Research and development statistics

R&D capitalisation in the knowledge module

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Explanation of symbols

.	= data not available
*	= provisional figure
x	= publication prohibited (confidential figure)
–	= nil or less than half of unit concerned
–	= (between two figures) inclusive
0 (0,0)	= less than half of unit concerned
blank	= not applicable
2005-2006	= 2005 to 2006 inclusive
2005/2006	= average of 2005 up to and including 2006
2005/'06	= crop year, financial year, school year etc. beginning in 2005 and ending in 2006
2003/'04–2005/'06	= crop year, financial year, etc. 2003/'04 to 2005/'06 inclusive

Due to rounding, some totals may not correspond with the sum of the separate figures.

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RESEARCH AND DEVELOPMENT STATISTICS

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Abstract: As formulated at the 2000 Lisbon Summit, the ambition of the European Union is to transform itself into "…the most competitive and dynamic knowledge-based economy in the world…".

Such policy strategies bring along new information requirements. In the national accounts, the significance of research and development (R&D) for economic growth is underexposed. This underexposure is partly related to a rather restricted capital concept that does not take hold of human capital and R&D as a way to create or produce knowledge capital. It is anticipated that in the upcoming revision of the System of National Accounts 1993 (SNA93) the capital concept will be extended to include R&D. In the Netherlands a satellite account, the so-called knowledge module, is being developed to increase the analytical strength of the core national accounts and to provide a framework for the indicators that are currently used to measure the role of knowledge in the economy. The knowledge module comprises indicators with respect to ICT-investment, internal training within enterprises, a decomposition of labour and R&D. In this paper the focus is on the R&D component. With the results of the knowledge module effects of the anticipated revisions of the SNA93 can be explored. Results and future work as well as some measurement issues with regard to R&D are discussed.

Keywords: Research and Development, GERD, Capitalisation, Knowledge Capital, Satellite Accounts, Knowledge Module, Depreciation, Service Lives, Service Patterns.

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1 Introduction

Post-industrialized economies are often characterized as being more and more knowledge and information oriented. Many policy strategies aim at enhancing this knowledge orientation as a way to increase productivity, competitiveness and job creation. For example, at the 2000 Lisbon Summit, the European Union formulated the ambition to transform itself in ten years time into “the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion”. One of the pillars of the Lisbon Strategy is improving investments in research, education and training as a way to strengthen the knowledge orientation of European economies. So-called structural indicators have been introduced to measure progress in these fields.

One important component of knowledge creating expenditure is undoubtedly expenditure on Research and Development (R&D). In the System of National accounts 1993[1] (SNA93), the significance of research and development (R&D) for economic growth is underexposed. This underexposure is partly related to a rather restricted capital concept that does not take hold of R&D as a way to create or produce knowledge capital. At this moment R&D expenditure is treated as an intermediate use in the production process in the national accounts. It is however anticipated that in the upcoming revision of the System of National Accounts 1993 (SNA93) the capital concept will be extended to include R&D. In this process it is important to make clear under what conditions R&D expenditure genuinely leads to the creation of an asset. In the Netherlands a satellite account, the so-called knowledge module, is being developed to increase the analytical strength of the core national accounts and to provide a framework for the indicators that are currently used to measure the role of knowledge in the economy. Especially the contribution of knowledge related expenditure to economic growth can be analysed. R&D is one of the main components in the knowledge module. In this report various steps and issues related to the measurement and capitalisation of R&D will be explained.

This paper presents the current state of the R&D capitalisation in the knowledge module. The development of the knowledge module is still an ongoing project and the capitalisation process is not finished yet[2]. In chapter 2 the methodology and the results of the determination of R&D output are given. The methodological overview of the capitalization process of R&D as well as some conceptual issues are discussed in chapter 3. In chapter 4 a list of future work is given. In chapter 5 some concluding remarks are made.

[1] The 1993 System of National Accounts is a conceptual framework that sets the international statistical standard for the measurement of the economy. It is published jointly by the United Nations, the Commission of the European Communities, the International Monetary Fund, the Organisation for Economic Co-operation and Development, and the World Bank.

[2] Results of the capitalisation of R&D will be showed at the Intellectual Capital Congress 2007.

2 Methodology of the determination of R&D-output

The current SNA-1993 does not provide a clear definition of R&D. The SNA only explains (cf. §6.163) that "R&D are undertaken with the objective of improving efficiency or productivity or deriving other future benefits so that they are inherently investments." The main principle of the Frascati[3] (OECD, 2002) definition is that R&D leads either to pure knowledge creation or the initial conception of a product or process innovation. In the Frascati Manual R&D covers three activities:

- Basic research, experimental or theoretical work undertaken to acquire new knowledge without any particular application or use in view;

- Applied research, is also original investigation undertaken in order to acquire new knowledge, however, directed towards a specific aim or objective;

- Experimental development, draws on existing knowledge gained from research or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services.

R&D plays a fundamental role in the competitiveness of firms by delivering the blueprints for product or process innovations. As such, knowledge created by R&D may lead to self standing, and principally exchangeable entities. Exclusive ownership rights can be enforced by way of legal protection, maintaining secrecy or by way of having (exclusive) access to tacit knowledge (i.e. human capital) needed to provide the knowledge asset its competitive edge. The existence of exclusive ownership is an important precondition for knowledge to comply with the general SNA definition of an asset. An important international discussion concerns the question whether R&D that is disseminated freely (freely available R&D) should be regarded as an asset in the SNA sense. Freely available R&D concerns especially R&D that is produced or financed by non-market sector producers. In section 3.1 the arguments for and against the capitalisation of freely available R&D are discussed.

