of year to year changes can be less than that of levels, because taking the difference between years will eliminate the systematic error component. Provided that the variance of this component is large enough, changes will again be measured more accurately than levels.

Barker, van der Ploeg and Weale (1984)

Barker, van der Ploeg and Weale (1984) produce a balanced version of the United Kingdom national accounts for 1975 at current prices within the framework of the SNA (1968 version). Their method closely follows the approach used by Byron (1978) and van der Ploeg (1982). The main point of interest in this work is the approach to deriving error margins for all the components of the accounts. The method is related to the error margins for major items of the accounts given in official UK sources (Maurice, 1968), which are in turn based on judgements by the compilers of the data components. This source, however, does not provide all the detail required for a full SNA matrix. In most of the matrix, only the standard deviation of the marginal figures is available.

Barker et al obtain an error margin for each element within a block of the matrix as the geometric mean of the errors for the row and column marginal totals. These error margins are further adjusted by applying a common scaling factor to each element in a block, these factors being intended to represent a subjective view of the reliability of the data sources for each block. For elements of the matrix which are known only through accounting identities, they use the device of Byron (1978) of assigning an infinite error margin. In addition to these results, they produce another balanced account, based on a "neutral" assumption of a common percentage error margin for all items in the account. The discussion of the results in Barker et al points out that the two sets of error margins give very different answers. They indicate a preference for the "subjective" results over the "neutral" case, but they do not give any strong argument.

From a computational point of view, the method used is similar to that of Byron (1978) and van der Ploeg (1982). Since they work in current prices only, the system to be solved is entirely linear. The algorithm used exploits the fact that the matrix of constraints is very sparse and that the economic accounting matrix has a very special structure; in this way, it is possible to avoid storing and manipulating large matrices, thereby economising on storage space and computer time.

<u>Stone (1987)</u>

Stone (1987) provides two further extensions to the model. First, he shows that the quantity in equation (3) above should, provided the errors are normally distributed, follow a chi-squared distribution with degrees of freedom equal to n - m - 1, where n is the number of elements in the account and m is the number of constraints. Stone in fact considers only the case of uncorrelated errors, corresponding to (6), but the more general form in (3) is valid for the correlated case also. This test is equivalent to that known as the Mahalanobis criterion.

Provided that the distribution assumptions are valid, this statistic can be used to test whether the balancing process is internally consistent, meaning that the sizes of the balancing adjustments are consistent with the error margins. However, it is not immediately obvious how a significantly large chi-squared value could be interpreted unambiguously. There are at least three different explanations for such a result:

there are major errors or biases in the initial figures, leading to balancing adjustments which are much larger than would be expected;

the variance matrix has been seriously underestimated;

(c) the assumption of normality has been violated, leading to large outliers in the distribution of errors.

In the presence of such ambiguity, the test does not enable us to identify the source of the problem. Nevertheless, a significant result can serve as a warning that there are inconsistencies in the approach being used or in the data.

Following from this, Stone considers using the chi-squared statistic as a means of adjusting the variance matrix, assuming that any inconsistency shown by the test is an indication of incorrect error margins. He assumes that the relative magnitudes of the errors are known, but that they may all be in error by a common scaling factor. Dividing the chi-squared statistic by its degrees of freedom gives an estimate of the appropriate scaling factor for the variances. In his worked example, which covers the UK National Accounts for the period 1969 to 1979, Stone finds that the scaling factor needed for the variances is about 0.005, meaning that the estimated error margins are too large by a factor of about 14. He claims that this is generally true, and hence that there is evidence that error margins are systematically overstated.

There is of course an alternative explanation, namely that the balancing errors in the accounts are smaller than would be expected based on the raw error margins of the components, because the national accounts statisticians have used informal partial reconciliation methods in producing the published accounts.

Sefton and Weale (1995)

While Stone's method assumes that the relative errors are known and simply looks for an appropriate scaling factor, Sefton and Weale (1995) try to the obtain an appropriate covariance matrix directly from the data with no prior assumptions. Their method, which is a development of that described in Weale (1992), assumes that we have a sequence of data values, all generated from observations with the same error covariance matrix. They also assume that the errors are normally distributed. They then show that, if we substitute the covariance matrix of the observations for the covariance matrix of the errors in equations (5) and (7), the result is an estimate of the balancing adjustment which converges in probability to the true adjustment (5) as the number of time points increases.

More specifically, let W be the covariance matrix of the T consecutive values:

$$W = \frac{1}{T}\sum_{t=1}^{T}(x_t - \bar{x})(x_t - \bar{x})'$$

where

$$\bar{x} = \frac{1}{T}\sum_{t=1}^{T} x_t, \qquad (8)$$

and consider the result of substituting W for V in equation (5). If we substitute

$$x_t = x_t^0 + \varepsilon_t$$

in (8) first, and then assume that, in virtue of (2),

$$Ax_t^0 = c,$$

we have:

$$WA' = \frac{1}{T}\sum_{t=1}^{T}(x_t^0 + \varepsilon_t - \bar{x} - \bar{\varepsilon})(\varepsilon_t - \bar{\varepsilon})' A',$$

where

$\bar{\varepsilon} = \bar{x} - \bar{x}^0$,

since the x terms in the second bracket cancel out when post-multiplied by A'. We also assume that the errors are independent of the true values. It then follows that:

$$E(WA') = VA' - VA'/T,$$

and, since the variance of W is of order 1/T, it follows that:

$$plim(WA') = VA',$$

where plim means the limit in probability, that is the probability that the value will be in a small neighbourhood of the limit tends to unity as T tends to infinity.

Furthermore, we can see immediately that AWA' is the covariance matrix of the balancing items. It follows that, as $T \to \infty$, the solution of the balancing equation with W substituted for V tends to the solution of (5).

The practical utility of the method of Sefton and Weale depends on the validity of the underlying assumptions, and on having a sufficiently long sequence of accounts. In practice, these two requirements will conflict. It is unlikely that the covariance matrix of the observations can be determined with sufficient accuracy with less than about 20 years of data. However, it is highly unlikely that methods of data collection will remain sufficiently stable to justify the assumption of a common covariance matrix for a period of 20 years.

Sefton and Weale describe two extensions to this method, which are intended to deal with weaknesses which have been identified. Firstly, they consider the case of general serial correlation in the errors. They do not need to consider the case of a common serial correlation, since, as mentioned above (paragraph 17), this type of correlation may be ignored. In the case of more general correlation, they consider the effect of balancing all periods simultaneously, with a covariance matrix which allows for all the possible correlations between different periods. This makes it necessary to estimate the covariance between errors in different periods.

Sefton and Weale show that the between period covariance may be estimated from the data in the same way as described above for the covariance of a single period. The only complication is that, in estimating the covariance between periods which are k steps apart, the number of available observations is reduced by k. As argued above, the available observations are likely to be too few to estimate a single period variance reliably; the reduced number of observations available for between period covariance makes this problem even greater.

Their other extension is to consider the case of an error covariance which changes over time simply due to the effect of growth or inflation in the economy; in other words, the covariance matrix is changed simply by a scaling factor which is a function of time. They show that it is possible to deal with such a situation, provided that there is only one constraint to be applied to the account. Their method involves an analysis of the changes in proportional or logarithmic terms. They apply this method to the simple problem of reconciling income and expenditure measures of US Gross Domestic Product. However, there seems little prospect of extending the method to deal with balancing of a full set of national accounts with numerous accounting constraints. The prospect of extending the method to cope with more general changes in the error covariance over time, for example due to changes in the methods of data collection, seems even more remote.

