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Measuring R&D Output and Knowledge Capital Formation in Open Economies

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Measuring R&D Output and Knowledge Capital Formation in Open Economies

Summary: *Contrary to mineral exploration, computer software development and literary or artistic work, Research and Development is in the present SNA-1993 not considered as an activity leading to the creation of intangible assets. It is expected that this will change in the course of the coming SNA update. This paper discusses a number of conceptual and practical issues related to the representation of R&D expenditure in the national accounts, including its capitalisation. The paper introduces bridge tables showing the transformation of data on R&D expenditure to the national accounts recording of R&D supply and use. In addition, an assessment is made of the reliability of R&D import and export figures. For the Netherlands, the measurement of R&D import and export is of particular interest due to the open structure of the Dutch economy. Finally, the effects of R&D capitalisation on the main national accounts aggregates are illustrated.*

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 expenditure is undoubtedly expenditure on Research and Development (R&D). Gross Expenditure on Research and Development (GERD) is the most commonly used indicator for measuring R&D expenditure in an economy. GERD is also assigned as a structural indicator in the Lisbon process. GERD contains the sum of intramural current and capital expenditure devoted to R&D, performed within particular statistical units or sectors. This operational definition, as found in the OECD Frascati Manual, complies well with the general aim of internationally harmonised R&D indicators.

Obviously, the System of National Accounts (SNA-93) should not lose sight of the ongoing knowledge orientation of modern economies. As a comprehensive statistical framework, the national accounts are particularly helpful in illustrating the importance of knowledge related expenditure in the context of the entire economy. For example, the national accounts support the data needs of productivity studies with a focus on the contribution of knowledge related expenditure to economic growth. Therefore, the treatment of R&D expenditure and related knowledge capital receives currently quite some attention, also in relation to the upcoming SNA update.[1]

This paper discusses the recording of R&D expenditure in the Dutch national accounts. The paper also contains bridge tables showing the different steps in translating GERD to R&D output according to national accounting conventions. Subsequently, an assessment is made of the expected level of underestimation of R&D import and export. The case of the Netherlands is in this respect quite illustrative since the Dutch economy is very open. Also, in the Netherlands R&D is concentrated in a limited number of internationally operating companies. These companies may transfer R&D to

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[1] The Canberra II Group is currently responsible for developing supplementary or alternative guidelines regarding the recording of R&D and intangible capital in preparation of the upcoming SNA93Rev.1 update.

different company divisions without the presence of countervailing money flows. This may complicate the measurement of R&D trade and subsequently the measurement of the domestic stock of knowledge capital resulting from R&D.

Different from mineral exploration, computer software and literary or artistic originals, R&D is in the present SNA-1993 not considered as an activity leading to the creation of intangible fixed assets. Yet, it is likely that under certain conditions the creation of knowledge may very well lead to economic assets in the SNA sense. Therefore, it is expected that the recording of R&D expenditure will change in the course of the coming SNA update scheduled for 2008. This paper discusses a number of conceptual and practical issues related to capitalising R&D expenditure. Finally, the consequences of this alternative treatment on the main macroeconomic aggregates in the national accounts of the Netherlands are illustrated.

2 The recording of R&D output, sales and purchases

2.1 The Frascati definition

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 definition is that R&D leads either to pure knowledge creation or the initial conception of a product or process innovation. 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 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.

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 in the updated SNA-1993 a different definition. However, in pursuing a complete R&D expenditure inventory, the Frascati handbook 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.

When Frascati based R&D statistics are used as a source in the national accounts, the R&D expenditure (GERD) data have to be translated to R&D output according to national accounts conventions. This translation is discussed in the following section.

2.2 The R&D survey in the Netherlands

The Dutch R&D statistics are annually compiled according to three major, separately surveyed, R&D performing groups: enterprises, research institutes (government and other) and universities. The surveys include questions on the following R&D related outlays:

- Compensation of employees and labour input in full time equivalents, both subdivided by scientists, assistants and other personnel;
- Other operating costs (excluding consumption of fixed assets);
- Capital expenditure (buildings, land, machines etc.).