One may conclude that Frascati guidelines are a sound point of reference for the definition of R&D and the subsequent knowledge assets they may provide. There seems to be no need to follow a different definition in the revised SNA-1993. However, in pursuing a complete R&D expenditure inventory, the Frascati Manual logically considers certain parts of software development as part of R&D. Therefore, supplementary guidelines are needed in the SNA to define R&D output and related assets in consistency with other intangible assets covered in the system (see section 2.2).

[3] The Frascati Manual (OECD, 2002) is a proposed standard for the methodology for collecting and using research and development statistics.

R&D statistics in the Netherlands are compiled by means of three separate surveys of R&D performers: a survey of enterprises, research institutes and of universities. These surveys include information on the R&D related compensation of employees, other operation costs (excluding consumption of fixed assets) and capital expenditure (buildings, machinery etc.). GERD according to Frascati guidelines is calculated as the sum of these three expenditure categories. The survey also provides information on R&D purchases (by type of provider) and R&D sales (by type of purchaser). However some of the recording principles are not yet in accordance with the system of national accounts. The gross expenditure on R&D (GERD) has to be translated to R&D output according to national accounts conventions. A few steps are required to translate the Frascati based R&D statistics to take into account SNA guidelines. The translation of the R&D statistics comprises several steps:

- The revaluation of R&D expenditure data according to SNA guidelines (§2.1);
- The elimination of overlaps with software(§2.2);
- Reclassification of units(§2.3);
- Inclusion of subsidies in non-market and own-account output (§2.4).

2.1 The revaluation of R&D expenditure data according to SNA guidelines

Three different product groups are introduced in order to accomplish the translation process. These are:

- Market R&D production: is supposed to coincide with the sales and purchases as observed in the R&D surveys.
- Non-market R&D production: is by SNA convention valued by the sum of production costs. The sum of outlays as reflected by GERD does not fully coincide with the sum of production costs according to SNA principles.
- Own-account R&D production: according to SNA guidelines own-account production of R&D is not regarded as an ancillary activity. The SNA recommends, if possible, that separate units should be distinguished. If this is not possible, the European System of Accounts[4] (ESA1995, §3.64) recommends that all R&D of significant size should be recorded as secondary activity. To explicitly represent the own-account R&D production, a product group is introduced in the knowledge module. In the Dutch national accounts own-account production is recorded explicitly only when used as final consumption (in case of unincorporated enterprises) or when used as gross fixed capital formation (GFCF). The explicit representation of own-account R&D in the knowledge module anticipates a possible future SNA directive to record all own-account R&D production as gross fixed capital formation.

[4] The European System of National and Regional Accounts (ESA1995) is an internationally compatible accounting framework for a systematic and detailed description of a total economy, its components and its relations with other total economies. The 1995 ESA is broadly consistent with the System of National Accounts of the United Nations (1993 SNA) as regards the definitions, accounting rules and classifications. It nevertheless incorporates certain differences, particularly in its presentation, which is more in line with its use within the European Union.

In the System of National Accounts, non-market output is valued as the sum of compensation of employees, other operation costs and consumption of fixed assets. In the upcoming revision of the System of National Accounts 1993 (SNA93) it is anticipated that the consumption of fixed assets will be replaced by the user costs of capital.
User costs of capital are also included in the value of market R&D output. However, besides the user costs of capital, a mark-up for clear profits should be distinguished. Market R&D production is thus valued at the sum of compensation of employees, other operating costs, user costs of capital and a mark-up for clear profits[5]. The sum being equal to the sales as observed in the R&D survey.

Presently, in the Dutch national accounts all own-account gross fixed capital formation is being valued at production costs (compensation of employees, other operating costs and consumption of fixed capital). When there are no representative market prices available for own-account production, the SNA allows using valuation at production costs as a second best solution. As in the revised method for non-market R&D, user costs of capital are also used in the valuation of own account R&D. However it is questionable, as for non-market R&D, whether user costs of capital should replace the consumption of fixed capital in the valuation of own-account R&D.

The calculation of the user cost of capital follows the general method prescribed by the OECD (Organisation for Economic Development and Cooperation) manual “Measuring Productivity”. An extensive description of the method used to calculate the user cost of capital is given by van den Bergen, van Rooijen-Horsten, de Haan and Balk (2006). Here, only a summary of the method will be given.
The user costs of capital are calculated as the costs incurred when an asset is bought at the beginning of the year, used during this year, and sold at the end of the year. The user cost therefore consists of two parts. The first part is the (imputed) rent that has to be paid over the money that is borrowed to buy the asset. The second part is the decline (or, in rare occasions, the increase) in the value of the asset during the year.

This means that the user costs of a quantity of assets *K* of age *j* (measured halfway the year) is calculated as

$$U_j^t \equiv (1 + r^{t+,t-}) P_{j-0.5}^{t-} K_j^t - P_{j+0.5}^{t+} K_j^t \quad , \qquad (1)$$

where U_j^t denotes the user cost of the assets;

$t-$ denotes the beginning of year t;

$t+$ denotes the end of year t;

$r^{t+,t-}$ denotes the discount rate in year t

$P_{j-0.5}^{t-}$ denotes the price per asset of age j-0.5 at time t-;

K_j^t denotes the quantity of assets of age j in year t.