UK Central Statistical Office (1989 and later)

One of the few regular large scale applications of balancing methods has been that of the UK Central Statistical Office, which has published annual tables reconciled to eliminate sector balancing items since 1989. For details, see Central Statistical Office (1989) and Baxter (1992). In the earliest of these exercises, the method of Stone et al was applied to each year separately, with no regard to the effect of the balancing process on the inter-year changes. Later, it was decided to take into account the fact that there are some dependencies between balancing adjustments in consecutive years, which are not allowed for if each year is balanced separately. Consequently, in Baxter (1992) a method of partitioned balancing is used.

Partitioned balancing is necessary because a method which takes account of inter-year dependence in a simple way requires us to balance all the years simultaneously. This leads to an unmanageable size of problem. To avoid this situation, use is made of a result contained in the unpublished paper by Fisher and Durbin (1953) mentioned previously (paragraph 18). The effect of this result is that it is not necessary to balance for all the constraints simultaneously.

Let us suppose that the constraint matrix A is partitioned into two sets of constraints, represented by the matrices A_1 and A_2. Using the method of Stone et al, we balance for the first set of constraints A_1. This gives us a first balanced vector, given by the usual equation:

$$x^* = x - VA_1'(A_1VA_1')^{-1}(A_1x - c),$$

and also a first balanced variance matrix, again given by the usual equation:

$$V^* = V - VA_1'(A_1VA_1')^{-1}A_1V.$$

If we now apply the second set of constraints to the result of the first balancing, using the standard method but with the revised variance matrix $V*$ in place of the original matrix V, we have the equation:

$$x^{**} = x^{*} - V^{*}A_2'(A_2V^{*}A_2')^{-1}(A_2x - c).$$

The theorem of Durbin and Fisher states that the result of this process is exactly the same as if all the constraints had been balanced in one stage. Clearly the same principle will apply if the constraints are partitioned into three, four or more sets.

This result by itself reduces the size of the matrix which is to be inverted. However, we are still left with the problem of handling a variance matrix whose number of rows and columns is the same as the number of variables, which may be very large. To reduce this problem, we can identify a further simplification. In partitioning the constraints, we can choose the sets A_1 and A_2 so that A_1 applies only to a subset x_1 of the variables appearing in x, and A_2 applies to a different subset. It is easy to see that, in the first stage of balancing, the balanced values of x_1 can be obtained without taking any account of the remainder of the x vector. Similarly, in arriving at the first stage of the balanced variance matrix, only the part which applies to the x_1 variables will be affected unless there are correlations between the errors in the initial values of x_1 and the remainder of x.

We can extend these results to the situation where the x vector includes the values for all the years, while x_1, for instance, contains the variables for the first year. We can balance for all the constraints which affect the variables of one year only without considering any matrix bigger than a single year. In a final stage, we can apply the constraints which affect several years, which typically will be rather few. In this case, however, the proviso above will come into effect, since there will be correlations between the balanced values of the variables involved and the remainder. It is relatively simple to work out how a balancing adjustment to one set of variables will affect the values of another set of variables, correlated with the first set, but not involved in the constraints. This process, which was called "ripple back", involves much smaller matrices than the whole variance matrix V.

This whole process is referred to as partitioned balancing, and is described in summary form in Baxter (1992) and in more detail in Kenny (1991). Baxter also mentions the use of the Mahalanobis criterion as a diagnostic for the internal consistency of the balancing process. Contrary to the experience of Stone (1987), Baxter found that the chi-squared value tended to be larger than its expectation, though generally not significantly so. He also describes an approximate partition of the chi-squared value into single degrees of freedom associated with each of the constraints or balancing items. In the context of this work, which involved balancing the GDP accounts subdivided by sector, this made it possible to say which sectors contributed most to the size of the chi-squared, though of course not which items in those sectors.

Weale (1988)

In all the developments described so far, we have retained the assumption, set out in equation (2), that all the constraints to be satisfied are linear. In more general systems of accounts, this restriction is unsatisfactory. For example, if we are considering accounts in current and constant prices simultaneously, we will have a relationship between current prices, constant prices and the deflator of the form:

$C = K.D/100$

This constraint should be satisfied by the initial estimates and also by the balanced values. Consequently, the balancing adjustments to these three items must be constrained in this way, which is essentially non-linear. As another example of a non-linear constraint, we may consider the case of a sequence of accounts which include gross domestic product measured in expenditure and output terms. We will usually require that the period to period growth in the output measure shall equal the growth in the expenditure measure. Again, the constraint is essentially non-linear.

Weale (1988) has provided a method of handling such constraints, which involves a linear approximation and is therefore valid provided that the balancing adjustment is not too large. If we return to the multiplicative relation shown above, we may express this in the form:

$\log C = \log K + \log D - \log 100$.

Provided that the initial estimates, say $C_{0,} K_0, D_0$, also satisfy this constraint, we may write:

$$\log C - \log C_0 = \log K - \log K_0 + \log D - \log D_0.$$

Provided that the adjustment is not too large, we may expand the logarithm about the initial estimates, retaining only the first order term. This gives us the equation:

$$(C - C_0)/C_0 = (K - K_0)/K_0 + (D - D_0)/D_0,$$

which may be written as a linear constraint on the balanced values with a non-zero right hand side:

$$C/C_0 - K/K_0 - D/D_0 = -1.$$

By this means, we have turned the original non-linear constraint into an approximately equivalent linear constraint, which may be used in the standard balanced accounts methodology.

In practice, the approximation will be very good provided that no item involved in such a non-linear constraint is adjusted by more than about 3% in the balancing process. Even in this case, however, it may be found that there is some minor discrepancy after balancing. It is common, therefore, to assign one of the terms in the equation to take up the slack due to the approximation. For example, it may be decided that the current price and constant price balanced values will be retained, but the balanced deflator will be calculated directly as the ratio of the two. In many cases this is a minor refinement, but nevertheless it provides a way of avoiding obvious discrepancies.

Solomou and Weale (1993)

Solomou and Weale consider the problem of balancing the accounts in the
presence of general serial correlation and correlation between different accounts. They also consider the point, often made in other studies, that changes from year to year are measured more accurately than the levels in each year. This fact, which is generally accepted, is a clear argument for the presence of serial correlation in measurement errors. If there were no correlation, the variance of the difference in GDP, say, between one year and the next would be twice the variance of the GDP level in one year. In fact, it is necessary for the serial correlation of measurement errors to be at least 0.5 for the variance of the difference to be less than the variance of the level.

Solomou and Weale are considering the balancing of national accounts over a historical period (1920-1938), for much of which the necessary data were not collected in full at the relevant time. The estimates with which they begin are therefore the product of a series of interpolations between benchmarks and other forms of construction. Because of their detailed knowledge of this process, they are able to specify plausible values of the correlation coefficients involved. They find that many of their balanced values are at first sight rather surprising; for example, they find that the balanced value of current price GDP does not lie between the initial income and expenditure estimates.

Measuring the quality of the national accounts

Novak (1975) gives a comprehensive analysis of all sources of error and inconsistency in national accounts, starting with the basic collection of data from surveys or administrative sources, going through adjustments to national accounting concepts, and continuing to the aggregation of data to form major aggregates such as GDP. His criteria for reliability include accuracy (i.e. the closeness of the aggregates to the "true" value), the size of the revisions and the consistency of the accounts. Under the heading of consistency he distinguishes internal consistency, meaning for example that estimates of GDP by alternative routes are equal, and external consistency, which can include discrepancies between international trade estimates produced by exporting and importing countries.

Novak reports a number of analyses of relationships between the "statistical discrepancy" and components of GDP, as well as tests of whether the discrepancy is normally distributed, free from trend and not affected by cyclical fluctuations. These analyses have led to a few significant relationships, but

Novak questions whether they are usable in anticipating revisions; he considers them more useful as a tool for tracing possible errors in the accounts.