Gross Expenditure on Research and Development (GERD) according to Frascati guidelines is subsequently calculated as the sum of these three R&D related expenditure categories.

Table 1
Initial grossed-up R&D data according to Frascati guidelines
in the Netherlands, 1999 (million €)

	Research institutes	Universi-ties	(other) Enterprises	Rest of the the World	Total
Gross expenditure on Research and Development (GERD)	1 317	1 983	4 264		7 564
R&D Sales	609	415	1 099 [1]	441	2 564
R&D Purchases	608	12	1 249 [2]	694	2 564

Source: Statistics Netherlands (2001)
[1] Including sales to affiliated enterprises (78 million €)
[2] Including purchases from affiliated enterprises (78 million €)

In addition, the survey also provides data on the sources of flows of R&D funds. These data are used for measuring R&D purchases (by type of provider) and sales (by type of purchaser) in a supply and use framework. However, these sales and purchases do not yet include the intra-enterprise R&D (own account R&D) produced by separate entities on behalf of affiliated producers. A first balanced presentation of sales and purchases for 1999, as directly derived from the R&D surveys, including import and exports is shown in table 1.

2.3 Reclassification of R&D performers

The present SNA considers own-account production of R&D not as an ancillary activity and recommends that separate units must be distinguished for it when possible. In contrast, the Dutch R&D survey of industries observes R&D in connection to those enterprises that directly benefit from it. This recording follows Frascati recommendations.

In order to reconcile these data with national accounting principles, separately distinguishable research units must be presented as part of the R&D industry (NACE-73). The beneficiary enterprises (or one or more of its individual domestic divisions) are in a subsequent stage identified as the purchasers of their R&D output. In this way, an institutional classification is logically combined with the identification of those industries that benefit from the R&D of these separately distinguishable research units. These imputed intra-enterprise sales and purchases must be valued according to representative market prices.

For the year 1999 an estimated amount of GERD of 1014-million € of separately identifiable establishments mainly occupied with R&D production is transferred from the enterprises in those industries to which these establishments are affiliated to the R&D industry (NACE-73). Since such a reallocation can only be made on the basis of grossed up survey results, the composition of GERD being transferred to NACE-73 represents the average composition with respect to compensation of employees, other operating expenses and capital expenses in the originating industry. The corresponding sales reallocated from these industries to the R&D industry amounts to 265-million €. It is assumed that all R&D purchases have been made by the affiliated enterprise. In other words, no purchases are being transferred to the R&D industry.

In addition, the surveyed population of R&D research institutes includes several institutes that are at present recorded as part of public administration (NACE-75) in the Dutch national accounts. For 1999 the corresponding amount of GERD is estimated to equal 283-million €. This amount is therefore moved from the GERD of research-institutes (approximately NACE-73) to public administration. Again, the resulting decrease in output of research-institutes implies a proportional decrease of compensation of R&D employees, other R&D operating costs and R&D related capital outlays. These estimated decreases of compensation of R&D employees, other R&D operating costs, R&D related capital outlays and labour-inputs in NACE-73 are moved to NACE-75.

The two reallocations discussed in this section are summarised in table 2.

Table 2
Reclassification of R&D expenditure and sales, the Netherlands, 1999 (million €)

	Research institutes (NACE-73)	Public administation (NACE-75)	Universities (NACE-8030.2)	(other) Industries
Gross expenditure on Research and Development (GERD)	731	283		- 1 014
R&D Sales	265	-		- 265
R&D Purchases	-	-		-

2.4 *Determining R&D output*

R&D expenditure (GERD) as measured according to Frascati guidelines comprises compensation of R&D employees, other R&D operating costs (excluding consumption of fixed assets) and R&D capital outlays (buildings, land, machines etc.). This implies that several additional calculations are needed to arrive at a R&D output in accordance with national accounts conventions.

