

FEATURE

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Developing an R&D satellite account for the UK: a preliminary analysis

SUMMARY

This article presents preliminary analysis treating expenditure on research and experimental development (R&D) as investment in an intangible scientific asset, in line with proposed revisions to the United Nations System of National Accounts. The purpose of this analysis is to communicate to users of statistics the potential impacts of capitalising R&D in the National Accounts in a new set of satellite accounts. Capitalising R&D raises the level of UK GDP by approximately 1.5 per cent, but has limited impact on estimates of recent GDP growth. These figures are preliminary, based on experimental methods, and should therefore be interpreted with caution. The author welcomes comments and complementary evidence that can be used to substantiate or revise the assumptions made throughout this article.

There is considerable consensus amongst economists, politicians and the public in general that research and experimental development (R&D) is a key determinant of economic growth and improvements in living standards. This is reflected by the importance of R&D performance indicators in policy making, as demonstrated by the UK Government's Public Service Agreements and the EU Lisbon competitiveness indicators, which track R&D expenditure as a ratio to gross domestic product (GDP). ONS plays a major role in collecting the required evidence and publishing such indicators, which have National Statistics status.

The Organisation for Economic Co-operation and Development (OECD) provides detailed guidance on how R&D expenditure should be measured in its Frascati Manual (FM).¹ This measurement framework is independent from the National Accounts (NA), which provide a systematic statistical framework for summarising and understanding economic events and the wealth of an economy. It is therefore legitimate for users of statistics to ask how R&D is reflected in the official statistics and whether the measurement framework enables an adequate understanding of the economic impacts of R&D.

International standards for the 1993 System of National Accounts (SNA) and the 1995 European System of Accounts (ESA) set out how countries must record economic transactions and wealth in their

National Accounts. According to these guidelines, business expenditure on R&D is treated as intermediate consumption, namely goods produced and consumed in the same period for the production of other goods and services. For instance, the output of an R&D laboratory, affiliated to a pharmaceutical company or undertaking R&D on its behalf, is counted as output of the R&D sector and as intermediate consumption of the 'using' pharmaceutical sector. By treating its use as current expenditure, the production of R&D does not directly contribute to increasing gross value added (GVA) or GDP, which net out such expenses from gross output.²

The treatment of R&D use as current expenditure is at odds with the evidence that the knowledge acquired as a result of R&D often delivers benefits to the owner of the intellectual property over several years. That is in essence the National Accounts definition of investment. From that point of view, R&D should be treated no differently from the production of a new piece of capital equipment with an expected service life of more than one year.³ The current treatment is unsatisfactory for three main reasons. Firstly, it is inconsistent that artistic and literary originals are recognised in the System as produced assets while scientific originals achieved through R&D are not. Secondly, exclusion from the production boundary leads to estimates of GDP that may provide a partial picture of the flow of goods and services produced in the economy at the point in which structural

changes may lead to increased specialisation in the production of intellectual goods. Thirdly, the analysis of the sources of productivity growth can also be incomplete as a result, because productivity changes are not attributable to the accumulation of knowledge assets. This could in turn distort fiscal and monetary policy insofar as potential supply could be underestimated.

Statistical agencies, including ONS, are aware of these limitations and agree that measurement frameworks need to evolve to reflect the changes in the economy and users' needs. These demands need to be assessed against the need for comparability across countries and over time, while addressing the problems involved in the reliable valuation of R&D as an asset. In this context the United Nations Statistical Commission officially called in 2003 for an update of the 1993 SNA in order to reflect new user needs and developments in the economy. Once agreed, the SNA revisions will lead to a revision of the ESA. This is likely to result in a pan-European requirement for member countries to produce supplementary tables reporting the new proposed treatment for R&D. Some countries have already published preliminary satellite accounts on R&D and a few, including the United States, have already developed a satellite account as a prelude to capitalisation in the core accounts. Satellite accounts are extensions to the main National Accounts that seek to facilitate the analysis of the wider impact of economic change using similar concepts and classifications while avoiding conflict with the core conceptual framework.

This article documents the preliminary outcomes of an ongoing research programme aiming to develop satellite accounts that treat R&D use as investment in an intangible 'scientific knowledge' asset. While the revision timetable spans a number of years up to 2014 and detailed guidance is yet to be produced, Eurostat has asked statistical agencies to conduct early assessments and communicate the potential impacts to users before detailed mandatory guidance is issued. Figures in this article should therefore be treated with caution, noting their preliminary and experimental status.

The capitalisation of R&D expenditure: challenges and methods

What are the main R&D measurement challenges?

R&D exhibits a number of features that

complicate its measurement on a conceptual and practical basis within an accounting framework:

- R&D knowledge exhibits public good features because it is not depleted as it is consumed
- access to R&D knowledge can be restricted, but companies use secrecy to prevent their knowledge from being used by others without paying for it
- partly as a result, R&D is often performed on own-account, for internal use within companies
- each R&D project by definition is unique, therefore limiting the basis for value comparisons
- the public good features of R&D knowledge provide a rationale for government involvement in the funding and performance of R&D, thus affecting valuations

The recording of scientific knowledge transactions in the SNA

Market contract research involves the undertaking of an R&D project by one firm on behalf of another, with the objective of obtaining knowledge that will be owned by the customer firm. A producer's R&D output is treated as intermediate consumption by the purchaser of the services. In the SNA revision, the consumption of R&D would be treated as gross fixed capital formation (GFCF) instead of intermediate consumption. While it is often the case that the internal R&D transactions within companies are not recorded, the output of R&D should always be captured in the SNA revision because its use will no longer be treated as intermediate consumption that offsets output, but as GFCF of a produced intangible asset which adds to GDP.

A key problem with the current methodology is that no connection is made between the R&D activity that leads to improved scientific knowledge and its appearance as intellectual property. When a patent or other form of protection to scientific knowledge is awarded, the System adds a non-financial non-produced asset, known as 'patented entity', to an account that reflects changes in assets which are generated outside the System and are not produced by units within it. Following the SNA revision, the recognition of scientific originals requires the outright removal of patented entities from the System.⁴ In the 1993 SNA, the licensing of intellectual property is treated as lessors' output but matched by lessees' intermediate

consumption. This treatment is also appropriate for the SNA revision because the licensee only buys services from the asset rather than the knowledge asset itself.

