ANNEX

R&D DEFLATORS AND CURRENCY CONVERTERS

Introduction

1. This annex examines special methods for deflating and converting data on R&D expenditures expressed in national currencies at current prices to a numeraire currency.

2. Both these issues involve adjusting R&D expenditures for differences in price levels over time (*i.e.* intertemporal differences) and among countries (*i.e.* interspatial differences). In the case of deflators, the price differences are intertemporal, and the question is clearly of interest both in individual countries and for international comparisons of changes over time.

Deflation and currency conversion in the OECD's international R&D statistics

3. As far as possible, the same methodology should be used for both deflation and conversion. In the absence of a full set of R&D deflators and R&D converters for all Member countries, the Manual recommends the use of the implicit gross domestic product (GDP) deflator and GDP-PPP (purchasing power parity for GDP), which provide an approximate measure of the average real "opportunity cost" of carrying out the R&D.

Special R&D deflators and currency converters

4. The implicit GDP deflator and GDP-PPP are, respectively, output-based intertemporal and interspatial deflators. This annex suggests a way to establish special R&D deflators and PPPs either by compiling price indices using data from price surveys of R&D (input) expenditures or by combining proxy prices or price indices.

5. Currency converters are mainly important for international comparisons, including, of course, those of estimated growth rates. However, the choice of currency converters is also relevant when examining sectoral or other breakdowns of R&D or when it is necessary to take account of relative international variations in price levels in order to compare R&D with other economic variables. For example, an estimate of R&D expressed as a proportion of GDP, even if both quantities are deflated to "constant prices" using appropriate national price indices, is still affected by differences in relative price levels of R&D activities and all productive activities (*i.e.* GDP), as compared to some international average. In other words, the ratio may be affected by whether it is relatively expensive or inexpensive to perform R&D, as compared to other activities.

The need for R&D deflators

6. R&D deflators are justified if it is believed that the cost of R&D has moved in a way that is significantly different from general costs and/or if trends in the cost of R&D have varied considerably among sectors or industries. In general, over the long term, it is reasonable to suppose that the implicit GDP (output) deflator would tend to increase less rapidly than a "true" R&D (input) deflator because of productivity increases.

7. The optimal solution is to calculate special R&D deflators based on weights and prices that are specific to R&D. The cost and complexity of carrying out the price surveys needed for this exercise rules out using them except for specialised analysis. The most common approach is to use weights derived from R&D surveys combined with proxy prices.

Past OECD and national efforts

8. Work at the OECD was originally governed by five guidelines laid down in the third edition of the *Frascati Manual* (OECD, 1976):

- Deflators should be produced for homogeneous sectors of the economy, whether or not these correspond to the existing sectoral approach.

- They should be of Laspeyres form.

- In view of the relative importance of manpower in R&D activities (almost 50% of expenditure), it should receive special attention.

- Practical characteristics should take precedence over theoretical niceties.

- The best possible use should be made of existing sources of information.

9. During the 1970s, Member countries and the OECD were active in this area, particularly in preparing deflators for the business enterprise sector. National experts presented papers on their experience at various meetings. Some of the methodologies were very detailed, but most broadly followed the same lines developed by the OECD for a study on industrial trends from 1967 to 1975. (OECD, 1979).

10. In consequence, the fourth edition of the *Frascati Manual* (OECD, 1981) included a special chapter, which described some fairly simple ways of calculating R&D deflators, using weights derived from R&D surveys and proxy prices derived from various national or international sources. The methods were presented as examples for the business enterprise sector in an imaginary country rather than in technical form. Three methods were explained and illustrated:

- Applying a composite index number to all expenditures using fixed weights.

- As above, but using changing weights.

- Applying separate price indices to individual expenditure items within subclasses of a sector.

Further details were given on the preparation of sub-weighted indices for labour costs. A technical presentation of the calculation of R&D deflators was included as Annex 4.

Selection of the index-number formula

11. The recommendation to use the Laspeyres formula needs re-examination. Hill (1988) has pointed out that theoretical advances have shown that the index number formulas in common use (Laspeyres, Paasche, etc.) have weaknesses with important consequences for economic analysis and policy making. He argues for the use of chain indices, which have attractive properties from both the theoretical and practical viewpoint and highlight the biases of conventional fixed-weight indices of the Laspeyres or Paasche type.

12. Deflation essentially involves a comparison between situations at two different points of time. The tendency of Laspeyres and Paasche indices to diverge ("index number spread") over time is well known. A chain index should be used when the two situations being compared are dissimilar and when linking can be achieved by passing through an intermediate point. Ideally, the intermediate situation is one in which the pattern of relative prices is approximated by some average of the relative prices in the two situations being compared. In such a case, chaining reduces the index number spread (between Laspeyres and Paasche).

13. Why chaining? In the real world, the problem faced by compilers of index numbers is that some commodities are only found in one of the two situations. The quantity vector is always complete (its elements are positive or zero). However, there are many missing prices (*i.e.* missing commodities), and it is impractical to suggest estimating shadow prices on a large scale, as old products disappear as a result of obsolescence and new products appear as a result of technological progress. This is particularly true of the commodities likely to be included in R&D price indices.