[5] At this moment subsidies are left undisturbed. This will be explained in section 2.4

Expression (1) can be rewritten as

$$U_j^t = r^{t+,t-} P_{j-0.5}^{t-} K_j^t + (P_{j-0.5}^{t-} - P_{j-0.5}^{t+}) K_j^t + (P_{j-0.5}^{t+} - P_{j+0.5}^{t+}) K_j^t \quad (2)$$

With the help of the depreciation rate δ

$$\frac{P_{j+0.5}^t}{P_{j-0.5}^t} \equiv 1 - \delta_{,j} \quad (3)$$

and the price index i

$$\frac{P_{j-0.5}^{t+}}{P_{j-0.5}^{t-}} \cong 1 + i^{t+,t-} \quad (4)$$

expression (2) can be rewritten as

$$\begin{aligned} U_j^t &= r^{t+,t-} P_{j-0.5}^{t-} K_j^t + (1 - i^{t+,t-}) P_{j-0.5}^{t-} K_j^t + \delta_j P_{j-0.5}^{t+} K_j^t \\ &= (r^{t+,t-} - i^{t+,t-} + \delta_j (1 + i^{t+,t-})) P_{j-0.5}^{t-} K_j^t \end{aligned} \quad (5)$$

For the calculation of the user costs, the real discount rate is set at 4 percent. For the price index, the producer price index is used. The depreciation rate is determined by dividing the consumption of fixed capital by the net capital stock[6].

To illustrate the way that R&D output value is determined in the knowledge module, the determination of R&D output in the R&D industry is described in detail below. The same method is also used for the universities industry and the public administration sector.

The first step in the determination the R&D output value is the identification of market output. Market output is supposed to coincide with the sales. Non-market output then is determined as the residual sum of R&D production costs that is not attributable to market output. Figure 2.1 shows the result of the determination of R&D output for the R&D industry in year 2004. All bold figures in the table represent point of departure data that are known from the R&D survey. There is one important assumption used to calculate market R&D output. In case of market R&D output the operating surplus consists of the user costs of capital and clear profits. It is assumed that the clear profits equal 5% of the total production value. The ratio of market R&D output in total R&D output is used for the distribution of the compensation of employees, purchases of R&D and other operating expenditures over market and non-market output

In the future, calculations will be made, with the help of micro-data, to estimate the rate of return on R&D for a few R&D intensive industries and for the total of industries. This will improve the determination of clear profits in the business-sector.

[6] In section 3.4 more is told about the measurement of capital stocks.

Figure 2.1 Estimating R&D output of the R&D industry, the Netherlands, 2004 (million €)

	Compensation of employees	Purchases of R&D	Other operating exp.	User costs of capital	Clear profits	Production (value)
R&D totaal	925	788	321	216	37	2288
Market R&D output	301	256	105	45	37	**744**
Non-market R&D output	624	532	217	171		1543
Own-account R&D output		-				
Total costs	**925**	**788**	**321**	216	37	2288

Table for the distrubution of compensation of employees and other operating costs				
	Compensation of employees	Purchases of R&D	Other operating exp.	Total
Market R&D output	301	256	105	**662**
Non-market R&D output	624	532	217	
Total	**925**	**788**	**321**	2034

Note that in the R&D industry and in the universities industry purchases of R&D are included in the production costs. For these two industries these purchases are costs used for the production of R&D. These costs are not included in the other operating costs as registered by the R&D survey.

The procedure as explained for the R&D industry is also followed for the determination of R&D output in other industries. However, in these industries all R&D output that is not attributable to market output is attributable to own-account output of R&D instead of non-market R&D output. Own-account R&D output is estimated in the same manner as non-market R&D output.

2.2 Overlaps with software

R&D production and software development are two activities that can be interwoven. There are two kinds of possible R&D overlaps:

- R&D performance with the aim of developing a software original.
- Development of software for R&D performance.

The capitalisation of R&D output[7] may lead to a double count in the gross fixed capital formation figures of the national accounts.

The ESA-1995 explicitly excludes the expenditures on R&D incurred in the production of software: "Expenditure on R&D does not include the costs of developing software as a principal or secondary activity. However, their accounting treatment is nearly the same; the only difference is that software is regarded as a produced intangible asset… " (§3.64). In the Frascati Manual, R&D related to software development is in principle included. Data from the Netherlands indicate that R&D connected to software development can be substantial.

[7] Software expenditure is already part of gross fixed capital formation in the national accounts.

We assume that R&D fully devoted to the development of a new software original, will generally constitute an inseparable part of the production process with one single identifiable output, being the software code that defines the original. In our opinion, the most straightforward recommendation that could be made in this respect is that, all R&D with the specific goal of developing a software original should be identified as software and not as R&D. This is also in line with the present recording of software in the SNA-1993. In case the R&D concerns basic or applied research of a more general nature that could be of use in several software development projects, it would be meaningful to identify this R&D output (and the resulting knowledge asset) separately from software.

In our opinion, when the development of software is an inseparable part of an R&D project (not resulting in the development of a software original), this software should not be identified as a separate asset. The costs of this software development should be an integral part of the R&D project. In case software is being developed as a supplementary tool, the accounting recommendations of Mantler & Peleg (2003) could be adopted. That is, when the developed software can be identified as an independent multipurpose software tool, this software should be defined as a separate asset, and the consumption of fixed capital of this software should be part of the production costs of the R&D output.