Scope of the R&D capitalisation exercise

Defining R&D

The first step in this exercise is to define what economic activities can be consistently characterised as R&D for the purposes of capitalisation within the National Accounts. The SNA provides a functional description rather than a formal definition of R&D, excluding related activities such as routine technical testing and market research, and placing a strong emphasis on the fact that R&D must help deliver new goods and improved processes. The FM definition has potentially a wider scope, defining research and experimental development as '... creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture, and society, and the use of this stock of knowledge to devise new applications' (OECD, 2002). In the absence of 'an appreciable element of novelty and the resolution of scientific uncertainty', activities are not considered to be R&D. While it has been agreed that the FM definition should provide the basis for recognising a new scientific knowledge asset, it has been made clear this should not be interpreted as including human capital as capital formation within the System.

Success, failure and the 'at cost' valuation approach

Accounting standards do not allow individual businesses to capitalise R&D expenditure when there is substantial uncertainty about its value. While many projects are unlikely to recoup their costs, a few will succeed. For profit-seeking firms, economic theory argues that they are willing to invest in R&D up to a level where the marginal pound spent is expected to deliver a marginal return at least as high as the next best investment opportunity. This 'at cost' approach is the preferred basis for the valuation of the output of R&D because, as explained, it is not systematically traded in transparent markets where prices aggregate all the relevant information. This is consistent with the approach adopted for capitalising mineral exploration costs, which are included in GFCF whether or not the exploration is successful.

R&D in the social sciences

R&D in the social sciences and humanities is an R&D subsector and a product subcategory in the SNA. Both the concept and units in this sector are also covered by the FM definition and sources. Although there may be some measurement bias against including social science R&D, for example, due to their ineligibility for R&D tax credits, this article assumes no adjustment is required to account for omitted R&D in the social sciences. In the UK, the social science R&D sector accounts for a very small fraction of business R&D expenditure, less than 1 per cent, with approximately £30 million worth of estimated R&D. This is in contrast with the reported turnover for the subsector, £170 million, which suggests that an upward adjustment may be necessary once more detailed international guidance is available.

Potential overlap with other recognised intangible investments

R&D and software development are intimately related, but software is already recognised as a produced asset in the National Accounts while scientific originals are not. The methodology for estimating own-account software development includes the earnings of programmers that could be working on genuine R&D projects. Given the lack of auxiliary information, the complexities of the interdependencies, and the wish to avoid revising software estimates, this analysis deducts 50 per cent of total R&D in the computer services industry, assuming that this represents activity already counted in and correctly assigned to software estimates.

Inclusion of non-market R&D, exclusion of spillovers

In line with OECD recommendations, only the portion of economic benefits arising from the acquisition of R&D should be recorded as an asset in the System. It is this magnitude that will theoretically match with the R&D cost estimate used to estimate R&D output. Neither rented knowledge (through patent licensing for example) nor knowledge freely available following a patent expiration would count as an asset. However, R&D undertaken and effectively owned by non-market producers such as government is to be included in the System. This treatment is analogous to that of toll-free roads.

Capitalisation methodology options

There are three possible approaches to compiling an experimental set of accounts

that treat R&D knowledge as an asset; these are listed below.

Same sources, different allocation to uses

This option entails using data on R&D services currently recorded in the Input-Output Supply and Use Tables (SUTs) and reclassifying expenditure from intermediate consumption to investment. This method is fairly straightforward to implement but has two key shortcomings. Firstly, SUTs underestimate the extent of R&D output because many businesses do not report separately on their own-account R&D activities by identifying a separate establishment, as recommended by the 1993 SNA. Although this underestimation has no impact on GDP when R&D is treated as intermediate consumption, capitalising only identified R&D output would underestimate the true impact on GDP. Secondly, expenditure on R&D by government and non-profit sector is likely to be assigned to uses of other services such as health, defence and education because of the limited detail of information available.

New integrated sources and methods

This option would lead to revised statistical inquiries with more detailed questions on R&D output and purchases which can then be built into core systems. This would involve considerable changes to the Annual Business Inquiry, which is the major source of output and purchases data used for constructing SUTs. Although this should be considered thoroughly as a long-term alternative for full consistency with the core accounts, the substantial resource implications make it unfeasible for the purposes of a preliminary satellite account.

Bridging approach from FM sources

This approach has been adopted by all the statistical agencies that have already produced R&D capitalisation estimates, including Australia (Australian Bureau of Statistics 2004), the US (Robbins 2005; Okubo *et al* 2006; Robins and Moylan 2007), Israel (Peleg and Brenner 2006) and The Netherlands (De Haan *et al* 2006).

Because the FM methodology differs from National Accounts measurement principles, a number of adjustments need to be made to adjust FM R&D expenditure to measures which are conceptually consistent with the National Accounts. The main advantage of this method is that, by and large, it is not necessary to collect additional sources at the current development stage and despite the need for assumptions, it makes the preferred choice for the

purposes of evaluating the impacts of R&D capitalisation in a satellite account. This is also the OECD recommended approach on the compilation of R&D satellite accounts within its forthcoming *Handbook on Measuring Intellectual Property*, to be released in 2008, in coordination with Eurostat (OECD 2007).

Evaluating the impact of R&D capitalisation in the National Accounts: R&D resources and uses

Outline of the FM-SNA bridging methodology

This article proposes a methodology to estimate the impact of R&D capitalisation on the National Accounts that is consistent with the product by product balancing of supply and demand of resources. This is done within the context of the latest available SUTs, consistent with the ONS *Blue Book* 2006 (BB06), which includes figures from 1997 up to 2004 (ONS 2006a, 2006b, 2006c).

Because the FM sources gather information on the cost of performing (the FM term for 'producing') R&D, the first step involves adding up such costs leading to an overall estimate of R&D gross output. This is calculated by adding intermediate consumption, compensation of employees, gross operating surplus and taxes less subsidies on production linked to R&D production across all sectors. In this version, no detailed industry analysis is provided. In future development stages, detailed production accounts should be built up from the individual establishment level. The gross output estimate at basic prices is used to define the domestic output of R&D in the supply table. Additional imports and tax information help estimate the full value of R&D resources. This total will be balanced to total uses (demand) of R&D. Information on funding and assumptions on ownership of R&D services are then used to apportion total demand across different uses and users, completing a full picture of R&D supply and uses.

In this exercise, the new supply-use estimates for R&D services replace BB06 R&D estimates. However, further steps are required. By recognising an additional asset in the System, its consumption by non-market producers needs to be added to their output, which is generally measured at cost of production. Furthermore, since the FM may capture R&D in these units assigned to other public services in BB06, it is then necessary to make corrections to avoid

double-counting of non-market output.

The Frascati sources for the experimental R&D satellite account

Due to an emphasis on simplicity and transparency of estimates in this preliminary satellite account, this article builds on two main sets of published inputs.