Novak also describes methods for measuring and controlling errors, using such techniques as replication of data collection, multiple estimates by different routes, and various quality control procedures. In addition, he has an extensive discussion of the problems of aggregating errors for components in order to arrive at an error measure for an overall measure such as GDP. He admits the occasional necessity of subjective judgements in error or reliability analyses, and has helpful comments on aggregating judgmental error margins. Although the Novak paper contains no numerical analyses, its thorough and systematic discussion of the topics provides a useful framework for other studies.

A number of papers have attempted to produce quality measures for the accounts. For example, Young (1993) gives measures of accuracy and reliability of the US GDP figures. He defines "reliability" simply in terms of revisions in the estimates, while "accuracy" refers to the unobserved total measurement error. As he points out, the total error in the first estimate can be expressed as the sum of the revision plus the total error in the final estimate.

Having introduced this terminology, Young devotes the major part of his paper to the question of revisions. For example, he tests whether the direction of change shown by the early estimates is the same as that shown by the final estimates, whether the mean amount of revision has changed over time and whether the mean revisions provide evidence of bias in the first estimates.

Young discusses accuracy in the context of analysing the dispersion measures for revisions, which have declined over some periods. He argues that "it is reasonable to conclude that this decline in dispersion corresponds with increases in the accuracy of both the initial and final estimates." However, he does not attempt to quantify the accuracy of the final estimates.

Gallais (1995) gives an extensive analysis of the accuracy and revisions of the French national accounts, together with an international comparison of revisions in particular. He concedes that the accuracy of the final figures, when revision is stopped after three years, cannot be quantified in a wholly objective way. Nonetheless, he analyses in detail the way in which the definitive accounts are constructed, with judgements about the inherent accuracy of the various processes, including the detailed reconciliation of the three approaches to GDP estimation. By this means, he is able to produce a plausible, though admittedly to some extent subjective, estimate of the overall accuracy of GDP levels and changes.

Gallais makes international comparisons of the extent of relations to GDP and its major components at various stages. He relates these to the nature of the estimation and reconciliation processes used in each country. In addition, he undertakes a detailed analysis of revisions to French data, in particular identifying a systematic component of the revisions which is related to the stage of the economic cycle. He indicates that Insee propose further work which will seek to include models of the revision process which make it possible to anticipate revisions.

Penneck (1995) reports on a comprehensive study of all aspects of accuracy of the national accounts. The approach used was to consider each possible cause of error in the national accounts variables, such as sampling error, register errors, incorrect imputation of late returns, double counting and so on. Separate pilot studies were mounted for each of these sources of error, to attempt to identify and quantify then as far as possible. Based on these pilot studies, an attempt was made to define a framework for regularly measuring the magnitude of errors, as far as possible integrating this with the routine production of the accounts. Although the project made good progress in considering individual components of error, it did not reach the stage of integrating these results into a measure of overall accuracy.

Calzaroni and Puggioni (1995) give a preliminary analysis of the overall accuracy of an integrated system of accounts. As they point out, this accuracy is a function of the accuracy of the individual components and of the methods of reconciliation used in assembling the overall account. They mention an application of their proposed methods to a component of the Italian national accounts, namely an annual survey of the economic accounts of businesses. However, no details of the results of this application are given.

Jullion (1995) gives mainly an account of the current Canadian system of national accounts, focusing on the use of the system structure as a tool for improving quality. Many of the points he makes are similar to those in Gallais (1995), in that estimates are compared and reconciled at a fairly detailed level; for example, detailed income and expenditure accounts are used in this way. He does however discuss the use of reliability measures for components of the accounts in producing fully reconciled figures.

Jullion states that Canadian national accountants are producing experimental balanced accounts, using error margins which are largely based on root mean square revisions where these are available. Where revisions are very small simply because not much new data will be available, the error margins are increased in a judgmental way. Similarly, judgements are made about the accuracy of financial figures, which are generally not subject to any revision. However, the analysis is not extended to producing an implied error margin for aggregates such as GDP.

When quality is defined primarily in terms of revisions, there are many studies which may be quoted. For example, the UK Central Statistical Office has carried out an annual series of studies of revisions to quarterly estimates of GDP, starting with Kenny (1987). The primary purpose of this work was to test for the existence of bias in the initial estimates of GDP. Earlier evidence had suggested that initial estimates of growth tended to be revised upwards, and the study sought confirmation for this and also tried to identify the components which contribute most to this systematic revision. It was also established that upward revision was greater in the expansion phase of the economic cycle than in the contraction phase.

Even after allowing for the effect of the economic cycle, it was found that the revisions to successive periods tended to be positively correlated. It was necessary to modify the test for significant bias and economic cycle effect to allow for this correlation, initially by using the regression method of Cochrane and Orcutt. Further studies, most recently Rizki (1996), have continued the process of testing for systematic revision, in the context of the framework document setting out the requirements of users of the national accounts.

Application to the Eurostat project.

In the light of the discussion above, it is possible to make some general suggestions about how to approach the question of assigning accuracy measures to national accounts aggregates. It should be possible, provided countries have information available about their balancing procedures, to construct a model of the balancing within each country. All these models will have some common features, and it should be possible to express them within a single framework. In particular, it should be possible to develop standard computing frameworks which may be applied, with suitable changes to reflect the national systems, in different countries. Given the results above, it should be possible to derive an implied error margin for each balanced aggregate. These can then be compared with data on revisions for the same aggregates, to see whether there is consistency.

In considering the application of the methods described here to the Eurostat project, there are a number of questions which will be raised:

If we wish to apply balancing methods, how can we obtain usable estimates of the error margins? As discussed above, in many of the studies carried out so far, the error margins assigned to national accounts variables are based essentially on the professional judgement of the statisticians responsible for their compilation. There are objective methods, notably that of Sefton and Weale, but these have not been used extensively. As mentioned above, it seems doubtful whether, in a study such as this, it will be feasible to construct error margins by this method, because either there will not be a long enough run of data or the assumption of stable errors over the whole period will not be valid.

What is the relevance of revisions data? As pointed out, some studies use the size of the revisions directly as a measure of the quality of national accounts data. Young, for example, explicitly says that a small revision between first and final estimates indicates that the final estimates themselves are more reliable. In the Eurostat project, the objective is to produce a quality measure for the GDP figures after three years of revision. Although it might be possible to compare amounts of revision in different periods, as in the study by Young, and deduce that estimates have become more accurate, it would be very dangerous to use the same method to compare estimates from different countries. The process of revision is too easily affected by policy decisions, the most extreme of which would be to allow no revisions of initial estimates.

It should be noted, of course, that revision histories can give information about two aspects of data quality, namely bias and random error. The literature about balancing methods tends largely to assume that initial estimates are unbiased, and hence that the only relevant error measure is a standard error. Direct information about error margins on national accounts components generally does not admit the possibility of bias, although some work, such as that of the UK CSO, has obtained bias estimates by allowing the compilers to assign confidence intervals which are not symmetrical. Revision history provides another route to estimating the bias component of national accounts error.

Is it possible to use information about the construction of estimates to deduce useful error margins? If a component is based directly on a sample survey, it is usually possible to use information about the survey to assign an error margin. The sampling error may be calculated from internal evidence using the methods of Cochran (1977), while non-sampling errors may be considered using the methods of Lessler and Kalsbeek (1982), for example.

Based on the discussion above and on knowledge of the likely availability of data, the approach to the Eurostat project will use three sources of error information in combination. These will be:

i. Subjective and objective estimates of reliability produced by the Statistical Offices responsible for the data or by other sources.

ii. The size of the discrepancies to be removed in balancing, where it is possible to identify the initial estimates and the final balanced figures.

iii. Information on revisions to previously published data, which will act as a lower bound on the error margins.