Three product groups are introduced to translate GERD into the national accounts oriented supply and use of R&D services:

– Market R&D;
– Non-market R&D;
– Own-account R&D.

Market R&D is supposed to coincide with the sales and purchases as directly observed in the R&D surveys. Its value is consistently determined by the price at which it is exchanged. In addition, market R&D also includes the intra-enterprise supply and use of R&D discussed in the former section. Since, the intra-enterprise transfer of R&D is rarely observed either as a sale or a purchase, a representative market price must be imputed in order to determine its value.

In the national accounts, *non-market output* is by convention valued by the sum of production costs. However, the sum of outlays as reflected by GERD does not fully coincide with the sum of production costs in accordance with national accounts principles. This problem is further discussed below. All non-market output is by convention consumed by the government sector.

The SNA considers *own-account* production of R&D not as an ancillary activity and recommends that separate units should be distinguished for it when ever possible (*cf.* §6.142). The European System of Accounts (ESA-1995, §3.64) recommends that in case separate units cannot be distinguished, all R&D of significant size should be recorded as a secondary activity. Following these guidelines, a product group is introduced to explicitly identify the own-account R&D output. Following current practice in the Netherlands, own-account production is only recorded when used either as final consumption (in case of unincorporated enterprises) or as gross fixed capital formation. In this respect, the explicit representation of own-account R&D output anticipates a future SNA directive to record (at least part of) own-account R&D production as gross fixed capital formation. The capitalisation of R&D is discussed in section 4.

The standard SNA rule is to use a representative market price (SNA 1993, §6.84) to value own-account production. When a reliable market price cannot be obtained, a second best option is to determine own-account production as the sum of production costs. Since, in the Dutch national accounts, all own-account gross fixed capital formation (including software) is presently being valued at production costs, valuation at production costs is also applied to the recording of own-account output of R&D.

Establishing a (cost-based) value for the non-market and own-account output of R&D is not straightforward. Several production units observed in the R&D survey are expected to produce market as well as own-account output of R&D. For these production units, the own-account production of R&D can only be determined after production costs related to R&D sales (market output) have been identified first. As already mentioned, the sum of outlays as reflected by GERD does not fully coincide with the sum of production costs in accordance with national accounting principles. The figures on capital expenditure (buildings, land, machines etc. used to generate R&D) included in GERD should therefore be replaced by an estimation of the consumption of fixed assets as far as non-market and own-account output is concerned and by an estimation of gross operating surplus as far as market-R&D is concerned.

To determine a value for non-market R&D output in the R&D industry (NACE-73) a subdivision between intra-enterprise R&D[2], (other) market output and non-market output is first established in this industry. The omission of a well-established production survey for the R&D industry complicates the

[2] This intra-enterprise R&D that was moved to the R&D industry (NACE-73) as described above is considered market R&D (sales) and should therefore be valued accordingly.

identification of market and non-market producers and their output. Therefore, the non-market output is identified after the corresponding production costs connected to sales have been determined. In other words, non-market output is determined as the residual sum of production costs that is not attributable to market output.

Table 3 summarises the results. The bold figures in this table are the points of departure. They represent R&D survey data as summarised in table 1 and reclassified as described in the former paragraph. Clearly, this information is not sufficient to determine total R&D output. For the time being, it is therefore assumed that the gross operating surplus of market R&D encompasses a 19% share of sales. This share is derived from the "Other business services industry" (NACE-74). This results in a gross operating surplus of 213-million € connected to intra-enterprise R&D and 116-million € connected to other market output. This assumption enables the subsequent allocation of production costs, including a substantial sum of R&D purchases[3], to other market output and non-market output. After adding an estimated sum of 83-million € for the consumption of fixed capital (7.5% share of total non-market output; derived from the "universities" industry), total non-market production amounts to 1.1 billion €. The total output of the R&D industry then approximates 2.8 billion €.