‘Research and Development in UK Business’ (MA14) is an ONS publication based on business surveys that documents R&D expenditure in the Business Enterprise (BE) sector, with detail by type of expenditure on inputs, funding sector, civil versus defence uses and functional type of R&D (for example, basic or applied research), R&D personnel and product field the R&D contributes to, for example, pharmaceuticals and transport equipment. The BERD expenditure split by input is crucial in identifying the necessary bridging changes to a National Accounts-consistent output figure. In the absence of similar input data for non-market producers, this article assumes all sectors have identical cost structures.

The second and main source of information is the ONS release on ‘UK gross domestic expenditure on R&D (GERD)’. This provides FM-consistent estimates for the total R&D expenditure performed in, and funded by, the different FM sectors, building on a number of statistical and administrative sources. The construction of bridge tables for capitalisation in the National Accounts relies heavily on Table 1 in the release, which reports R&D performed in the UK in each sector according to source of funding. This helps translate the performance and funding information in GERD into National Accounts-comparable information about supply and use. Figures for 2004 are reported in **Table 1**.

Performance, funding and ownership of R&D

For bridging purposes, it is necessary to draw a correspondence between the FM sectors and the institutional sectors in the SNA. For the purposes of the satellite account, some simplifying assumptions are made and summarised in **Table 2**. Government, research councils and the higher education funding councils make up the total of the general government sector for R&D purposes. Higher education (HE) is entirely assigned to the non-profit institutions serving households (NPISH) sector, grouped with private non-profit (PNP) organisations, which includes charitable organisations that perform R&D.

The BE sector comprises three different SNA sectors: public corporations, financial corporations and private non-financial corporations. They account for 5, about 1 and 94 per cent of BE R&D, respectively. Quasi-corporations such as partnerships and sole traders account for a very marginal share of BERD. Finally, the FM ‘abroad’ sector is identified with the rest of the world sector in the SNA.

Introducing R&D as an asset in the system requires a clear definition of ownership. The characteristics of R&D make this task particularly difficult, which is partly why the FM methodology does not attempt to measure ownership. However, information about who funds R&D can provide a reasonable first-order approximation to identifying who owns the output of R&D. There are two main problems to using funding data without further adjustments.

Firstly, funding of R&D is constrained to equal total R&D expenditure and data are in most cases collected from the performers rather than the funders of R&D. As a result, it will fail to reflect the full costs of R&D to the user of the R&D services. The assumption made in this article is that funding provides a good approximation to the share (rather than the level) of R&D output performed in a sector which is

funded by another.

Secondly, funding R&D does not always imply ownership over its output. For market producers, funding is bound to equal ownership, with the exception of corporate donations. This is also likely to apply to non-profit private institutions which fund the work of charitable institutions at home or abroad. This article assumes that these funds are negligible relative to the total funds provided. R&D funded by government provides room for a more significant departure from the funder-owner identity. The reason for this is the potential inclusion of R&D grants in R&D funding estimates. This preliminary satellite account makes a number of assumptions about the relative importance of grants in total funds provided by government to R&D in other sectors. These are summarised in **Table 3**.

Table 3 is structured in three main panels. The panel on the left depicts the share of R&D performed in sector ‘i’ in each row funded by each sector ‘j’ in columns, using the estimates for 2004 provided in Table 2. The central panel summarises the assumptions about the share of funds provided by ‘j’ to ‘i’ which do not involve ownership by ‘j’. For example, of the total funds provided by government to the business sector, the table indicates that

Table 1
R&D performed in the UK in each sector according to source of funding, 2004

Sector providing the funds (funder)	£ million, current prices							
	Sector carrying out the work (performer)						Total (UK)	Abroad
	Gov	RCs	HE	BE	PNP			
Government (Gov)	1,053	120	242	1,325	82	2,822	428	3,250
Research councils (RCs)	3	630	1,354	9	88	2,084	220	2,304
Higher education funding councils (HEFC)	0	0	1,804	0	0	1,804	0	1,804
Higher education (HE)	1	10	212	0	6	229	0	229
Business enterprise (BE)	158	37	243	8,484	69	8,991	1,421	10,412
Private non-profit (PNP)	11	78	761	5	105	960	0	960
Abroad	15	54	388	2,993	57	3,507	-	3,507
Total	1,241	929	5,004	12,816	407	20,397	2,069	22,466

Source: National Statistics

Table 2
Simplified relationship between FM and SNA sectors

Frascati Manual (FM) sector	System of National Accounts (SNA) sector
Government	General government
Research councils (RC)	General government
Higher education funding councils (HEFC)	General government
Higher education (HE)	Non-profit institutions serving households (NPISH)
Private non-profit (PNP)	Non-profit institutions serving households (NPISH)
Business enterprise (BE)	Financial, public and private non-financial corporations
Abroad	Rest of the world (RoW)

Source: National Statistics

Table 3
Funding of R&D in 2004 and sectoral ownership assumptions

Funder (j)	Share of sector i's R&D funded by sector j				Share of sector i's R&D funded by j that is owned by sector j				Share of sector i's R&D owned by sector j			
	f(i,j) ¹				Z(i,j) ²				S(i,j) ³			
	Business enterprise	General government	NPISH	Rest of world	Business enterprise	General government	NPISH	Rest of world	Business enterprise	General government	NPISH	Rest of world
Business enterprise	0.66	0.10	0.00	0.23	1.00	0.50	1.00	0.90	0.74	0.05	0.00	0.21
General government	0.09	0.83	0.05	0.03	1.00	1.00	1.00	0.90	0.09	0.84	0.05	0.02
NPISH	0.06	0.66	0.20	0.08	1.00	0.10	1.00	0.90	0.06	0.07	0.80	0.07
Rest of world	0.69	0.31	0.00	1.00	0.90	1.00	0.76	0.22	0.00	-	-	-
Source	GERD funding data				Assumptions				Estimate			

Notes:

1 Funded share $f(i,j)=F(i,j)/F(i,*)$, where $F(i,j)$ is R&D performed by i funded by j and $F(i,*)$ is total R&D performed by i .

2 Residual ownership stays with performer.

3 $S(i,j)=f(i,j)*Z(i,j)$ for $j=i$. $S(i,i)=f(i,i)+(1-Z(i,i))*f(i,i)*1$ ($j=i$).

this article assumes only 50 per cent is undertaken as procurement (owned by government) while the rest consists of grants. This proportion falls to 10 per cent for funds provided to the NPISH sector, because of the significant share of grants to the HE sector allocated by the funding councils. R&D funded by the rest of the world is adjusted for the possibility that some of the funds provided to domestic sectors are grants from abroad. Similarly, R&D performed abroad funded by the UK government is adjusted for the possibility of grants being provided to R&D performers abroad. This article assumes that the residual 'non-owned' component of funds is effectively owned by the performer. This is reflected in the estimation of ownership shares over each sector's R&D output, displayed in the right-hand panel. The assumptions made imply that the business and NPISH sectors own significantly higher shares of their own output than implied by the funding shares, 74 per cent and 80 per cent respectively, compared with 66 per cent and 20 per cent implied by funding. It is important to emphasise that this is entirely based on assumptions that will be tested against more detailed information on R&D grants and procurement data.