14. The further apart the periods are, the greater the problem. The share of total value of the expenditures in the two periods actually covered by direct price comparisons decreases. Insisting on direct comparisons between the two periods means accepting that price relatives can be compiled only for a small proportion of the expenditures in both periods (in addition, the index number spread between the Laspeyres and Paasche indices tends to be very large).

15. If a chain index is used and the amount of usable price information is greatly increased, this is true at each link. It is also true that the amount of price information actually used from the first and last periods will be far greater.

16. If the evolution of prices and quantities is fairly smooth, a chain-Laspeyres will lie below a direct Laspeyres and *vice versa* for a chain Paasche, thereby reducing the index-number spread. Hill describes a limiting case of a "smooth" chain index (the "smooth" Divisia index) which eliminates the index number problem and is quite operational.

Choosing the level of aggregation at which to deflate

17. It is possible to prepare a single R&D price index for the whole of GERD, one for each sector or even one for individual industries in the business enterprise sector or fields of science in the higher education sector. The choice will depend on whether there are significant differences between the different levels in the cost structure of R&D expenditures and whether there are significant differences between the levels in price trends for the same cost item. For example, it is probable that trends in wages and salaries of researchers will be different in universities, where they are often fixed by public-sector pay agreements, and in industrial firms. On the other hand, it is debatable whether trends in the wages and salaries of researchers will vary significantly between industries. The choice is also dictated by the availability of suitable price series, whether compiled from specific price surveys or whether proxy indices are used.

Establishing the weighting system

General

18. A simple weighting system can be derived from the recommended breakdown by type of cost. The following shows the average breakdown in industry in the OECD area in 1989 and 1999.

	Percentage	
	1989	1999
Labour costs	43	44
Other current costs	43	45
Land and buildings	3	2
Instruments and equipment.	10	9
Total	100	100

More detailed treatment of labour costs

19. Labour is typically the major cost item. It is therefore desirable, whenever suitable salary price indices are available, to create a subsystem for labour costs for each sector.

The weighting systems

20. Labour costs are not usually broken down by category of R&D personnel, but staff and salary ratios can be used to estimate relative weights for labour costs of different categories of personnel as follows:

	Quantity ratio (%)	Relative salary ratios	Labour cost ratio (%)
Researchers (RSE)	50	x 1.00 = 50.00	59.7
Technicians	25	x 0.75 = 18.75	22.4
Other supporting staff	25	x 0.60 = 15.00	17.9
Total	100	83.75	100.0

More detailed treatment of other current costs

21. The share of other current costs has risen rapidly. Early versions of the Manual recommended that this category should be subdivided between:

- Materials.
- Other current costs.

This distinction has since been abandoned in OECD surveys and in most national ones. It is therefore difficult to establish a sub-weighting system.

Selecting proxy price indices

General approach

22. When it is not possible to carry out meaningful price surveys of R&D inputs, proxy price indices for each of the classes identified in the weighting system may be selected from the country’s national accounts or other general sources; alternatively, an attempt can be made to identify the series whose characteristics are most similar to R&D. As the final result will tend to be more sensitive to the evolution

of the price series than to that of the weights, the choice of proxy price indices is the single most important decision in the preparation of the R&D deflator and should be made with great care. It is not possible to make firm detailed recommendations, as the amount and type of price index data available vary from country to country. Furthermore, some series would be relevant for a deflator for industrial R&D but not, for example, for university R&D.

Proxies for labour costs

23. For labour costs, quantity data are usually available (number of researchers, etc.), and two general approaches are possible: using average R&D labour cost per total R&D person-years; using separate proxy series based on wages and salary data. The first type of series is specific to R&D but is not very exact if there is a significant change in the occupational qualification pattern within the R&D labour force over the period. Given that such changes have occurred in most Member countries, it may be preferable to use the second method. Here, it is important to select series which are as comparable as possible with the R&D data. Thus, earnings data are generally preferable to rates, and weekly or monthly earnings are preferable to hourly payments. The use of salary scales as proxies for trends in labour costs poses serious problems, notably concerning "grade drift", changes in employers' social security payments and other fringe benefits, and declining "quantity" of labour inputs owing to shorter hours and longer holidays.

24. It is usual to make a distinction between trends in the private and public sectors. There may have to be a trade-off between breaking down labour costs and establishing indices for separate industries. For example, salary indices may be available for all scientists and engineers or all technicians in industrial employment, but they may not be broken down by individual industry. On the other hand, "average weekly wages" may be available for these industries. The choice of method will depend on whether the salaries of researchers move in line with those of the mass of workers in their industry or in line with researchers in other industries.

Proxies for other current expenditures

25. This is the most difficult area to deal with. R&D surveys usually do not reveal anything about the balance of types of expenditures included, and it is not clear which are R&D-specific and which are industry-specific (or sector-specific).