In the Netherlands a correction is made to prevent double counting of the gross fixed capital formation. The R&D survey (enterprises) and the research institute survey both include a question on the percentage of total R&D labour input in full time equivalents that is devoted to ICT (in full time equivalents). This percentage is used to estimate the subtraction that must be made to avoid overlaps. The estimate is used to diminish the own-account R&D production of industries. A corresponding decrease is assumed in all production cost categories (compensation of R&D employees, other R&D operating costs, and gross operating surplus). Besides for all own-account R&D production in all other industries, the correction is also made for all non-market output of the R&D industry and government. No correction is been made for the universities industry. In the Dutch national accounts there is already a sound delineation of output between education services, R&D and own-account gross fixed capital formation in software in the universities industry.

The percentages used for the correction are based on the year 1999. As can be seen in the bridge table (Table 2.2) the overlap correction leads to a subtraction of 658-million € in 2004.

Possible overlaps with other fixed intangible capital are not investigated at this time. A few examples of overlaps could occur in case of mineral exploration, entertainment and artistic originals. The expectation is that the overlaps will not be as substantial as with software development.

2.3 Reclassification of units

A part of the surveyed population of R&D research-institutes that are at present classified as part of the research-institutes industry are reclassified as part of public administration in the Dutch national accounts. For the sake of consistency with the national accounts, in the knowledge module the same amount of GERD is moved from the research-institutes industry to public administration. The compensation of employees, other R&D operating costs and R&D related capital outlays are proportionally moved to the public administration.

2.4 Other taxes less subsidies on production

A final correction on the R&D data is made for other taxes less subsidies on production. While the other taxes are quite insignificant in the Netherlands, the subsidies are substantial (e.g. 318 mln. € in 2004). The subsidies on production consist of a general subsidy on labour costs of R&D performing personnel. The amount of the subsidy is obtained from the national accounts. The subsidy is distributed among the industries in proportion of the labour costs (excluding general government and non-market production of the universities industry). The subsidy must be subtracted from own-account R&D output in order to arrive at production against production costs. The market R&D (external R&D) part however is already valued including the subsidies (earlier we assumed that the production value was equal to the total sales).

In figure 2.2 a bridge table between GERD and the R&D output in accordance with national accounts guidelines is shown. Figure 2.3 is an example of the supply and use tables that can be constructed from the data that result from the knowledge module.

Figure 2.2 A bridge table between the GERD and the R&D output in accordance with national accounts guidelines, 2004 (million €)

	GERD	Reclassification	Capital EXP	Purchases of R&D	User costs of capital	Clear profits	Overlaps with software	Subsidies on production	R&D output SNA/ESA
Agriculture, forestry and fishing	47	0	-12	0	16	0	0	-2	48
Mining and quarrying	83	0	-8	0	11	74	0	0	159
Manufacture of food products, beverages and tobacco	227	0	-20	0	30	2	-3	-13	223
Manufacture of textile and leather products	21	0	-2	0	2	0	-1	-2	19
Manufacture of paper and paper products	24	0	-2	0	1	0	-1	-2	20
Printing	6	0	0	0	1	0	-2	0	5
Publishing	18	0	0	0	0	0	-5	-1	11
Manufacture of petroleum products	5	0	0	0	1	0	0	0	5
Manufacture of basic chemicals and man-made fibres	528	0	-34	0	72	1	-2	-34	531
Manufacture of chemical products	723	0	-85	0	116	7	-2	-33	726
Manufacture of rubber and plastic products	38	0	-2	0	7	0	0	-3	40
Manufacture of basic metals	51	0	-2	0	13	12	0	0	74
Manufacture of fabricated metal products	35	0	-3	0	13	0	0	-3	41
Manufacture of machinery and equipment n.e.c.	503	0	-24	0	63	2	-62	-26	456
Manufacture of transport equipment	182	0	-3	0	16	0	-2	-12	180
Manufacture of building material	33	0	-7	0	2	0	0	-2	26
Manufacture of ICT Hardware	1168	0	-47	0	110	9	-159	-53	1027
Manufacture of (other) electronic equipment	324	0	-17	0	48	4	-91	-7	260
Other manufacturing	12	0	-1	0	2	0	0	-1	12
Electricity, gas and water supply	23	0	-7	0	3	0	-2	-1	16
Construction	65	0	-3	0	5	1	-29	-3	36
Trade, hotels, restaurants and repair	225	0	-21	0	18	6	-14	-7	207
Transport and storage	30	0	-2	0	3	0	-10	-2	19
Post and telecommunications	10	0	-1	0	7	0	-8	0	8
Banking, insurance & pension funding	142	0	-14	0	19	0	-111	-3	33
Computer and related activities	166	0	-15	0	20	3	-79	-5	89
Research and development	1324	-97	-78	779	216	37	-20	0	2161
Legal and economic activities	49	0	-1	0	3	0	-6	-4	41
Architectural and engineering activities	89	0	-7	0	10	1	-6	-6	80
Advertising	2	0	0	0	0	0	0	0	2
Other business activities	33	0	-6	0	5	1	-4	-2	27
University education	2430	0	-292	14	311	0	0	0	2463
Public administration and social security	97	97	-6	0	7	0	0	0	196
Other service activities n.e.c.	10	0	-1	0	2	0	0	0	10
Total	8722	0	-726	793	1152	160	-620	-229	9252