The exact combination of these approaches will depend on the extent and reliability of the information which can be collected.

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Annex B: COUNTRY ANALYSES

FINLAND
FRANCE
ITALY
NETHERLANDS
UNITED KINGDOM

FINLAND

Note based on meetings in Statistics Finland, Helsinki, 19 May 1998
Those present: Eeva Hamunen
Raimo Nurminen
Olli Savela
David Wroe

Introduction

There are roughly 70 people working in the Economic Statistics Department of Statistics Finland. The Director of the Department is Markku Suur-Kujala, who joined us for lunch. Eeva Hamunen is the Head of the National Accounts Division, which comprises 18 staff, but particular staff in other Divisions also participate in the compilation of the full, annual national accounts. These include production accounts and gross fixed capital formation by industry, consumption by purpose, sectoral income and expenditure, capital and financial accounts.

The accounts will move to ESA95 in December of this year, for all parts of the accounts except supply and use tables and integrated balance sheets. Since 1979 the accounts have been based on SNA68. There have been official national accounts in Finland since 1948 - the accounts on ESA95 will mark the 50th anniversary - and historical series go back to the 1860s. The GDP estimates are considered to be sufficiently close to ESA79 definitions not to require any adjustment, but some amendments have to be made to component series before they are submitted to Eurostat. The industrial classification used, SIC-95, is the Finnish version of NACE Rev.1. Consistent, detailed time series are available from 1975.

The national accounts at present have 1990 as the base year. The move to ESA95 will be accompanied by a switch to 1995 as the base year, with revisions taken back to 1975. The change of base year is the occasion both for changing the constant prices which are used and for re-aligning the level of GDP if this is necessary. The primary aim in the intervening years is to ensure that growth rates are estimated as accurately as possible. In preparation for the move to the new base, the estimates for the new base year are prepared with particular care, e.g. by scrutiny of more relevant data sources, and then the necessary revisions are carried backwards and forwards from the base year. The 1990 base was introduced in July 1993. Rebasing takes place every five years.

Compilation of annual estimates of gross domestic product

(a) Sequence of estimates

The timetable for the successive estimates of GDP for year t is usually as follows, though there are departures from it in some years, either with extra or fewer revisions:

First estimate	February t+1
Revised first estimate	March t+1
Complete annual accounts	July t+1
Revised complete annual accounts	December t+1
Final accounts	July t+2

(b) First estimates

The first estimates of GDP in the year are compiled in a different manner from the estimates included in the complete annual accounts. The first estimate rests on the method used in the quarterly accounts. Output volume indicators are used to extrapolate value added in each industry at constant prices. This estimation involves the grouping of activity in the economy into 20 industries, though many more volume indicators are used - weighted together as appropriately as possible. Separately expenditure based estimates of GDP are prepared at current and constant prices, to obtain a GDP deflator. This is then applied to the output based estimate of GDP at constant prices to obtain an estimate of GDP at current prices. This becomes the official estimate. Sectoral income and expenditure accounts are prepared at the same time. Gross operating surplus is treated as a residual in the income breakdown of GDP. The GDP estimate is not usually revised in March, but there are usually some revisions to the sector accounts at that time.

(c) Complete accounts, t+1

These are based on much more complete information. The estimation of GDP involves estimation of value added for 100 industries at current and constant prices. The activity units involved are establishments rather than enterprises or other legal units. The data are drawn from many sources, but at this stage there are preliminary data from the Structural Business Surveys (in manufacturing) and from Value Added Tax data. Different methods are used for different industries, including double deflation for agriculture. Some of these depend in part on relationships, e.g. between value added and gross output, in the preceding year's accounts. Estimates are also made of final expenditure in each sector. Large discrepancies (e.g. in excess of 1 per cent in levels or an impact of 1 percentage point on the growth rate) would be investigated very thoroughly, particularly in relation to fixed capital formation and changes in inventories in industries not covered well by the data sources. Any remaining residual is presented on the expenditure side. In the income breakdown, the gross operating surplus is treated as a residual. The complete accounts are published in July. There is a further publication in December, which incorporates any revisions to the t+1 accounts by that stage. A copy of the publication including figures for 1991-96 was provided.

(d) Final accounts t+2

These are prepared in the same framework as the estimates in t+1, but a fresh start is made because by this time more comprehensive information from the Structural Business Surveys and detailed tax returns. The tax returns are used particularly to estimate value added outside manufacturing and to ensure that small businesses are covered. The availability of the tax records, which are matched with the survey data, also help to ensure complete coverage in each industry. The incorporation of this additional data, particularly on occasion through the extra light it throws on the level of intermediate consumption, can affect the level of GDP noticeably. The final accounts for the relevant year (completed eighteen months after the end of the year) are settled, at least contingently, before work starts on the first set of complete accounts for the following year. In general, the "final estimates" are not revised further until rebasing, but, if need for significant revisions becomes apparent, they will be introduced.

Expenditure and income breakdowns of GDP are prepared in the same way as in the first set of complete accounts. On an experimental basis, a fully independent assessment of GDP using the income approach has been prepared. This turned out about 3.5 per cent below the level of GDP estimated from the output approach. The main priority in developing the methods of compiling the estimates of GDP after rebasing will, however, be the reconciliation of output and expenditure estimates through supply and uses tables. At present, input-output tables are compiled after the GDP figures are settled. The tables for 1992 and 1993 have been completed; the tables for 1995 will be completed by the end of the year 1998. They are compiled with 2000 product headings and published with 34. The main difficulty is that of collecting sufficient details on inputs.

Assessments of reliability

As described above, the level of GDP is determined almost exclusively on the basis of value added in each industry, at basic prices, plus the relevant tax yields to move to market prices. The tax data are considered to be highly reliable. Any error in the GDP estimates therefore stems from errors in the estimates of value added. Statistics Finland does not have assessments of the reliability of each of the estimates, though in general they feel that the nature of the business tax records to which they have access helps to ensure that the estimates are very reliable. Possible errors in particular components are thought not to be correlated, but an aspect which has caused some difficulty in the past is the estimation of value added. (Changes to estimates of intermediate consumption were mainly responsible for revisions to the level of GDP when the 1990 base was introduced in July 1993.) The need to allocate data on enterprises to estimates for establishments could conceivably introduce some negative correlation (which would tend to reduce the error in GDP), but certainly any such correlation cannot be quantified. There could also be some negative correlation between the errors in successive years (which would help to reduce errors in estimated growth rates). For estimates at current prices, the relative levels of reliability, in ascending order of reliability, might be:

Building construction, trade and personal services, non-profit institutions, support services related to transport

Gas, electricity and water, manufacturing, agriculture, forestry

Government services

Adjustments for the hidden economy are included in construction and transport

The reliability of the elements used to move from GNP to GDP is also difficult to establish. The amounts involved in respect of compensation of employees are very small. The amounts of property and entrepreneurial income are much larger, and include remitted profits on direct investment. These are estimated through a survey of foreign direct investment. (Unremitted profits are excluded under ESA79.)

Revisions

Statistics Finland has undertaken some analyses of revisions and provided relevant extracts from the results.

Statistics Finland also offered to explore whether they could provide details, in the form of revision triangles, of the successive estimates for each year - of GDP in particular and of components, and NNI (or GNP) and re-invested earnings if possible - going back for 20 or more years from the latest figures, depending on the feasibility of doing so. For this purpose, they would work entirely with the definitions used in their accounts (SNA68) to avoid the need for the detailed adjustments to move to ESA79. (Statistics Finland subsequently confirmed that they could supply such analyses, and made them available for the study.)