Table 3
Estimating the output of the R&D industry (NACE-73), the Netherlands, 1999 (million €)

	Compensation of employees	Purchases of R&D	Other operating costs	Gross operating surplus	Total output
R&D	1 150	608	663	412	2 833
Intra-enterprise	**512**	**-**	**398**	213	1 123 [1)]
Other market output	208	198	87	116	**609**
Non-market	430	410	179	83	1 101
Total, costs	**1150**	**608**	**663**	412	2 833

1) This output includes the directly observed sales of 265-million € (*cf*. table 2)

This estimation of the output of the R&D industry is based on the assumption that a sound subdivision can be made between market and non-market output. Yet, such a split is being complicated by the fact that non-market producers may sell part of their output. As a result, gross operating surplus and total

3 In the R&D industry (NACE-73) and the universities industry (NACE-8030.2) purchases of R&D are included in the production costs because they are costs in the production of R&D and are explicitly excluded from the Frascati variable "other operating costs". In all other industries purchases of R&D are not considered part of the production costs of R&D.

output may be somewhat overestimated. This can be compensated by a downward adjustment of the assumed gross operating surplus share in total market output.

The total output of the intra-enterprise R&D now comprises 1123 mln € of which 265 million € are directly observed sales. The remaining 858 million € of the intra-enterprise output is by convention purchased by the domestic industries of origin (data not shown).

A similar procedure is followed to determine the (cost-based) own-account output of R&D in other industries. In those industries with R&D sales, the production costs related to sales (market R&D) are identified first before the own-account production can be determined as the residual sum of production costs. For those industries without R&D sales, the own-account output is directly calculated at the sum of production costs. Consumption of fixed capital is estimated by assuming that this part of costs equal 7.5% of total own-account output.

2.5 Overlaps with other intangibles

Software

It is important to settle boundary issues with other intangible assets alongside general recommendations about R&D capitalisation. Data from the Netherlands indicate that R&D connected to software development can be substantial. The ESA-1995 explicitly excludes the expenditures on R&D incurred in the production of software from R&D activities: "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.

Mantler & Peleg (2003) recognise two kinds of possible R&D-software overlaps:

- Firstly, R&D may be performed with the aim of developing a software original;
- Secondly, the development of software may be part of a R&D project.

Mantler & Peleg argue that "…in the case of R&D on software, as in other cases where assets are being produced using R&D, there are in fact two products:

a) an asset – the software – that can be used repeatedly in production;

b) R&D that is a product in itself, whether regarded as an asset or as intermediate consumption".

Contrary, to this view, 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.

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 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, starting in 1997, every other year, both the enterprise survey and the research institute survey, include a question on the percentage of total R&D labour input (in full time equivalents) that is devoted to ICT. We used this information to estimate the amount of R&D output that should be subtracted in order to avoid overlap with software output. Firstly, the average ICT percentage of full time equivalents is calculated per industry for the year 1999. This is subsequently used to diminish the own-account R&D production of industries, assuming a corresponding decrease in all production cost categories. For universities, no duplication with own-account software production is expected. In the Dutch national accounts, a sound delineation of output has already been established between education services, R&D and the own-account gross fixed capital formation in software.

In summary, only non-market and own-account production are corrected for software overlaps. Data on R&D sales and purchases have not been adjusted. The total effect of eliminating software-R&D overlaps amounts to a total reduction of 484-million € (*cf*. table 4, column 5).

Mineral exploration

Although the Frascati manual indicates that "...surveying and prospecting activities of commercial companies will be almost entirely excluded from R&D", it seems relevant to look also at possible overlaps between R&D and mineral exploration. According to Frascati guidelines, R&D involved in 'mining and prospecting' is restricted to the following two activities:

The development of new or substantially improved methods and equipment for data acquisition, processing and study of the data collected;

Surveying undertaken as an integral part of an R&D project on geological phenomena *per se*.