26. A wide range of proxy indices can be used for other current costs. For example, the average wholesale price index for materials and supplies consumed by manufacturing industry, the implicit price index of the domestic product of industry (DPI) and the consumer price index (CPI) (excluding food and beverages) have all been used.

27. Where indices are calculated for separate industries, it is possible to use indices for their general input costs, but they may not be typical of R&D. For example, it is suggested that much of the increase in "current costs" is due to growth in the contracting out of support services (matching the decline in the average number of support staff per researcher) and the greater use of leased machinery.

Proxies for capital expenditures

28. Expenditures on land and buildings absorb a relatively low share of R&D expenditures, and a suitable proxy index can easily be selected from the relevant class of gross fixed capital formation (GFCF) in national accounts. The same approach can be used for R&D expenditure on instruments and equipment, but the extent to which such general price indices reflect changes in R&D instrument costs is uncertain.

Currency converters for R&D

The need for special currency converters

29. Using GDP-PPPs to convert R&D expenditures to a common numeraire currency such as the US dollar or the euro (*i.e.* deflating interspatially) effectively involves adjusting to allow for differences in general price levels between countries, not for differences in price levels for R&D. If R&D is relatively expensive in one country, as compared with another, the use of the GDP-PPP will distort the comparison of real expenditures on R&D.

30. As for intertemporal deflators, the ideal solution is to calculate specific currency converters based on relative prices for R&D inputs. Once again, carrying out the price surveys needed for this exercise (using a standard "basket" of R&D inputs) would be both costly and complex. The more practical solution is to use weights from R&D surveys and detailed parities from general PPP exercises conducted by the OECD and Eurostat in the context of the International Comparison Project (ICP) carried out under the aegis of the United Nations Statistical Office. A major difficulty arises because the general PPPs are calculated using a standard basket of goods and services entering GDP or, more precisely, final demand (*i.e.* output), whereas R&D expenditures are mainly inputs.

Past national and OECD efforts

31. The first OECD reports on R&D statistics issued in the early 1960s used purchasing power parities based on R&D weights and price ratios derived from salary studies and from the 1960 benchmark calculations of general purchasing power parities (Freeman and Young, 1965; OECD, 1968). Further efforts were made in the late 1970s when new sets of purchasing power parities became available. This situation was described in Chapter 7 of the fourth edition of the Manual (OECD, 1981). Since 1990, PPPs have been calculated every three years for OECD Member countries (1993, 1996, 1999) and annually for EU countries. Data collection for the 2002 round is under way.

The method

32. The methodology for calculating R&D PPPs should correspond to that established in the context of the ICP.

33. The OECD and Eurostat regularly calculate PPPs for GDP (and its expenditure components) for OECD Member countries. Although the PPPs published by the OECD are expressed in units of national currency per USD and those published by Eurostat are in units of national currency per euro, they are:

- Consistent (*i.e.* the France-Germany PPP obtained by dividing the euro PPPs for these two countries is the same as that obtained by dividing the USD PPPs), as "block fixity" for the EC countries has been imposed in the calculations.

- Transitive (the PPP between countries A and B multiplied by the PPP between countries B and C gives the PPP between countries A and C).

Choosing the level of aggregation at which to calculate R&D converters

34. Ideally, the level chosen should match that chosen for R&D deflators. In practice, special R&D PPP rates might be calculated for the business enterprise sector and the public sector, perhaps distinguishing government and higher education.

The weighting system

35. As for deflators, the weighting system can be derived from the recommended breakdown by type of cost. However, since the PPP calculations involve the simultaneous use of the weight and price data for all the countries included in the comparison (to ensure transitivity), it is necessary to have a matching set of weights for all the countries in the group.

Choosing the proxy prices

36. Ideally, data from price surveys of a standard "basket" of R&D (input) expenditures in each weighting category should be used. As in the case of intertemporal price indices, such an exercise would be costly and extremely complex and can be ruled out for all practical purposes. The next best solution is to use proxy prices (for which the best source is the set of comparable price data already available from the ICP), combined, if necessary, with proxy interspatial price indices (*i.e.* the disaggregated parities calculated for final expenditure components in the ICP).

Labour costs

37. No intermediate or primary input data are collected in the ICP for the business enterprise sector, hence no data on wages and salaries. For non-market services, however, the ICP uses input prices and thus includes data on total employment compensation for a selected standard basket of occupations in the public sector, notably in education, health and general government services. This information might be supplemented by the results of international surveys of wages and salaries of scientists and engineers or of certain categories of business management.

Other current costs

38. Once again, the major problem is the lack of price data for intermediate consumption, whether or not for R&D activities, in the business enterprise sector. Certain final goods and services for which prices are collected in the context of the ICP may also be inputs to R&D (*i.e.* "other current costs").

Capital expenditures

39. Suitable proxies for expenditures on land and buildings and on instruments and equipment can be obtained from the ICP, subject to the reservations already noted for estimating intertemporal R&D deflators.

OECD (2002), "R&D Deflators and Currency Converters", in *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*,
The Measurement of Scientific and Technological Activities, OECD Publishing, Paris.
DOI: http://dx.doi.org/10.1787/9789264199040-en