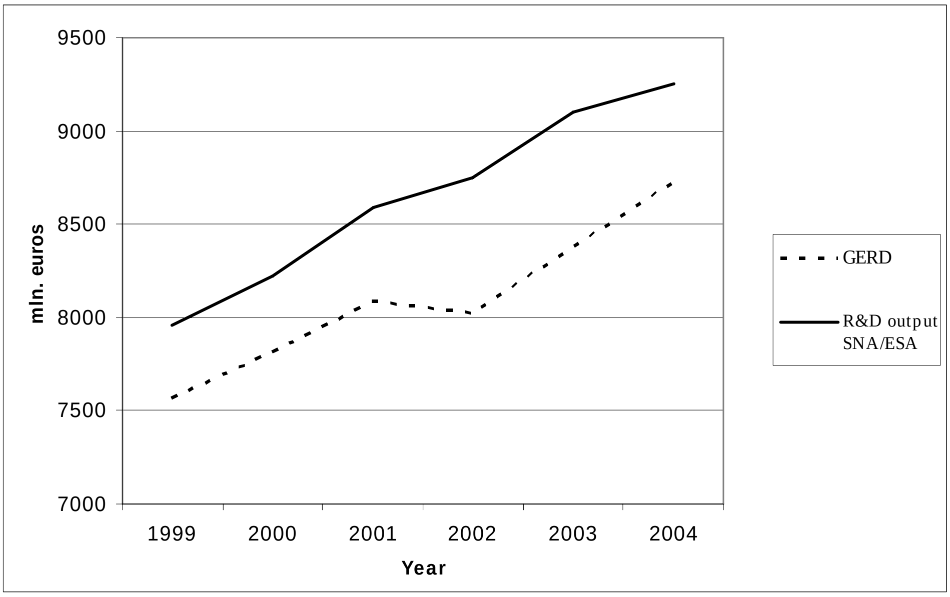
Figure 2.3 Supply and use of R&D, 2004 (million €)

Supply 2004 mln euro	Research institutes	Universities	Public administration	Industry	Imports		Total
External R&D	744	635	0	1025	567	0	2971
External R&D, non-market	1523	1815	99	0	0	0	3437
Internal R&D	0	0	0	3407	0	0	3407
Total	2268	2450	99	4432	567	0	9815
Use 2004 mln euro	Research institutes	Universities	Public administration	Industry	Exports	Government consumption	Totaal
External R&D	788	14	0	1389	780	0	2971
External R&D, non-market	0	0		0	0	3437	3437
Internal R&D	0	0	0	3407	0	0	3407
Total	788	14		4796	780	3437	9815

Note that total supply minus the imports in figure 2.3 should be equal to the total R&D output in figure 2.2. In this case there is a difference of 4 million euros due to rounding offs.

The calculated R&D output according to SNA guidelines for the period 1999-2004 is shown in figure 2.4. Although GERD declines from the year 2001 to 2002, the R&D output figure shows a positive change. One reason for this may be that in comparison with other years the calculated user costs of capital and clear profits are higher in 2002.

Figure 2.4 R&D output according to SNA guidelines, 1999-2004 (million €)



3 Capitalisation of R&D

The System of National accounts 1993 (SNA93) does not take hold of R&D as a way to create or produce knowledge capital. It is however anticipated that in the upcoming revision of the System of National Accounts 1993 (SNA93) the capital concept will be extended to include R&D. In the Netherlands the knowledge module explores this anticipated extension of the capital concept.

The capitalisation of R&D in the knowledge module is work in progress. It is expected that all issues regarding the capitalisation of R&D will be solved in the near future. This chapter gives an overview of the work in progress regarding the capitalisation process.

3.1 Conceptual issues

Internationalisation of R&D

Data on R&D imports and exports are based on questions of the R&D surveys regarding the financing of R&D. It is assumed that R&D financed by foreign entities is exported after its production and reversely, that domestically financed R&D carried out in other countries is imported. The R&D survey does not explicitly ask for R&D sales and purchases (in case of sales and purchases to and from other countries, these are exports or imports). A weakness using the questions about funding is that it does not take hold of possible other transfers or donations. The focus of the R&D survey on R&D performers is another weakness that could lead to an underestimation of R&D obtained from non-domestic producers.

Before R&D is capitalised it is important that the destination of knowledge capital created by R&D is clear. The determination of the destination is complicated for internationally operating companies. These companies have a lot of foreign affiliates. Knowledge capital can of course be exported to or imported from these affiliates (and/or other non-affiliate companies). However, it may be possible that R&D is transferred within multinational companies (multinationals) without the presence of countervailing money flows. These rather complicated flows and the mentioned weaknesses may induce an error in the estimation of the amount of R&D that potentially accumulates in the domestic economy.

Past studies of de Haan and van Rooijen-Horsten (2004) point out that a large part of the R&D personnel of most multinationals is concentrated in the Netherlands. Of eight multinationals 11% of the personnel worldwide was situated in the Netherlands in 1999, however in case of R&D personnel this percentage was 44%. This indicates that there is a concentration of R&D activities in the Netherlands. Therefore the expectation is that there should be a transfer of a certain amount of R&D to foreign company divisions. However, only two out of eight multinationals reported a substantial R&D export (>80% of GERD). The other six multinationals reported zero R&D export or a very small amount of export (3% of GERD). These results strongly point to a substantial amount of R&D being transferred abroad but remaining unobserved by way of the R&D survey.