Estimating R&D output

Adopting an 'at cost' valuation approach for R&D output requires summing over the full range of economic costs incurred in performing R&D. This article relies on input expenditure for R&D available for the business sector to estimate such costs.

Table 4 summarises the main similarities and discrepancies between the BERD sources and the requirements of an SNA-consistent valuation approach.

Compensation of employees

According to FM and BERD guidance, wages and salaries on R&D and auxiliary personnel should also include non-salary employment costs, making the reported figure comparable to the SNA concept of 'compensation of employees'. A deflator for this component is calculated using additional information on full-time equivalent R&D employees by broad occupational category and auxiliary information from the Annual Survey of Hours and Earnings. The latter provides hourly wage estimates for detailed occupational groups such as scientists, engineers and technicians, which can be matched to the BERD occupational categories.

Intermediate consumption of goods and services other than R&D

Information on 'other current expenditure' captures all purchases of goods and services necessary for R&D but excludes extramural R&D to avoid duplication of primary R&D expenditure in the computation of an overall GERD estimate. This category should include payments for the use of intellectual property such as licence fees to patent holders. According to the FM, this is also supposed to include gross taxes on the

production of R&D. There is no information about the relevant subcomponents of other current expenditure. For simplicity, this article uses a deflator that combines, equally weighted, the aggregate PPI for purchases of goods and the deflator for technical and testing services output as a reasonable proxy for the specific services required to undertake R&D.

Intermediate consumption of R&D services

There is limited information about the purchases of R&D services required for the production of R&D. If all R&D is treated as GFCF, then the R&D cost component of doing R&D follows from the consumption of R&D capital services as long as there is some residual value for the R&D asset which can be used for other purposes. Some countries have identified all acquisition of extramural R&D as an input in R&D production. Because counting R&D extramural purchases as R&D costs inflates R&D output and R&D intermediate consumption, the impact on most indicators of interest turns out to be nil. However, it seems conceptually preferable to impute only those R&D purchases as R&D intermediate consumption when the R&D performer does not use the outcomes

Table 4
Relationship between components of R&D expenditure and output

FM R&D expenditure	NA economic cost of R&D production	Source
Wages and salaries current expenditure	Compensation of employees	Data from BERD, MA14
Other current expenditure	Purchases of goods and services other than R&D	Data from BERD, MA14
-	Intermediate consumption of R&D services	Estimated, various sources
Capital expenditure	-	Data from BERD, MA14
-	Consumption of fixed capital used in R&D production	Estimated, various sources
-	Net operating surplus (net return on capital used)	Estimated, various sources
-	Taxes less subsidies on R&D production	ONS from R&D tax credits data
Sum: intramural R&D expenditure	Sum: gross R&D output at basic prices	

for the production of other goods and services. In this article only R&D purchases by companies in the R&D sector are treated as R&D intermediate consumption.

Gross operating surplus

Capital expenditure is the third and final component of intramural R&D expenditure. According to the BERD survey guidance, this includes both acquisition and lease of fixed capital goods. For simplicity, this article assumes that reported capital expenditure only includes purchases or long-term financial leases, with rental payments included in the other current expenditure figure. The BERD survey collects more detailed information on two types of assets, land and buildings on one hand and plant, machinery and equipment (PME) on the other. Among the first, buildings are an asset within the production boundary and its formation is already captured in the National Accounts. This article treats the land and buildings figure as the current investment in a buildings asset strictly used for R&D activity. Expenditure on plant, machinery and equipment is broadly equivalent to the formation of the National Accounts asset which includes computers and purchased software. This expenditure should therefore count not as R&D production costs, but as build assets, the use of which for R&D purposes generates economic costs to their owners.

Currently it is not possible to identify whether capital expenditure includes expenditure on intangible assets recognised in the SNA, such as software development, mineral exploration or artistic and literary originals. Abstracting from these problems, stocks of fixed assets used for R&D for the two separate categories reported in BERD are estimated. Constant price investments in such assets are estimated by deflating land and buildings expenditure with the buildings deflator for the business services sector (ONS code RIWW) and PME with the equipment (including computers) deflator for the R&D sector (ONS code RKZA). Stocks are calculated using the perpetual inventory model (PIM) and geometric depreciation rates of 1.5 per cent and 15 per cent respectively. Capital services for the use of both stocks are calculated using an assumed net rate return of 7 per cent nominal applied to the Hall-Jorgenson formula, which characterises an equilibrium in the rental market for assets, to infer rental rates that equal the sum of a net return plus depreciation net of capital gains (Hall and Jorgenson 1967).

Taxes less subsidies on production

BERD sources do not explicitly collect information on this item but, as noted, the FM requires other current expenditure to include taxes on R&D production. The FM states that subsidies should not be netted out from gross R&D expenditure and are therefore excluded. For National Accounting purposes, it is, however, necessary to discount such subsidies in order to arrive at a gross output figure at basic prices. R&D tax credits in the UK provide incentives to companies to perform R&D, which reduce the required return on investments for companies to undertake R&D.

There has been some discussion about whether R&D tax credits, which are integrated in the corporation tax system, should be counted as production subsidies rather than tax adjustments. Because small and medium companies can claim an enhanced relief on what they spend on R&D for corporation tax purposes and claim a credit when there is no net tax liability, ONS decided to treat payable tax credits as a subsidy on production for R&D (ONS 2002). HMRC (2006) currently publishes data on claims for the various R&D tax credit schemes as a new set of National Statistics. This article adopts the ONS R&D subsidy figures in Mahajan (2006).

Estimates of output for the business sector

For this sector, gross output at basic prices is calculated as follows: half of the R&D performed by the computer services sector is subtracted from the total R&D expenditure performed by the business sector. Capital expenditure is also subtracted and replaced by estimates of capital services for buildings and equipment used for R&D. An estimate of intermediate consumption of R&D services equal to the estimated extramural expenditure in R&D by the R&D sector is added. Gross output at basic prices is estimated by subsidies on R&D production. Estimates of gross output at purchasers' prices are derived by adding taxes less products on R&D services, as obtained from the SUTs.