FRANCE

Note based on meetings in INSEE, Paris, 14 May 1998
with Francois Lequiller

Introduction

The full annual "campaign" to up-date the French annual national accounts starts in September of year n with the determination first of the final accounts for year n-3, then the semi-final accounts no. 2 for n-2, the semi-final accounts no. 1 for year n-1, and finally the provisional accounts for year n, all to be published around mid-April of year n+1. Once the "final" estimates are made they cannot be changed until the "base" is changed.

The accounts in respect of 1992 are however the latest to have been produced in the four versions. Three estimates were made for 1993, there will be only two for each of the years 1993 to 1996, and one for 1997 - on the 1980 base. This is because INSEE is preparing to introduce a new base, the 1995 base, in April 1999, and needed to free staff time for this purpose. Following the introduction of the new base, there will be three, rather than four, successive estimates for each year.

The use of the term "base" refers to a particular set of data sources and methodologies rather than the use of a particular year as a benchmark. Once the data sources and methodologies have been selected, they are not changed until the next change of base because this would upset the growth rates apparent from the figures. The prohibition on revisions to "final" estimates also means that data from sources that are less frequent than annual cannot be taken into the accounts. Because the level of GDP cannot be adjusted to take account of weaknesses in estimation which have become apparent since the base was adopted, INSEE national accountants sometimes state that they are working at "constant error". The GNP returns include an adjustment "23a corrections directive PNB". This adjustment is not included in INSEE's publication and is [omitted too from Eurostat's publications - to be checked].

The base is changed roughly every 10 years. This involves re-examining fully the estimates for several years, bringing in new data sources, reviewing parameters used in estimation etc. The move to the 1980 base involved thorough review and re-estimation of the accounts for the years 1997-81. The changes in methodology were then taken back to 1970. For the 1995 base, the review and initial re-estimation involves the years 1992-94. When the methodology is settled, the figures back to 1990 will be re-estimated at the same level of detail. Figures for earlier years back to 1970 will be re-estimated similarly, but in less detail.

With the introduction of the1995 base, the national accounts in INSEE's publications will include coverage of economic activity in the French overseas Departments, the DOMs. At present these are not covered in the national accounts in INSEE's publications and are unlikely to be covered in Eurostat's publications, particularly in respect of earlier years. They are, however, included in the returns under the GNP Directive. The DOMs account for about 1.2 per cent of French GDP and will in future be covered indistinguishably in the accounts, both in the course of balancing the accounts and in their presentation.

Analysis of revisions

Gallais's paper published in 1995 is the most recent attempt at a systematic analysis of revisions to the French national accounts. There is a suggestion that the pattern of revisions varied with the phase of the economic cycle, but this has not been researched and documented.

In any analysis of revisions, it is necessary to take account of the following:

(i) whether or not the DOMs are covered at each stage;

(ii) whether the estimates have the same status, i.e. provisional etc.;

(iii) the fact that for the latest years the "campaigns" have been shortened - estimates for 1992 are the latest which are "final" in that they have been the subject of four successive estimations;

(iv) whether figures include or exclude the "GNP correction".

Balancing of the accounts

At each stage - provisional semi-final and final - the same level of detail is involved, as it is also in the balancing in the years studied when the base is revised. The differences in successive estimates stem from the availability of more information. The annual accounts are compiled quite differently from the quarterly accounts.

When the provisional estimates are made there are no company accounts available for use. At this stage GDP is derived from the information available on output and expenditure. At the later stages information becomes available from the structural business surveys and then the fiscal returns for the corporate sector (i.e. business accounts submitted to the tax authorities). At the final stage greatest weight is given to the income based estimates of value added. These take as their starting point the information on profits in the accounts for the corporate sector.

The starting point in making a new estimate for the year in question is the completion of supply and use balances for each of 500 products. These draw on all the available indicators (consistent with the practice in the current base, as described in the inventory). In each case one item is treated as a residual, often stock changes, but the balancing is completed after aggregation to about 90 product/industry categories because data on stock changes is not available in more detail. The supply and use totals are then balanced at both current year and previous year's prices.

Separately from the supply and use balances for each product, the technical coefficients from the previous year's input-output table are used to estimate details of intermediate consumption by product, though for some branches (e.g. agriculture) up-to-date information on intermediate consumption is available and so can be used in preference. Information on use of some other inputs is also available directly. Next the marginal totals from the resulting matrix are compared with totals from the supply-use balances to reveal the extent of discrepancies. A "trade-off" then ensues to reach a fully reconciled matrix of supply and uses, possibly involving changes to the input coefficients. In this manner the expenditure and output figures of value added are reconciled, leading to an estimate of GDP. Except in the final round this is taken as the estimate of GDP, with the income breakdown constrained to it.

In the semi-final stages of estimation, information is available from the structural business surveys on turnover and gross fixed capital formation. Details of production make it possible to switch from the enterprise to the branch basis. This new information and the possible impact of changes to the previous year's estimates mean that the balancing process then starts from different, and in some cases much more reliable, estimates.

In the preparation of the final estimates the same procedure is followed in balancing expenditure and output, though information is now available from accounts submitted to the fiscal authorities. The information used includes that on outputs and gross fixed capital formation, but not inputs. In fact, before the estimation starts the business accounts and the returns under the Structural Business surveys are matched. Information from the survey returns is often added to the details in the business accounts.

It is however the final stage of the process which constitutes the major difference compared with the earlier stages. Separately from the balancing of output and expenditure, as described above, estimates of value added in each institutional sector are derived. The sources used depend on the sector, but for the non-financial corporate sector the process starts from the profits figures in the tax returns. The other income components are estimated from various sources, to lead to an estimate of value added (excluding stock changes). These estimates of value added are then apportioned to each branch of the 90 branches according to the production in the sector, making use particularly of information from the Structural Business Surveys. There are then two estimates of value added for each branch - one from the income side, the other from balancing estimates of output and expenditure. In general, the former are given preference at this stage, though it has proved difficult in practice to cope with the consequences for the supply and use estimates. (A new algorithm has been developed to help with this process when the new base is introduced.)

Assessments of reliability

INSEE does not have explicit assessments of the reliability of the various inputs to the accounts, though some assessments are implicit in the process. In the “final” estimates, in principle at least, the income figures are taken as much more reliable. The information on value added based on the income approach is afforded a “privileged” status. The figures from government accounts are taken as being highly reliable. No changes are made to the values of external trade.

<u>Availability of information on discrepancies</u>

As there is no archiving of successive stages in the balancing process, it is not possible to provide details before balancing. There are however detailed, balanced matrices (roughly 40x40) contained in INSEE’s annual publication “Comptes et Indicateurs Economique”.

<u>Adjustments to move from GDP to GNP</u>

The adjustments are relatively small and are unlikely to affect the accuracy of the

GNP estimate significantly. The estimates are based on banking settlements data. In respect of compensation of employees the figures should be quite reliable, at least in respect of compensation net of deductions.

On property and entrepreneurial income it is difficult to capture accruals of income on bonds, e.g. zero coupon bonds. A statistical method of estimation is likely to be introduced. Re-invested earnings are also missed. Efforts to measure them have not yielded plausible results.

ITALY

Note based on meetings in ISTAT, Rome, 8 May 1998
Those present: Manlio Calzaroni
Augusto Puggioni
David Wroe

Introduction

Manlio Calzaroni and Augusto Puggioni are employed in a section of the National Accounts Department of ISTAT which is concerned with the quality of the data used in the national accounts and with the integration of sources, that is procedures to make the best use of all the sources available. Manlio Calzaroni is likely to be presenting the results of the study they undertook as part of SUPCOM 1996 to the meeting of the EU GNP Group at the end of June. They are still finalising the report and so could not provide a copy even in Italian. They explained, however, that it aims to develop a method which can be used in each EU Member State to estimate the "error profiles" associated with each input to the national accounts. The method follows the approach set out in their paper of which we have a copy, "A Preliminary Approach for the Analysis of the Quality of National Accounts Estimates". It therefore appears to complement well the work we are doing in moving from assessments of the reliability of components to assessments of the reliability of aggregates. They supplied copies of additional relevant papers. I gave them a copy of the latest draft of our literature review.