In the Netherlands a small amount of multinationals constitute a large part of R&D expenditure. Asking a few large multinational companies to give an indication of their R&D transfers with abroad is probably enough to cover a substantial amount of R&D exports. At this moment a study is done to investigate the feasibility of interviewing domestic multinationals. The expectation is that the interviews will start in 2007.

Freely available R&D

An essential part of the capitalisation process is to identify the part of R&D-output that leads to the creation of a knowledge asset in the SNA sense. The main question is if a broader capital concept including knowledge capital without any form of enforceable ownership rights[8] is desirable. For example knowledge created in the public domain may be identified as financed and performed by government. It is however not necessarily true that the government is the owner of this public knowledge. When the knowledge is made freely available, no ownership rights can be enforced.

There are however some researchers who propose the inclusion of R&D-output without enforceable ownership rights in the capital concept. In these opinions enforceable ownership rights are not necessary for R&D to be included in the capital concept. It is stated that the fact that the ownership rights cannot enforced does not change the asset nature of R&D. A parallel can be drawn with public assets, such as roads. The services are provided free at charge yet they are considered as assets owned by the government on behalf of the community at large. In this non-competitive, non-market situation, these assets provide benefits to the group. All R&D provide one way or another, benefits to the economic owner (or the members of its collective group). Effective management and control of the knowledge asset is needed in order to ensure the expected benefits are obtained. The proposition is that the treatment of such R&D should therefore be the same as the treatment of public assets (Aspden, 2005). However, this idea is not favoured at Statistics Netherlands. Public assets are still owned by the public sector and could be sold if desired. This is simply impossible for knowledge once it has been made freely accessible to the public. After the dissemination of R&D, there is no value left to the original owners. The government has no control over the knowledge and cannot recover its costs. In addition, if freely available R&D is seen as an asset, the receiver of the R&D would be allowed to put this asset on his balance sheet. To take this to the extreme, in this case freely available R&D could be put on every single balance sheet in the world, which is clearly not advisable. When R&D is made freely available, the use of this knowledge to the producer of the R&D is not in owning the R&D, but is having personnel which can use this knowledge. The expecting benefits for the producer of the R&D are therefore not in the R&D itself, but in the human capital of the people working with this R&D. Since human capital is not regarded an asset in the SNA, therefore no asset remains.

Statistics Netherlands therefore favours the exclusion of freely available R&D. At Statistics Netherlands the presence of enforceable ownership rights is seen as a requirement in the classification as an asset. In the knowledge module, freely available R&D will not be included in the capital concept. It is not yet clear what the SNA is going

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[8] Exclusive ownership of scientific knowledge is not necessarily obtained by way of patenting only. Other possibilities are secrecy or by complementary tacit knowledge which cannot easily leak.

to recommend on this issue. The AEG[9] (Advisory Expert Group) recommendation was: "…in priciple, freely available R&D should not be included as capital formation but in practice it may not be possible to exclude it. The assumption is that including freely available R&D would not lead to significant error." However, this assumption does not hold for the Netherlands. If the R&D output of non-market producers is taken as an indication of freely available R&D, the amount that has to be excluded from capitalisation is substantial.

Although some businesses make some R&D freely available, it seems fair to assume that businesses only perform R&D when they expect the total value of the R&D to be higher than the costs of performing this R&D, including the costs of freely available R&D. Therefore including all R&D by businesses in GFCF is favoured. As for R&D done by non-market producers, the expectation is that almost all R&D is made freely available. Only on defence R&D, which is usually kept secret, and on R&D done in cooperation with businesses it is expected that ownership rights are enforced. The best estimate for the R&D done in cooperation with businesses is by taking the share of R&D that is funded by businesses. Of the R&D by non-market producers, the preference is only to include defence R&D and R&D financed by businesses in GFCF.

Unsuccessful R&D
The nature of R&D activities is that successful attempts are only possible at the expense of failures. One may argue that all R&D contributes to acquiring a commercially profitable knowledge stock, whether successful or not. For mineral exploration the SNA-1993 recommends that all mineral exploration should be treated as gross fixed capital formation (§166) since both successful and unsuccessful exploration efforts are needed to acquire new reserves. In a similar way one may conclude that the value of the knowledge capital stock should include both the costs of successful and unsuccessful R&D. This conclusion will probably be favoured in the upcoming revision of the System of National Accounts 1993.

3.2 Time series of R&D output

The time series of the user costs of capital on behalf of R&D production cover the period 1970-2004. The R&D capital stock estimates in the knowledge module will therefore cover the same period. Data on GERD for the period 1999-2004 seem very reliable. These data will be used as a reference to construct time series that cover the period 1970-1998. The time series will be constructed at the same industry level as is used for the years 1999-2004.

[9] The Advisory Expert Group on National Accounts (AEG) to the ISWGNA takes decisions on the scope of the updating and on technical and conceptual issues in conjunction with the ISWGNA. The Intersecretariat Working Group on National Accounts (ISWGNA) was given the mandate to oversee the update of the 1993 SNA.

3.3 R&D output in constant prices

The Frascati manual recommends the use of the GDP price index for the calculation of real R&D output. In general this method is considered as a second best solution. Although an output price that takes quality adjustments into account is preferred, the heterogeneity of R&D makes this impossible. Another method to arrive at R&D output at constant prices is to use input based prices. In earlier papers of de Haan and van Rooijen-Horsten (2004) it was shown that the R&D price index based on input based prices did not differ very much from the GDP price index. Besides some incidental differences in the early seventies, the R&D and GDP price index followed very similar patterns.