Adjustments for non-market sectors

The earlier calculations for the business sector provide an indicative adjustment factor for the FM R&D expenditure in the government and non-profit sectors to be converted into gross output figures. Because these are essentially non-market producers, consistency with National Accounts methods requires imposing a nil rate of

return in estimating the capital services of fixed assets used in R&D production.

Estimating total R&D supply

The FM methodology largely focuses on the identification of R&D performed in individual countries. However, a country has access to a larger scope of R&D resources if it can acquire these services from abroad. Understanding the total level of resources is crucial in estimating how much the UK economy invests in scientific knowledge.

Imports and international trade in R&D

There are two alternative sources of information for estimating R&D imports (and exports). GERD figures on R&D performed abroad, funded by domestic UK sectors (R&D performed in the UK funded by the rest of the world), provide a possible estimate of R&D imports (exports). An alternative source is the UK Balance of Payments (BoP) (*Pink Book*), which provides official estimates for the UK's international trade in services, including a separate category for R&D services' exports and imports. These are essentially based on quarterly and annual business surveys on International Trade in Services (ITIS). Although the definitions of R&D in Frascati and ITIS sources are identical, there are conceptual and practical differences between these sources which can lead to differences in values.

For the purposes of this analysis, stronger emphasis is placed on the internal consistency of the estimates by using the export and import figures implied by the FM R&D sources, subject to the adjustment for grants explained above. Full incorporation into the National Accounts will require the complete resolution of discrepancies between the BoP and ITIS figures and a better understanding of knowledge flows within multinational companies.

Resources

The estimation of total R&D resources in the economy builds on the estimates of R&D gross output, which is then added to estimates of R&D imports, taxes less subsidies on the R&D services provided (using data from the SUTs), and other intermediation margins (nil for R&D) that depict total supply at purchasers' prices. The results for 2004 are summarised in **Table 5**. Total resources are approximately £2 billion higher than gross output because of the inclusion of R&D imports.

Estimating R&D uses

Consistency with National Accounts methodology requires supply and demand for R&D to be fully balanced. Since the bridging methodology relies on a single main source, this condition is automatically imposed by equating total R&D uses to estimated total R&D supply. Uses of R&D are then apportioned to the various institutional sectors using the estimated ownership shares for each sector's output in Table 3. The results are provided in Table 6.

The total estimated use of R&D services by each sector is split by type of use. In the case of uses by the rest of the world, all uses fall into the export category. Estimates of intermediate consumption for each sector build on earlier estimates used in constructing R&D output. There is therefore no intermediate consumption of R&D services for purposes other than the production of R&D in the R&D sector. The residual uses within each sector are subsequently allocated to GFCF in the R&D knowledge asset. It is important to note that neither government nor NPISH undertake final consumption of R&D services in this analysis. This happens to be currently the case only for government, although NPISH are currently portrayed as final consumers of R&D services. The solution to this problem is to treat the use of R&D as investment, with the R&D asset contributing to an activity other than R&D, for example, health services for medical research. Further detail will be provided in future analysis.

R&D projects can extend over more than one accounting period. This implies that they should be treated as work in progress before completion. Because the knowledge arising from a research project follows continuously and can be used for other purposes, this article ignores any gestation

Table 5

Estimation of R&D output from Frascati R&D expenditure, 2004

	£ million, current prices			
	Corporations	General government	NPISH	All domestic sectors
Starting point: Frascati Manual intramural R&D expenditure	12,816	2,170	5,411	20,397
less software adjustment	-550	0	0	-550
equals: within scope R&D expenditure	12,267	2,170	5,411	19,848
plus adjustment for tangible fixed assets	1,316	-36	-89	1,191
equals: cost of R&D production excluding R&D IC	13,582	2,134	5,322	21,039
plus intermediate consumption (IC) of R&D in production of R&D	72	39	2	113
equals: R&D output at producers' prices	13,655	2,173	5,325	21,152
less subsidies on production	-717	0	0	-717
equals: R&D gross output at basic prices	12,938	2,173	5,325	20,435
plus taxes less subsidies on R&D services	324	0	0	324
equals: R&D gross output at purchasers' prices	13,262	2,173	5,325	20,760
plus imports of R&D	1,421	583	0	2,004
plus intermediation margins	0	0	0	0
equals: total R&D supply	14,683	2,756	5,325	22,764

Source: Author's calculations on a number of ONS sources

lag times in R&D knowledge production, therefore excluding changes in inventories (work in progress) for R&D.

The impact of R&D capitalisation on the National Accounts

In order to incorporate a new set of estimates for R&D uses and resources in the accounts, it is necessary to perform a number of adjustments to the SUTs.

In the case of R&D services, the first step is to remove current estimates of R&D supply and uses, in order to avoid double-counting. However, further adjustments are required. Treating most of R&D uses as capital formation and estimating their value from independent Frascati sources has a number of impacts on the supply and use of other goods and services in the SUTs.

Avoiding non-market output double-counting

By measuring R&D output 'at cost', this article adopts a very similar methodology to that generally used for valuing the output of non-market producers, particularly at current prices. If R&D output by non-market producers is fully reflected in the National Accounts estimates, the revised non-market output estimates of R&D should not add to the total R&D output. All changes to total output should stem from the inclusion of own-account R&D. However, this does not appear to be the case, as Table 7 shows.

Levels of R&D performed (FM definition) and produced by sector (as estimated above) are reported against those estimated in BB06. Since the split of R&D output in the National Accounts is not available by institutional sector, indicative values are estimated by apportioning the

Table 6

Estimates of uses of R&D services

	£ million, current prices									
	1997	1998	1999	2000	2001	2002	2003	2004	2005	
Total uses (= total resources)	16,066	17,069	18,366	19,320	20,046	21,608	21,991	22,764	24,700	
Uses by corporations	8,874	9,244	10,062	10,561	10,527	11,049	10,892	11,702	12,309	
Intermediate consumption	45	57	76	77	66	96	96	72	88	
Gross fixed capital formation	8,829	9,187	9,986	10,484	10,461	10,953	10,797	11,630	12,221	
Uses by general government	2,707	2,726	2,762	2,922	2,512	2,543	3,228	3,440	3,474	
Intermediate consumption	33	36	43	39	32	39	48	39	37	
Gross fixed capital formation	2,673	2,690	2,719	2,883	2,480	2,503	3,180	3,401	3,438	
Uses by NPISH	2,436	2,581	2,789	3,162	3,583	4,060	4,145	4,377	4,995	
Intermediate consumption	1	2	2	3	2	3	3	2	2	
Gross fixed capital formation	2,434	2,579	2,786	3,159	3,581	4,057	4,142	4,375	4,993	
Uses by rest of world (exports)	2,050	2,518	2,754	2,675	3,424	3,956	3,725	3,244	3,922	

Source: Author's calculations on a number of ONS sources

Table 7
Comparison of alternative R&D output estimates, by institutional sector, 2004

	£ million, current prices			
	Corporations	General government	NPISH	All domestic sectors
R&D FM gross expenditure	12,816	2,170	5,411	20,397
R&D gross output at basic prices (NA) ¹ (Estimates based on SUT total output)	6,587	723	723	8,032
R&D gross output at basic prices (Bridging methodology: satellite account)	12,938	2,173	5,325	20,435
Difference: experimental satellite less NA	6,351	1,450	4,602	12,403
Difference: experimental satellite less FM	122	3	-86	38

Note:

¹ Imputed across sectors on basis of R&D employment shares.