ISTAT hope that we will be willing to complete on a trial basis the questionnaire which they have developed to build up the error profiles. They would like to discuss this, and related matters of mutual interest, with us at a meeting in London early in June.

Most of our discussion focused on estimation and balancing. ISTAT have not analysed their successive revisions to aggregates in the way in which we are attempting - they have focused much more on the micro level estimates - and were interested to see the results so far. On the change in sign of first revisions during the 1990s, it was said that some of the parameters used in the earlier estimates were changed following the 1991 Censuses and that the downturn in the economy may also have been a factor.

National accounts estimates for Italy

(a) Sequence of estimates

The quarterly and the annual estimates are compiled following quite different procedures. The quarterly estimates are extrapolated from the latest annual estimates using an econometric model. The quarterly estimates for both recent and for earlier periods are therefore realigned when new annual estimates become available.

In respect of each calendar year three estimates are made in successive years. Thus, in respect of 1994 there were the following estimates:

the provisional estimate in 1995
the semi-provisional estimate in 1996
the final estimate in 1997

There are no further revisions to the "final estimates" until new "benchmark" accounts are established. The current benchmark accounts are those for 1982, which were published in 1987. A new benchmark, in respect of 1992, is to be introduced next year when further adjustments for exhaustiveness are also to be incorporated, in line with EU requirements.

<u>(b) Compilation of annual estimates in non-benchmark years</u>

Each year annual estimates are prepared for the three preceding calendar years. For each year the preparation of the estimates starts from those for the previous year. Thus, in 1997 the final estimates for 1994 were prepared first, then the semi-provisional estimates for 1996 and finally the provisional estimates for 1996.

By the time the final estimate is made, more information is available to estimate year-to-year movements in components than is available at the time the semi-provisional estimate is made. In turn, the information available at that stage is more extensive than what is available at the time of preparing the provisional estimates. However, basically the same method of estimation is used at each stage. In brief, the available information is used to estimate the growth in the components since the previous year. The unbalanced accounts which result are then balanced by the method proposed by Stone, Champernowne and Meade (the SCM method). Stone had spoken about the method at a conference in Rome held by ISTAT’s predecessor organisation.

The growth in value added compared with the previous year is derived by examining changes in:

(i) per capita value added by branch of economic activity;
(ii) the full time equivalent of the labour input.

The growth rates in these two (at the 4 digit level of NACE) are applied to value added in the previous year to give value added in the year under consideration. Similar procedures are adopted in relation to other components of the accounts, which are then balanced without further reference to estimates for other years. The first run of the balancing procedure is often used in practice as a diagnostic run to identify any major discrepancies. These are usually the result of special circumstances, such as the production of large items over more than one year, which has not been handled consistently in the estimates. Such a problem needs to be dealt with before attempting to balance the accounts using the SCM method. The SCM method cannot be expected to deal with it satisfactorily. With such anomalies removed, the impact of the SCM balancing is not found to distort growth rates even though each year is balanced sequentially as described.

When the first, provisional annual estimates are made, information is available from a survey of enterprises employing 20 or more people. These enterprises account for 60-70 per cent of GDP. The survey obtains information on value added, gross fixed capital formation and changes in inventories. Information from the survey is used in conjunction with information from the labour force survey and the register of businesses held by the Chamber of Commerce in each of the 100 provinces of Italy. Each business registered for VAT is required by law to register also with the local Chamber of Commerce. The registers hold information on employment which is up-dated annually. First estimates are also available from the household budget survey. No breakdown of value added into different income components is undertaken at the provisional stage, so the balancing involved in preparing the first provisional estimates amounts essentially to balancing output and expenditure estimates in the framework of supply and use tables. These amount to a slightly reduced version of the matrix presented on page 117 of the GNP inventory supplied by ISTAT. The full matrix on page 117 is used in the semi-provisional and final estimates. The income breakdown of GDP is derived using the total of GDP, estimated as described, from information on output and expenditure.

At the stage when the semi-provisional estimates are prepared, information from the structural business surveys is available, covering all large enterprises (i.e. with at least 20 employees) and a sample of smaller businesses. This is supplemented by fiscal data on businesses, including the self-employed, and on salaries and wages. Since 1995, it has also been possible to make use at this stage of VAT and social security registrations, and data from telephone companies, to up-date the register of businesses more completely. Final estimates from the household budget survey are also available. Thus, much more reliable estimates can be made at this stage for the components of both supply and uses of resources. In years when a detailed survey of intermediate consumption is held (e.g. 1992 and 1995), that data would be used to up-date the related "technical coefficients".

At the definitive stage, the estimates of growth from the previous year can be based on final data from the up-dating of the register. By this time the register benefits from the integration of additional information, particularly on employees and on closures, from other sources. After that no more information becomes available until a benchmark year is reached. At this stage, too, the level of GDP estimated from the available information on output and expenditure is used to complete the analysis of GDP by industry.

(c) Estimation in benchmark year

The benchmark years are years when censuses are held of population, of businesses and of agriculture. It is then possible in respect of the benchmark year to make a much better assessment of the coverage of the surveys, and to re-estimate accordingly. The balancing of the GDP estimates for the benchmark year is undertaken in the same way as for other years, using the SCM methodology, but it is carried out at a rather more detailed level of disaggregation, with around 100 separate product/industry branches - 92 in the 1982 benchmark and 100 in the 1992 benchmark.

Assessments of reliability and balancing

For each year other than the benchmark year, the accounts compiled in the manner described above are balanced according to the procedures described in the GNP inventory, in particular using the matrix presentation set out on page 117 of the inventory. The variance matrix currently used, which is based largely on subjective assessments by appropriate ISTAT staff in consultation among themselves, is thought to reflect more adequately the relative reliability of particular components rather than their proper level. The variances do relate however to the levels of the variables involved, as opposed to their growth rates, and are considered to take account of the errors in the benchmark estimates as well as errors which may have been introduced in moving from the benchmark to the year to which the estimates apply. The estimates of output are considered to be among the most reliable components and accordingly receive a high weight (by virtue of a low variance) in the balancing process. It is in this sense that the output approach is dominant in the estimation of GDP for Italy. Some estimates are however given a zero variance because it would not be acceptable to change them e.g. tax revenues. All covariances are assumed to be zero.

Some experimentation has been made using the Mahalanobis criterion to try to establish whether the variances are pitched generally at the right level, and evidently this does not suggest that they are seriously wrong. Assessments are not available in respect of the reliability of the estimated growth rates which are used to derive the latest year's estimates from the estimates for earlier years. ISTAT hope, however, to have error profiles, based on the more objective approach being recommended in the report which Manlio Calzaroni and Augusto Puggioni are preparing for Eurostat, in time to complete the new benchmark estimates next year in respect of 1992. These will include error profiles associated with the three different stages of estimation - provisional, semi-provisional and final.

Information requested for ONS work

We discussed the availability of estimates in the form of the matrix described on page 117 of the inventory. Luisa Picozzi, Head of the National Accounts Department in ISTAT has kindly agreed to make available to us (on diskette) the matrices before and after balancing, and the matrix of variances, for 1993 and 1994. ISTAT would not be able to supply provisional, semi-provisional and final matrices for the same year as the earlier versions are over-written as the later versions are prepared.