The input based price index is calculated with the help of the components of the production costs. In percentages of 2004 the sum of production costs consists of:

- Compensation of employees (54%)
- Intermediate consumption (35%)
- Gross operating surplus (11%)

A price is determined for each component of the production costs. From the Dutch annual supply and use tables, information on the compensation of employees and the intermediate consumption is obtained. The GDP price index is used for the deflation of the gross operating surplus. In the figures 3.1 and 3.2 the results are given for the years 1999-2004.

Figure 3.1 Annual price changes of GDP and R&D (1999-2005)

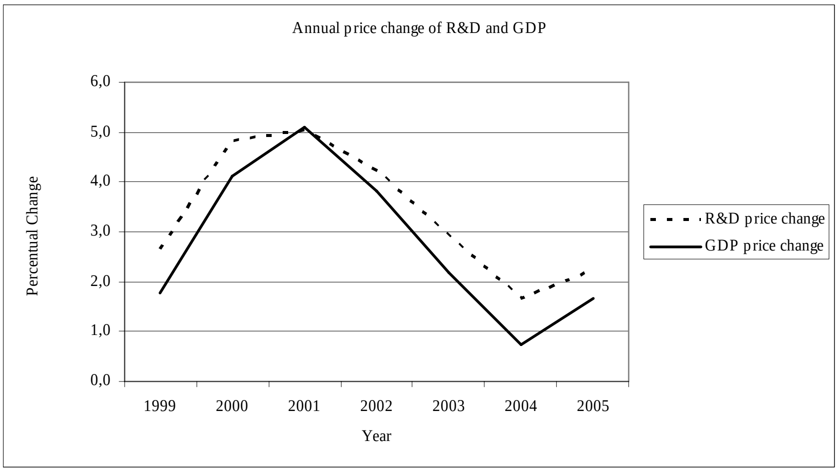
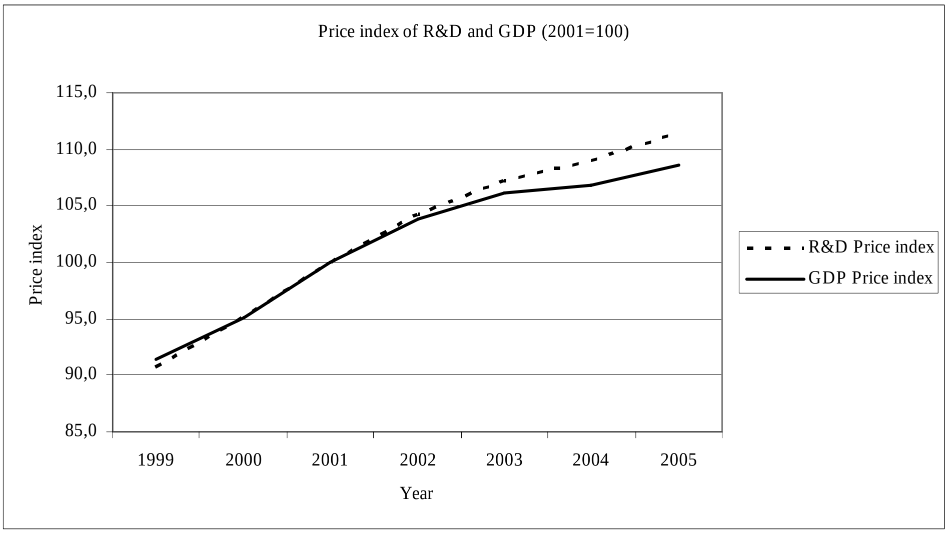


Figure 3.2 Price index of R&D and GDP (1999-2005)



As already concluded by de Haan and van Rooijen-Horsten (2004), figures 3.1 and 3.2 show that the GDP price index does not differ much from the input based R&D price index. Therefore, in the knowledge module the input based R&D price index will be used. R&D output will be estimated in constant and current prices for the period 1970-2004.

3.4 Measuring capital stocks

The OECD (2001) handbook on Measuring Capital provides the methodological underpinnings of capital related macroeconomic statistics such as consumption of fixed capital, net capital stocks and capital services. The handbook shows that these different statistics are interrelated and should be constructed preferably in a consistent way, based on one conceptual framework. In this framework the following types of capital stocks are being distinguished:

- The framework starts off with the compilation of gross capital stocks on the basis of estimated discard functions. The gross capital stock represents the replacement value of all fixed assets used in production. Replacement value means that these assets are valued according to current market prices;
- The productive capital stock is subsequently derived from the gross capital stock. The productive stock reflects the level of capital services an asset is able to generate. The productive capacity of assets is postulated with the help of so-called age-efficiency profiles. It is assumed that the age-efficiencies of most assets decline over their service lives as a result of wear and tear. The total productive capital stock of a particular asset type is derived from aggregating

assets of various vintages according to their productive capacity. Productive stocks are particularly useful for productivity measurement purposes;

- The net capital stock represents the actual market value of all fixed assets used in production. Since most capital goods are sparsely traded on second hand markets, market values are approximated on the basis of estimating the net present values of current and future rentals. The rentals are assumed to be proportional to the capital services the asset can produce. These expected capital services are being determined with the help of the above mentioned age-efficiency profiles.