Source: ONS and author's calculations on a number of ONS sources

reported total, using R&D employment shares from the Inter-Departmental Business Register establishment data. These suggest that NPISH and general government accounted each for about 9 per cent of total R&D establishment employment. These shares are used to estimate the share of National Accounts R&D output that would theoretically correspond to each sector. The results for the business sector are as expected, with R&D basically doubling, which is consistent with the estimate from MA14 that about half of business intramural R&D expenditure is financed out of own funds. However, the results also suggest that R&D output in the government and NPISH sectors is substantially underestimated. Since the valuation methodologies for overall output should be near identical, the only plausible explanation is that government and NPISH output estimates for other goods and services include part of the costs allocated to R&D in the FM methodology. This implies that a negative adjustment should be made to the output of other products and services and, indirectly, to their associated uses, including final consumption.

Consumption of capital services of the new asset by non-market producers

While the above suggests that capitalisation of R&D implies no contribution to the revised GDP estimate from non-market producers of R&D, because of the identical basis for measurement 'at cost', an additional adjustment needs to be made to account for additional production in these sectors. The rationale for the upward adjustment stems from the fact that by introducing a new intangible asset in the system, the 'at cost' output of these

institutions needs to recognise the cost of consuming part of that new asset. This adjustment is not required for market producers because the consumption of R&D services will be reflected (although not separately identified) in the economic profits (gross operating surplus) estimated directly or as a margin.

R&D knowledge stocks and services

The special treatment of consumption of R&D knowledge by non-market producers requires the upfront estimation of R&D knowledge stocks and their depreciation. This will also turn out to be useful in estimating the impact of knowledge accumulation on productivity growth, as discussed further below. There are three main steps required to estimate the services form the new R&D asset.

Deflation of R&D investment

In order to produce constant price series for R&D investment by sectors, it is necessary to calculate an appropriate R&D deflator. The deflators for various subcomponents of R&D expenditure were discussed in an earlier section and the results are summarised in **Figure 1**.

The profile for R&D wages and salaries shows that labour is the most inflationary R&D input, while equipment prices exhibit negative growth, probably reflecting reductions in the cost of computers which are predominantly used for R&D. A steeper profile for the GDP deflator suggests that if the ratio of nominal BERD to GDP stays constant, its constant price equivalent should be increasing. This phenomenon is more accentuated if we look at the behaviour of the implied deflator for R&D output, which is broadly flat over the period. This Paasche chain-linked

price deflator for R&D is calculated using estimated rentals of fixed assets instead of payments for new fixed assets. It is referred to as an implied deflator because it is derived from, and consistent with, a chain-linked Laspeyres volume index for R&D output. This article uses this deflator to estimate R&D output and investment volumes.

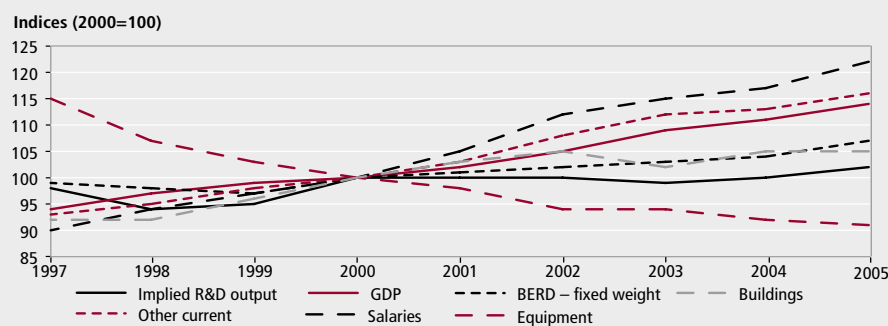
At this stage in the project, quality adjustments for R&D output have not been implemented. This is because the evidence on productivity growth trends in R&D appears to be mixed. In future work, deflation and productivity adjustments would have to be made at a lower level of aggregation, in order to reflect differences in R&D performance across activity sectors in terms of technology, but also market structure. It is plausible that some of the productivity gains could be captured by the R&D workforce, and R&D employers may agree to pay higher wages to retain their control over the knowledge asset.

Compilation of R&D (scientific originals) stocks

Based on constant price series for R&D GFCE, a PIM model with a geometric depreciation rate is used to estimate R&D stocks at the end of each period. This is considered to be a reasonable approximation to the behaviour of the aggregate stock which would certainly exhibit a much more stochastic behaviour at the level of individual 'pieces' of knowledge. Following completion of an R&D project, many individual companies write off a project's costs if it has not been successful, while a successful outcome could in principle lead to the revaluation of the knowledge asset to a much higher level, reflecting the commercial value of the intellectual property. It is of course a subject for future investigation to test whether an aggregate geometric depreciation rate is a reasonable approximation to the knowledge asset value dynamics. Future revisions will also allow for in-year depreciation, as opposed to assuming instant depreciation at the end of each accounting period.

Implementing a PIM estimation of R&D stocks requires a number of assumptions about the depreciation of the stocks. This article applies a depreciation rate of 20 per cent for the business sector's R&D stock, which is consistent with a ten-year service life under a double-declining balance rate. This assumption fits with the upper bound of the estimates by Baruch and Sougiannis (1999) and Ballester *et al* (2004), and is close to the 24 per cent depreciation rate

Figure 1
Deflators for R&D expenditure, components and GDP



Source: Author's calculations on a number of ONS sources

estimated by Schankerman and Pakes (1986), based on patent renewal methods applied to the UK. However, a 2.5 per cent geometric depreciation rate, close to that of buildings, is adopted for assets owned by the government and NPISH sectors on the basis that it is likely to depreciate more slowly than knowledge owned by individual companies. This is due to systematic differences in the type of knowledge produced by non-market producers, which tends to be general as opposed to focused on specific applications. Furthermore, the use of a lower depreciation rate also contributes – in steady state – to a more conservative estimate of the contribution of R&D to non-market output.