NETHERLANDS

Note based on meetings in Statistics Netherlands, Voorburg, 27 May 1998
with Steven Keuning
Taeke Takema
Frits Bos
Brugt Kazemier

Introduction

Statistics Netherlands produces its first estimate of GDP for the year before the end of the year. The sequence of estimates for year t is:

First estimate	November, t
Quarterly flash	mid-February, t+1
Quarterly accounts	end April, t+1
Preliminary annual estimate	July, t+1
Improved preliminary estimate	June, t+2
Definitive estimate	April, t+3

The annual estimates, which are accompanied by a full set of sector accounts, are published in July of each year. The quarterly estimates are realigned to be consistent with the latest annual estimates. After the definitive estimates are published, no more revisions in respect of that year are allowed until a "revision year" is reached. The focus in the Dutch national accounts is on providing the most reliable estimates of changes, so new data sources etc. will be taken into account in the latest figures, but they will be used to show growth accurately - without disturbing the levels in earlier years. This policy is adopted because of the combination of very detailed accounts and the need of many users predominantly for the statistics to be consistent over time, though Statistics

Netherlands recognise that for other purposes the level of GDP or GNP is important. They would like to see an agreed EU policy on revisions, once Member States' accounts have all been brought up to a general standard.

There is a major revision introduced roughly every ten years, with the adoption of a new benchmark (or base year, as it is also referred to). The 1995 benchmark is to be introduced in 1999. The 1987 benchmark was introduced in 1992, and the 1977 benchmark in 1982. The 1968 benchmark, introduced in 1973, included the move to SNA68. The revision comprises a re-assessment of levels, introduction of new concepts, improvements in coverage, etc. The new benchmark or base year has no direct relevance to the estimation of volume changes. These are derived entirely in terms of comparisons with the previous year, at the prices of the previous year. When figures for the new benchmark year are finalised, the figures for later and earlier years are reworked. In the past, the reworking has been taken back for many years, but the time required for this has led to a change of policy. In the revision now being undertaken, the reworking will be taken back to the previous benchmark, and then applied to earlier benchmark years - with mathematical interpolation to re-estimate the accounts for the intervening years. (Two papers on revisions policy were provided - "New revisions policies for the Dutch national accounts", by Gert P. den Bakker, Jan de Gijt and Robert A.M. van Rooijen and "Backward Calculation of Dutch National Accounting Data", by Gert P. den Bakker and Robert A.M. van Rooijen.)

Analyses of revisions

Given the revisions policy followed, the main focus of work on revisions in the National Accounts department of Statistics Netherlands has been on the revisions to the estimates leading up to the definitive estimate. Some analyses of revisions stemming from the introduction of new benchmarks are however available in the paper on revisions policy referred to above. With the 1987 revision, levels of GDP for 1977-87 were revised upwards by between 1.1 and 2.4 per cent, but the impact on growth rates was not consistently in one direction.

Successive estimates of GDP

Each year, other than in a revision year, the up-dating of the annual estimates starts with the derivation of definitive accounts for year t-3 in April, then proceeds to the improved preliminary accounts for t-2 in June and preliminary annual accounts for t-1 in July. The same methodology is applied for each year, but the level of detail to which it is applied differs because of differences in the availability of data. All the estimates are derived by balancing within a supply-use framework - including the earlier quarterly estimates. The preliminary estimates are determined within a supply-use framework with 100 products and 100 industries. The later estimates are based on disaggregation to 800 products and 200 industries. Results are published at the 100x100 level, and then requests for more detailed figures are handled on an ad hoc basis with particular regard to the risks of disclosing confidential information.

The main reason for working with this level of detail is to improve the estimation of growth in GDP. Especially as particular weight is given, in the balancing process described below, to the estimates of value added in each industry at current prices, the process does not usually have much impact on the estimates of GDP at current prices. In relation to economic aggregates, the main reason for working in such detail is that the deflation can be carried out much more satisfactorily, given the availability of detailed price indices. This can be expected to lead to more reliable estimates of the components and, particularly, of real growth in the economy. The supply and use tables for a year are balanced at both current and previous year's prices simultaneously. The system was developed initially on the basis of annual input-output tables at current and constant prices, and the positive experience with that led to the development of the present system which can make full use of the information available on products and prices.

The preliminary estimates are based largely on sales indicators for the corporate sector. For the improved preliminary estimates there is some information from production surveys and from PRODCOM. Definitive information from these sources, with almost complete coverage, becomes available for the final estimates. The information from PRODCOM and from the production surveys is pooled for each business.

The data from the data sources are used by the industry specialists to estimate output and intermediate consumption in each industry at current and constant prices, giving an estimate of value added for each industry at both current and constant prices. An estimate is made of labour inputs at constant prices. The composition of intermediate consumption is estimated partly on the basis of the pattern shown in the tables for the previous year. When figures for all industries are balanced, the supply and use of each product which this implies is then examined. In each case the analyst would be looking at the data from the data source for the year under consideration, this year's value at the previous year's prices, and the value in the previous year at the previous year's prices. Information on the correction made to the previous year's figures in the balancing process is also shown on the screen. The objective is to balance the supply and the use of products, at both current and constant prices, having regard to the growth rate in real terms since the previous year and the validity of the implied deflator.

The standard screen displays used for these two processes, the industry overview and the product overview - are shown on pages 15-17 of the paper "Simultaneous compilation of current and constant prices in supply and use tables" by Sake de Boer and Wim van Nunspet. In the balancing of the product tables in particular, the analyst is confronted with a wide choice of components that could be amended if necessary, but certain elements are regarded as particularly weak, e.g. the unit value indices for imports.

The third stage of the process is to look at the impact the changes may have had on the balances for each industry, including value added. The results are therefore checked with the industry specialists. If necessary changes are made to accommodate the views of the specialists. As the GNP inventory states, "the influence of the integration process in the estimation of GNP is not insignificant, but it mainly alters its components and not its absolute size". Once completed, the supply-use tables are used to derive industry by industry input-output tables. In this process heavy use is made of automatic adjustment procedures.

The systematic storage of data in the database includes the storage of the data at current and constant prices, both before and after balancing. Taeke Takema kindly agreed to supply, in Excel format, the figures for 1994 - the latest for which final estimates are available at present. These would correspond to Tables X.1 and X.2 in the publication "National accounts of the Netherlands 1996".

Assessments of reliability of data

Table 3, page 17, in the GNP inventory, shows the industries for which the sources of data are considered to be of good quality. These account for about three quarters of GDP. Annual production surveys in the non-financial sector cover about half the economy. The data from these are matched with PRODCOM data, and with data from other sources. Adjustments for unreported income are also included.

Sector accounts for financial institutions and the government sector both provide the estimates needed on these sectors and help to validate estimates for other sectors. In particular, information from the government sector on subsidies, income transfers to corporations, taxes on products and imports, investment grants and social insurance contributions is matched with counterpart information. Similarly the amounts received by social insurance and private funds are matched with data on payments recorded and on the level of wages and salaries. Financial balance sheets are derived for each sector, and a Dividends and Interest Matrix is used to balance the estimates of flows of dividends and interest between sectors. Large and erratic fluctuations in the discrepancy between the non-financial and financial accounts for the non-financial corporations, the household sector and the rest of the world are investigated as an indication of possible problems of estimation in the non-financial accounts of these sectors, e.g. with respect to the estimation of final consumption of households.

The estimates for central government are considered to be highly reliable at current prices. However, for municipalities the reliability of the data has substantially declined due to relaxation of the official reporting requirements in combination with dynamic developments in the municipalities themselves (reorganisations, privatisation, fiscal constructions, contracting out of activities, special employment projects, etc.). Municipalities account for about 10 per cent of gross fixed capital formation. The breakdown by type of asset has become particularly difficult in relation to municipalities.