These two activities may overlap with mineral exploration as defined in the SNA. In §10.91, the SNA indicates that mineral exploration costs "...include not only the costs of actual drillings and borings, but also the costs incurred to make it possible to carry out tests, for example, the costs of aerial or other surveys...". It seems that these additional costs also apply to costs related to the two above mentioned R&D activities addressed in the Frascati manual.

Again, following the same arguments of Mantler & Peleg with respect to software development related R&D, when R&D related to mineral exploration can be regarded as the creation of self standing knowledge assets, this R&D should be capitalised apart from mineral exploration. As a consequence, R&D expenditure should be allocated over the various mining exploration projects by way of consumption of fixed capital. However, if this R&D is completely assigned to one single exploration project; it is not very meaningful to separately capitalize R&D and other expenditure on mineral exploration.

At this time, possible overlaps of R&D with mineral exploration and entertainment have not yet been investigated for the case of the Netherlands. As mentioned, such overlaps are expected to be of minor significance.

2.6 Other taxes less subsidies on production

Additional attention must be paid to other taxes less other subsidies on production. Although in the case of the Netherlands other taxes related to R&D are quite insignificant, the other subsidies are substantial (*e.g*. 234-mln € in 1999), comprising a general subsidy on the labour costs of all R&D performing personnel with the exception of general government and universities. This subsidy must be subtracted from own-account output of R&D in order to consistently determine output at production costs. In case of market output the subsidy straightforwardly becomes a separate entry in the generation of income account without any effect on output.[4] The ultimate reduction of R&D output, resulting from the subtraction of other subsidies on own-account production, amounts to 119-million € (cf. table 4, column 6).

[4] The 234 mln € other subsidies are allocated to the different industries and to market versus own-account R&D within those industries on the basis of wage-distributions. The general government, universities and the non-market production of the NACE-73 industry are excluded because the subsidy on R&D production cannot be applied for by the public sector.

2.7 An overview of adjustments

Table 4 represents a bridge table showing step by step all differences between GERD presented in column 1 and R&D output according to national accounts definitions presented in column 7. The second column shows the reclassification of economic units, earlier summarised in table 2. Column 3 eliminates the capital component in GERD as observed in the R&D surveys. Column 4 adds the gross operating surplus to the R&D related compensation of employees and intermediate consumption as measured by GERD. In addition, the R&D output of the R&D industry and universities explicitly includes R&D purchases and these adjustments are also reflected in this column. This shows that R&D output according to national accounts definitions inevitably contains double counting which is carefully avoided in GERD. Column 5 eliminates overlaps with gross fixed capital formation in software while column 6 excludes the other subsidies on own-account production. These preliminary results show that, in total, R&D output is only 3% higher than GERD. The largest overall adjustment in both absolute and relative terms is found within the R&D industry.

Table 4
Bridge table summarizing differences between gross expenditure on R&D and the R&D output in accordance with national accounts guidelines, the Netherlands, 1999 (million €)