The levels of R&D net stocks for corporate, government and NPISH sectors grow over the estimation period 1997 to 2004 at an average rate of 3, 1 and 7 per cent, respectively. Business and government stocks start from very similar levels, approximately £40 billion, while NPISH starts at about £35 billion in 2003 prices. Because of the acute differences in growth rates, the NPISH stock catches up and overtakes the government R&D stock.

Calculation of R&D capital services

Capital services of non-financial assets to the production process are not explicitly mentioned in the 1993 SNA. The OECD defines capital services as inputs that flow to production from a capital asset. For market producers that use their assets, their value is implicitly covered as part of the independently-estimated gross operating surplus. It consists of a return to capital (an opportunity cost), depreciation and a deduction for expected real holding gains. For R&D assets owned by non-market producers, consistency of treatment with other assets requires reflecting their consumption as part of non-market output, gross operating surplus (through

capital consumption) and final use as final government or NPISH consumption. Because National Accounts assume a nil net operating surplus for non-market producers, capital services for these sectors are estimated to comprise only depreciation.

Summary of impacts on the 'goods and services account'

The analyses above have provided all the necessary building blocks to evaluate the joint impact of R&D capitalisation and using FM sources to estimate R&D resources and uses. The 'goods and services account' provides the basic framework on which to evaluate the new treatment of R&D as it balances total resources, from output and imports, against all possible uses. A summary of the impacts for the 2004 reference year is provided in **Table 8**. On the resource side, the bridging approach leads to an increase in R&D gross output above £12 billion. Because some of that increase is due to the reallocation of output from other goods and services (OGS) to R&D for non-market producers, a deduction of about £9 billion is imputed for the government and NPISH sectors. A net increase in the output of OGS follows from the inclusion of the consumption of £4 billion of R&D capital services by these sectors. Finally, a small deduction applies to imports reflecting the use of an FM-derived measure as opposed to the BoP figure in the National Accounts.

The impact on demand is split over a wider number of categories. The adjustments to avoid double-counting of non-market output are reflected in reductions in intermediate consumption of OGS and final consumption of government and NPISH, marked as double-counting adjustments. Capitalisation raises R&D investment from zero to close to £20 billion, reflecting cuts to R&D intermediate consumption, identification of own-

account R&D output and reductions to final consumption of non-market sectors. Adjustments are also made to eliminate work in progress for R&D in the National Accounts and to record exports from FM sources as opposed to BoP data. By construction, these adjustments not only balance total supply and demand, but also uses and resources by product. To estimate the adjustments to OGS on the supply and use sides, this article imposes the constraint that non-market GVA only increases by the value of R&D capital consumption in the government and NPISH sectors. Further analysis will be required to allow for market output by non-market producers.

Impacts on key economic indicators

This article focuses on a number of key economic indicators to summarise the impact of the capitalisation methodology on the National Accounts. GDP is the headline indicator of economic activity and a primary focus of attention.

Table 9 shows that the overall impact on the current level of GDP ranges from 1.5 to 1.2 per cent, with a slight negative trend over the period. The market sector is responsible for almost two thirds of the overall impact, ranging between 0.8 and 1.1 per cent of GDP. Another economic indicator of interest is the net domestic product (NDP) which equals GDP less consumption of fixed capital. Because business-owned R&D knowledge is a relatively fast-depreciating asset, the impact on NDP is quite small and, in 2004, even negative. Although it may be of concern that R&D has limited direct impact on nominal NDP, which if expressed in real consumption terms is an indicator of the sustainability of consumption opportunities, it should also be noticed that this analysis does not capture the impact of R&D spillovers on such opportunities.

R&D intensity indicators

Many users will also find of interest how the R&D capitalisation methodology impacts on the headline R&D intensity indicator. The results are provided in **Table 10**. The headline GERD to GDP ratio is only affected by changes to the denominator, but the impact is barely noticeable. The new methodology enables the estimation of new R&D indicators that can help provide new insights on the R&D intensity of the UK economy, one of which is a genuine R&D investment share, defined as the proportion of GDP that goes to R&D GFCF.

Table 10 also documents a significant

Table 8
Summary of impacts on the goods and services account, 2004

		£ million, current prices	
Resources		Uses	
R&D output	12,403	R&D intermediate consumption	-5,274
Output of other goods and services (OGS) (double-counting)	-9,089	Intermediate consumption OGS (double-counting)	-1,363
Output of OGS from non-market consumption of R&D capital services	4,216	R&D gross fixed capital formation	19,407
R&D imports (adjustment from BoP to FM sources)	197	Gross fixed capital formation (other assets)	0
		Changes in inventories (elimination of work in progress)	12
		Final consumption of R&D by NPISH (elimination)	-325
		Final consumption of OGS by NPISH (double-counting)	-5,084
		Final consumption of services from R&D capital by NPISH	1,776
		Government final consumption of OGS (double-counting)	-2,641
		Final consumption of services from R&D capital by government	2,440
		R&D exports (adjustment from BoP to FM sources)	-1,219
Total supply of R&D	12,600	Total demand of R&D	12,600
Total supply of OGS	-4,873	Total demand of OGS	-4,873
Total supply	7,727	Total demand	7,727

Source: Author's calculations on a number of ONS sources

revision to the investment intensity of the UK economy. The share of GFCF over GDP increases by approximately 1.5 percentage points, as R&D now counts for about 9 per cent of total gross investment. This is also reflected in an increase in value of a profit indicator, namely the share of operating surplus (here including mixed income) relative to GDP, and the share of gross savings relative to national disposable income. The impact on both magnitudes is positive at around 1 to 2 percentage points. Capitalisation of R&D expenditure increases relative profits, investment and savings.

Volume GDP growth and impacts on productivity growth

The approach adopted here to evaluate the impact on volume GDP growth calculates a volume index for the net addition to

GDP using the R&D implied deflator. The 'new' GDP volume index is a Laspeyres chained-linked index of BB06 GDP volume index (ONS code YBEU) and the estimated adjustment volume index, using their respective nominal shares in the lagged 'new' current price GDP as weights. Annual volume GDP growth is only revised from an average of 2.93 per cent over 1997 to 2004 in *Blue Book 2006* to 2.91 per cent, while money-GDP growth is revised from 5.46 to 5.41 per cent.

Growth accounting

A final question of interest is how much R&D accumulation has contributed to productivity growth. Growth accounting is a technique designed to attribute changes in the volume of GDP to changes in the volume of various inputs. A weighted index of inputs can be derived to estimate

a measure of multi-factor productivity growth, based on the assumption that the contributions of each input are proportional to their share in national income. Although this relies on strong assumptions about the competitive nature of the economy and its production opportunities, it is a powerful tool for analysis (ONS 2007). Failure to control for particular inputs can imply that the growth rate of output steers away from the aggregate growth of inputs and is counted as residual productivity growth. Thus the question is how much capitalising R&D, as set out in the SNA revision, can help reduce this gap.