Such a framework, based on a Perpetual Inventory Method (PIM), has been developed as part of the Dutch national accounts. The calculation of consumption of R&D capital, net R&D capital stocks and R&D capital services will be performed in the context of this framework. This implies that R&D capital is treated as any other produced asset is treated in the Dutch national accounts. The characteristics of the Dutch PIM are described in detail by van den Bergen, de Haan, de Heij and Horsten (2005).

3.5 Service lives and depreciation patterns

The knowledge capital stock will be indirectly measured using cumulated R&D expenditure. Two (interrelated) factors are needed to determine the annual changes in the wealth of R&D capital: the distribution of service lives of R&D assets (i.e. amortisation patterns) and the decay in the value of R&D as a result of declining market advantage received from R&D capital (i.e. age-efficiency patterns).

In comparison to the service life of a tangible asset (like a machine), the service life of a knowledge asset is difficult to determine. R&D related capital is not subject to wear and tear. The reason why knowledge assets loose their value in time is because of the decay in excess revenues of its owner compared to other competitors. There is almost no evidence on the service life of knowledge capital. Depreciation rates mentioned and used in literature vary from 11% to 25%. That means that the average service life ranges from 5 to 10 years. Evidence from Australia (ABS, 2004) indicates that the median life for patents is around 9 years. In the Netherlands the median life for patents is around 7 years (Winnink, J. J. & S. F. Goutier-Juffermans, 2004). The amortisation of patents obviously gives a useful impression of the service lives of knowledge capital. However, one may argue whether or not obtaining legal property rights may increase the service lives of knowledge capital. Another important shortcoming of the median life is that it does not take the value of the patents into account. More expensive patents will probably have a longer service life. A service life between 7-9 years will be used till more research has been done on the service lives of knowledge capital.

Besides service lives of R&D, an age-efficiency pattern must be decided upon. An asset does not have a constant return over its service life. The older the asset gets the less efficient the asset will be. The so-called age-efficiency profile is used to show the decline in efficiency of an asset in time. This profile can be very different for each asset type. At Statistics Netherlands hyperbolic age-efficiency profiles are mostly used (for tangible assets). In hyperbolic profiles the efficiency loss occurs mostly at the end of the asset life. Contrary, the geometric profiles assume a large absolute efficiency loss at the beginning of the life of an asset. Although empirical evidence is scarce, estimates of the age-efficiency profiles of tangible assets do exist. However, unlike tangible assets, knowledge assets can be used infinitely, if desired. Nevertheless, one may expect the competitive edge of knowledge capital to decline over time, indicating declining age-efficiency. Still, more research is needed before an age-efficiency profile can be chosen.

4 Future work

The capitalisation of R&D is not yet finalized in the knowledge module. It is expected that all issues regarding the capitalisation of R&D will be solved in the near future. The remaining issues as mentioned in chapter 2 and 3 concern:

- Calculation based on of micro-level data of a rate of return on R&D;
- Solving conceptual issues related to the internationalisation of R&D (imports and exports) and the treatment of freely available R&D;
- Construction of time series in current and constant prices (1970-2004);
- Determination of a service life and a service pattern for R&D capital.

However, the determination of the R&D knowledge capital is not the end of the road. When R&D capitalization is finalized the significance of R&D for economic growth will be examined. In multifactor productivity studies the effects of a broader capital concept (including R&D capital) will be analysed. It is likely that the inclusion of R&D capital will lead to a larger explained part of the economic growth (and a smaller so-called 'residual'). Besides for the economy as a whole, the impact of R&D on growth in different industries can also be compared.

The list of intangible capital is not complete by adding R&D capital. Expenditure on for instance economic competencies, software and other computerized information could be added to constitute a more complete list (Hulten, Corrado and Sichel, 2005). Hulten (2005) examines the theoretical basis for the claim that all intangibles should be treated as capital. In order to facilitate analyses of the effects of including even more intangibles, a few other categories, such as expenditure on ICT and expenditure on business education will be included in the knowledge module.

5 Concluding remarks

R&D statistics according to Frascati guidelines are a good point of departure for the construction of R&D output according to SNA guidelines. One of the most important remaining issues concerns the measurement of imports and exports of R&D. Future revisions of the R&D statistics should take this issue into consideration. Another shortcoming is the focus of the R&D survey on solely R&D performers. A consequence is the difficulty to get reliable data on imports.

R&D may lead to the creation of knowledge that carries the properties of assets:

- Knowledge may lead to market power and subsequently to added profits
- Exclusive ownership can be enforced (by means of patenting or secrecy)

In our opinion these properties do not hold for most non-market R&D. Freely accessible knowledge has no owner and the user has no market advantage over others. In this case the (exclusive) access to presence of human capital can lead to market advantage. However human capital is not regarded as an asset in the SNA. Therefore we strongly favour the exclusion of this kind of R&D from the capital concept.

The methodological and conceptual issues in the process of capitalisation of R&D are subject to an international discussion at this moment. The OECD is working on an R&D handbook that will comprise harmonised solutions for most issues regarding the capitalisation.

One of the most important possibilities of R&D statistics is their usage in sources-of-growth analyses. They facilitate the exploration of the effects of R&D on economic growth at the industry level. However, it should be kept in mind that R&D is still only a fraction of the intangibles that could be seen as an asset. The future will hold whether a more broadened capital concept will be used in national accounting.

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