Industry	Gross Expenditure on R&D	Re-classification	Capital expenditure	Gross operating surplus[1)]	Overlaps with software	Subsidies on production	R&D output (SNA/ESA) = row sum
	1	2	3	4	5	6	7
Agriculture, forestry and fishing	87	-21	-26	6	0	-1	46
Mining and quarrying	86	-74	-2	2	0	0	13
Manufacture of food products, beverages and tobacco	250	-112	-17	13	-2	-7	125
Manufacture of textile and leather products	17	0	-3	2	0	-1	14
Manufacture of paper and paper products	16	0	-1	1	0	-1	14
Printing	11	0	-3	1	-3	-1	6
Publishing	3	0	0	0	-1	0	2
Manufacture of petroleum products	37	0	0	5	0	-1	40
Manufacture of basic chemicals and man-made fibres	354	-220	-12	14	0	-6	129
Manufacture of chemical products	564	-513	-4	5	0	-2	49
Manufacture of rubber and plastic products	42	0	-5	4	0	-2	38
Manufacture of basic metals	60	-44	-2	2	0	0	16
Manufacture of fabricated metal products	54	0	-6	5	-1	-4	49
Manufacture of machinery and equipment n.e.c.	339	-29	-40	26	-31	-13	252
Manufacture of transport equipment	155	0	-11	18	-1	-6	154
Manufacture of building material	17	0	-2	2	0	-1	15
Manufacture of ICT Hardware	1206	0	-91	118	-195	-42	996
Manufacture of (other) electronic equipment	101	0	-7	9	-15	-5	83
Other manufacturing	17	0	-3	1	0	-1	14
Electricity, gas and water supply	21	0	-2	3	-1	-1	21
Construction	61	0	-6	9	-18	-1	44
Trade, hotels, restaurants and repair	206	0	-20	24	-24	-7	179
Transport and storage	99	0	-4	15	-23	-2	85
Post and telecommunications	5	0	-4	1	0	0	2
Banking, insurance & pension funding	100	0	-14	9	-63	-2	29
Computer and related activities	107	0	-6	10	-69	-3	40
Research and development	1317	731	-235	1020	-20	0	2813
Legal and economic activities	22	0	-3	4	-1	0	22
Architectural and engineering activities	158	0	-10	25	-6	-4	163
Advertising	0	0	0	0	0	0	0
Other business activities	56	0	-6	5	-3	-3	49
University education	1983	0	-127	139	0	0	1995
Public administration and social security	0	283	-36	20	-3	0	264
Other service activities n.e.c.	12	0	-5	2	0	0	8
Total (=column sum)	7564	0	-711	1521	-484	-119	7771

[1)] This adjustment also includes 608 million € of R&D purchases in the Research and development industry (cf. table 3), and 12 million € of purchases of R&D in the University education industry (cf. table 1).

3 Measuring R&D trade

R&D import and export data are derived from survey information about GERD financed by foreign entities (apart from EU funding) and reversely, domestically financed R&D carried out in other countries. The strengths and weaknesses of using R&D surveys for measuring import and export flows are discussed in this section.

It should be kept in mind that the R&D survey does not explicitly ask for R&D export and import (foreign sales and purchases). A distinction between sales/purchases, donations and other transfers is currently not being made. Generally, R&D surveys mainly focus on R&D performers and this may lead to an underestimation of R&D obtained from non-domestic producers. In the Netherlands, this underreporting is expected to be of minor significance.

Data from the Dutch R&D survey illustrate that the Netherlands is a net R&D exporter. This is shown in table 5. A positive R&D trade balance indicates that the economy in question enjoys beneficial conditions for performing R&D. However, the positive effects of this R&D on for example labour productivity are likely to occur partly in the foreign countries the R&D is being exported to. Reversely, a negative R&D balance of trade implies the possibility of higher R&D related spill-over in the domestic economy than one would expect based on GERD.

Table 5
R&D balance of trade of the Netherlands, 1995-1999 (mln €) [1)]

	1995	1996	1997	1998	1999
R&D export (% of GERD)	423 (7,0%)	362 (5,7%)	735 (10,8%)	590 (8,6%)	694 (9,2%)
R&D import (% of GERD)	190 (3,2%)	230 (3,6%)	345 (5,1%)	352 (5,1%)	441 (5,8%)
R&D balance of trade (% of GERD)	232 (3,9%)	131 (2,1%)	390 (5,7%)	238 (3,5%)	253 (3,3%)

1) All figures derived from the R&D survey.

3.1 Non-priced transfer of R&D

Especially in larger companies, it may be possible that R&D is being transferred to different company divisions without the presence of countervailing money flows. Clearly, this complicates determining the destination of knowledge capital created by R&D carried out in these companies. For internationally operating companies, this may also lead to problems in describing R&D import-export relationships. Yet, these relationships are crucial in defining the R&D that potentially accumulates in the domestic economy.