Additional analysis on this issue has drawn on data reported by Goodridge (2007), also based on *Blue Book 2006*. Over the period, constant price GVA (excluding dwellings) grows at an average rate of 2.8 per cent. Accumulation of other

Table 9
Summary of impacts on current product (GDP)

	Gross domestic product (GDP)					Net domestic product (NDP)				
	Blue Book 2006	Satellite account		Satellite account (all sectors)	Percentage change	Blue Book 2006	Satellite account		Satellite account (all sectors)	Percentage change
		(market only)	Percentage change				(market only)	Percentage change		
1997	811,194	820,472	1.144	823,758	1.549	719,259	720,511	0.174	720,511	0.174
1998	860,796	870,110	1.082	873,368	1.461	765,745	767,161	0.185	767,161	0.185
1999	906,567	916,233	1.066	919,620	1.440	805,512	806,954	0.179	806,954	0.179
2000	953,227	963,456	1.073	967,125	1.458	846,855	848,074	0.144	848,074	0.144
2001	996,987	1,007,165	1.021	1,010,958	1.401	886,553	887,414	0.097	887,414	0.097
2002	1,048,767	1,059,404	1.014	1,063,311	1.387	932,760	933,850	0.117	933,850	0.117
2003	1,110,296	1,120,428	0.913	1,124,437	1.274	991,057	991,436	0.038	991,436	0.038
2004	1,176,527	1,186,479	0.846	1,190,695	1.204	1,048,100	1,047,990	-0.010	1,047,990	-0.010

Source: Author's calculations on a number of ONS sources

Table 10

Indicators of R&D intensity and impact of R&D capitalisation on key economic ratios

	GERD/GDP		R&D GFCF/ GDP	GFCF/GDP		Gross operating surplus/GDP		Gross saving/gross national disposable income	
	BB06	Satellite	Satellite	BB06	Satellite	BB06	Satellite	BB06	Satellite
1997	0.018	0.018	0.017	0.165	0.179	0.341	0.351	0.170	0.185
1998	0.018	0.018	0.017	0.176	0.190	0.329	0.338	0.177	0.192
1999	0.019	0.018	0.017	0.172	0.187	0.319	0.329	0.157	0.171
2000	0.019	0.018	0.017	0.169	0.184	0.307	0.317	0.150	0.165
2001	0.018	0.018	0.016	0.166	0.180	0.303	0.313	0.150	0.164
2002	0.018	0.018	0.016	0.165	0.180	0.311	0.321	0.151	0.165
2003	0.018	0.018	0.016	0.161	0.175	0.317	0.326	0.149	0.163
2004	0.017	0.017	0.016	0.165	0.180	0.322	0.330	0.151	0.164

Source: ONS and author's analysis of various sources

capital assets accounts for 1.4 per cent and quality-adjusted labour for 0.8 per cent. R&D accumulation only contributes 0.05 per cent to observed GVA growth, which is mostly the result of a particularly low income share of less than 1 per cent and an average growth of 2 per cent. Thus, the contribution of R&D accumulation to growth is minimal over this period. This result should be interpreted with caution, as the growth accounting exercise only considers the direct contribution from 'owned' R&D knowledge. To the extent that economic performance also depends on the stock of freely available knowledge, the growth accounting exercise can lead to an underestimation of the real contribution of scientific knowledge to growth.

Conclusions and future work

This article has documented the assumptions and methods underpinning a preliminary analysis of the capitalisation of R&D services in the National Accounts, in line with the proposed revision to the 1993 SNA. A bridging approach between Frascati sources and National Accounts methods is considered to be the best practical approach to constructing a new set of satellite accounts. The results suggest that R&D accounts for a substantial part of investment in the economy and that the value of goods and services produced in the economy is higher than estimated by conventional methods. Because investment in R&D has remained fairly stable in recent years, capitalising R&D has no significant impacts on the estimated rate of GDP growth.

The methods and results discussed in this article raise a number of questions that ONS will seek address in the near future. Key priorities for further research include:

- estimating R&D output and consumption by sector of activity,

in order to improve consistency and provide the basis for detailed Supply-Use, Input-Output analysis

- investigating in more detail the cost structure of R&D in the non-market sectors and the implications for non-market output and productivity
- exploring the relationship between funding and ownership, identifying the value of grants for R&D
- estimating the statistical distribution of service lives for knowledge assets by type of research and sector of activity
- comparing 'at cost' estimates of R&D knowledge stocks with market valuations of scientific intellectual property
- reconciling different sources on international trade in R&D services and related intellectual property transactions
- updating results with more recent figures and back-casting to provide longer time series and analysis, while assessing the availability of short-term indicators

ONS will also contribute to discussions on the implementation of the SNA revisions, feeding back the views and needs of its users, through its membership of the OECD and Eurostat Task Forces currently being put in place. These will provide more detailed methodological guidance and recommend further development of the underlying statistical sources required to produce satellite accounts.

Notes

- 1 The Frascati Manual (FM) owes its name to the Italian town where OECD experts in R&D statistics met for the first time in 1963 to set out standard practice on R&D surveys. Over the last 40 years, the FM has been revised on several occasions in order to

address emerging challenges to the measurement of human and financial resources devoted to R&D.

- 2 Currently, it is only when R&D is consumed by non-market producers or by the rest of the world that R&D contributes directly to GVA and GDP. For example, government health expenditure includes expenditure on medical R&D. This is part of non-market health output which is accounted for as government final consumption. R&D also contributes directly to GDP through its impact on the trade position. Since the UK delivers more R&D services to, than it buys from, the rest of the world, the net impact is positive.
- 3 To reconcile this approach with observed transactions on scientific intellectual property such as patent licensing, the SNA dictates that the capital accounts should include the category of patented entities. These are deemed to be non-produced, intangible assets, as opposed to other produced intangible assets such as mineral exploration rights or artistic originals. In other words, the 1993 SNA decided that there should be no 'scientific originals' within the production boundary, although it agreed that satellite accounts could potentially document on an experimental basis the alternative capitalisation treatment.
- 4 The 'other changes in the volume of assets' account registers new patents without recording matching liabilities, and writes them off as they expire – as it does when other non-produced assets such as natural resources are depleted. These changes are not related to economic transactions and are difficult to document. Like most other

countries, the UK does not produce this type of accumulation account.

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