An attempt was made in the seventies and early eighties to balance the supply and use tables automatically using indicators of possible correction margins. The results proved quite unpredictable; there was doubt about the validity of the correction margins. The work was abandoned (as reported in "Ten years supply and use tables in the Netherlands", by Wim van Nunspeet and Taeke Takema.)

Statistics Netherlands do not have estimates of the reliability of the components of the estimates which are provided for the supply and use tables, or for the adjustments to move from GDP to GNP. One suggestion was to look at the magnitude of the changes made in the balancing process. This would require however the extraction of a massive amount of information as it would be necessary to look over a lung run of years. I said that I thought we should first look at the figures Taeke Takema has undertaken to supply for 1994. It would however be useful to have, in addition, any estimates that had been made of the sampling, or other errors, in the production surveys. Brugt Kazemier said that he would find out what was available. (He subsequently reported that no such estimates were available.)

UNITED KINGDOM

Note based on meetings in Office for National Statistics , London on 12 February with
Sanjiv Mahajan and
on 16 February 1998 with
Martin Kellaway and
Richard Clegg

Balancing procedures

The annual estimates of GNP supplied by the United Kingdom to meet obligations under the GNP Directive are the result of two balancing processes applied in the course of finalising the annual estimates. One of these processes focuses on the determination of GDP through the preparation of balanced input-output tables; the other relates to the balancing of figures for payments and receipts of property income in the preparation of the "Dividends and Interest Matrix". There are also some adjustments needed to move to the definitions in ESA79.

(i) Input-output balancing

ONS's estimates of GDP for recent years (except the last one or two years) are those derived from the latest balanced input-output tables for those years. For each year T the Office for National Statistics in London prepares input-output tables for years T-2, T-3 and T-4. These are respectively the "provisional", "revised" and "final" versions of the tables. If data revisions or methodological changes necessitate it, the tables for earlier years are also rebalanced. In 1998 revised tables are being prepared for each of the years 1987 to 1996, on the basis of ESA95.

The methodology followed involves preparing “supply” and “combined use” matrices, with economic activity classified into 123 industries and products similarly classified according to the industry of which they are the principal product. Thus, the same classification is used for both industries and products. The details are set out in the publication “Input-Output Methodological Guide, 1997” which includes in particular the tables showing the summary structure of the two matrices. Staff responsible for the particular statistics involved supply their “best estimates” of the entries required to compile the two tables (e.g. households’ final consumption expenditure on footwear and income from employment in furniture manufacturing). If the two tables are consistent with each other then:

(i) for each industry, total output must equal total inputs (ie total output equals intermediate consumption plus incomes generated), and
(ii) for each product, total supply must equal total uses (ie total supply equals purchases by industry and final demand.)

Meeting the first condition ensures that estimates of GDP calculated following the production and income approaches are identical; meeting the second condition ensures that estimates following the output and expenditure approaches are identical. The two conditions may be restated respectively as:

(i) the sum of the entries in column I of the supply matrix equals the sum of the entries in column I of the combined use matrix (I = 1,2, ...123);
(ii) the sum of the entries in row J of the supply matrix equals the sum of entries in row J of the combined use matrix (J = 1,2,...123).

In economic terms these conditions are:

(i) for each industry,

total outputs of products 1 to 123 at producer prices = total purchases of products 1 to 123 at purchaser prices [+ sales by final demand] + other taxes less subsidies on production + compensation of employees + gross operating surplus + mixed income

(ii) for each product,

total sales by industries 1 to 123 at producer prices + taxes less subsidies on products + import duties + distributors' margin + imports of goods and services (= supply at purchaser prices) = final consumption expenditure (FCE) by households + FCE by NPISH + FCE by general government + gross fixed capital formation + net acquisitions of valuables + changes in inventories + exports of goods + exports of services

Adjustment to the entries in the supply and combined use matrices to meet the conditions set out above is achieved (as described in "National Accounts concepts, sources and methods", 1998, paras. 11.148-11.159):

(a) by a detailed examination of the discrepancies between output and input estimates for each industry and between the supply and demand estimates for each product using the formulae on each side of the above equations;

(b) by reference to the time series implicit in the estimates (eg growth rates, ratios of value added to gross output, volume changes, etc);

(c) by making use of the knowledge available about the relative accuracy of the various estimates;

(d) by making use of any other information available, eg about particular developments in an industry;

(e) by application of the r.A.s method to the details of intermediate consumption in the combined use matrix.

These considerations (particularly a-d above, and the arrival of extra data) may lead those responsible for the series to revise the statistics supplied earlier as their independent, best estimates, but whether or not a "best estimate" is revised it is then combined with an additional element, or "buffer", to make up the entry needed to balanced the tables. Details of the buffers for each element in the two matrices thus show the adjustments which are made beyond those considered necessary by the series compilers to provide what they regard as the best estimates. These are the adjustments made purely to achieve consistency in the accounts. We would therefore expect the scale of these adjustments to be consistent with the assessments of the accuracy of the series involved.

Work in the current year on the figures for 1988 to 1996 will provide a time series of buffers for each of the elements in the two matrices. The results are currently available for the years 1987 to 1994. However it would not be feasible for us to handle these, or to undertake reliability assessments, using the full detail of the industry/product classification used by ONS in its balancing process. Instead, it would seem more realistic for us to undertake our work using the 11 industry/product classification adopted in the input-output use matrices published in ONS's annual Blue Book. We therefore asked ONS to supply us with the two matrices for as many years as possible. For each entry in the matrices we required the supplier's "best estimate" and the "buffer" introduced by the input-output team to balance the accounts. The figures supplied relate to 1995.

ii) Dividends and interest matrix

Net property income from abroad, which (with relevant net compensation of employees) has to be added to GDP to obtain GNP, is estimated using the "Dividends and interest matrix". (Additional elements would be involved if ESA95 rather than ESA79 was being followed.)

The dividends and interest matrix covers all forms of income from financial or tangible non-produced assets receivable in return for making the asset available to another institutional unit. Each row of the matrix corresponds to one type of asset/liability, with the row headings following the standard classification of financial instruments used for example in Table 3.14 of the 1997 Blue Book. Each column corresponds to an institutional sector - the "Rest of the world" being the sector of relevance to "net property income from the rest of the world". The entry in a particular cell shows the net amount of income received/paid by the sector on the relevant category of assets/liability. Thus, since the payments from one sector must be the receipts of another, the sum of the entries in each row should add to zero.

For a few instruments , eg the Official Reserves and lending under the Exchange Cover Scheme, all the entries are provided from the same source, and so the relevant rows of the matrix can be completed directly. For most instruments the information is incomplete. Typically, there is information on payments (eg on public corporations' debt), and partial information on receipts by sector. Provided the available information looks plausible, the missing cells are then estimated using the information on income flows and holdings of assets/liabilities recorded in the balance sheet. If the data returns are not plausible they are investigated by the relevant ONS statistician.

Assessments of accuracy of estimates of property income to and from the rest of the world (distinguishing earnings on direct investment from other property income) were prepared in 1994. ONS would find out whether there was more detail underlying these assessments and would offer advice on up-dating the assessments to cover estimates for 1996 and earlier years. In the analysis for Eurostat it would preferable to work with the groupings of assets adopted for Table 7.1.2 of the 1998 Blue Book based on ESA95. Excluding the entries not relevant to ESA79 (which in particular ignores unremitted profits on direct investment) leads to the following categorisation:

Property income received

- Interest
- Distributed income of corporations

Property income paid

- Interest
- Distributed income of corporations