An attempt has been made to investigate whether data from the R&D survey in the Netherlands correctly reflect the international R&D flows of multinationals. In the Netherlands R&D is very much concentrated in a limited number of multinationals. For eight multinationals, whose R&D expenditure together comprises approximately 50% of the Dutch GERD, figures on turnover, number of employees, R&D personnel and R&D expenditure were gathered for the purpose of appraising the export data derived from the R&D surveys. Figures concerning the entire multinational (worldwide) were collected from annual business reports. Data concerning the Dutch establishments of these multinationals came from the R&D survey and the Financing of Corporations survey. The number of employees working in the Netherlands as a proportion of total worldwide employees was taken as an indication of the proportion of worldwide production that is performed in the Netherlands. Information about turnover (and profit) was also available for most multinationals, but since most annual reports only contain information on consolidated profit and loss accounts, it is less obvious how to interpret the share of worldwide turnover achieved in the Netherlands. However, when the proportion of the consolidated worldwide turnover generated in the Netherlands is taken as a measure of the proportion of total worldwide production concentrated in the Netherlands, the conclusions presented below remain the same (results not shown).

Due to requirements of confidentiality the figures of the eight multinationals cannot be shown. When the number of employees working in the Netherlands as a proportion of total worldwide employees is compared to the number of R&D employees in the Netherlands as a proportion of worldwide R&D employees, it is clear that a relatively large part of the R&D personnel of most of the multinationals is concentrated in the Netherlands. Aggregating the data of eight multinationals, 11% of total personnel worldwide and 44% of R&D personnel worldwide is employed in the Netherlands. Figures concerning expenditure on R&D suggest a similar kind of concentration. This concentration of R&D activities in the Netherlands indicates that these multinationals are likely to transfer a certain amount of R&D to foreign company divisions. Remarkably however, only two out of eight multinationals report a substantial amount of R&D export (> 80% of their GERD), whereas the other six report zero R&D export (five multinationals) or a very small amount of R&D export (3 % of GERD by one multinational). Of those six multinationals who report (almost) zero R&D export, five multinationals have a relatively high concentration of R&D in the Netherlands (for one of the six multinationals missing data on number of R&D employees worldwide prevented a conclusion). For these five multinationals the difference between the proportion of worldwide R&D personnel working in the Netherlands and the proportion of worldwide total personnel employed in the Netherlands ranges from 12% to 42%. These results strongly point to a substantial amount of R&D being transferred abroad but remaining unobserved by way of the R&D survey.

3.2 Implications

The analysis above is restricted to the measurement of R&D export only. The size of a possible underestimation of R&D import has not yet been investigated. In case import figures are less affected by the unobserved international R&D transfers of multinationals, the figures derived from the R&D survey lead to an overestimation of R&D use and the subsequent knowledge capital accumulation in the Netherlands. When recording domestic R&D supply and use, it was assumed that all R&D output produced by domestic research units of large enterprises is subsequently purchased by the domestic affiliated enterprise (or one or more of its individual domestic divisions). The results presented in the previous paragraph suggest this may be an incorrect assumption since some of this R&D output is likely to be exported in stead of being applied domestically.

The present Frascati Manual (2002) takes the globalisation process into account by suggesting more detailed breakdowns of sources of funds for R&D and extramural R&D for transactions with units abroad. The recommended sub-classification is as follows:

- Abroad:
    - Business enterprise:
        - Enterprise within the same group
        - Other enterprise
    - Other national government
    - Private non-profit
    - Higher education
    - International organisations

In addition it is stated in the Frascati Manual that "As the R&D activities of multinational groups of enterprises are usually organised, managed and financed at group level or group division level, it is sometimes very difficult, if not impossible, to identify R&D performed in units of the group in different countries and to obtain information on R&D flows between these units." Our analysis suggests this is indeed the case. To establish better estimations of R&D export and import in the future it is recommended for the R&D survey to include explicit questions concerning the allocation of R&D. Since it is likely that R&D may be transferred to different company divisions without the presence of observable countervailing money flows, the R&D survey should not be restricted to the observance of flows of funds only. Instead, the survey should include questions asking on whose behalf (domestic versus foreign) R&D is undertaken. Similarly, questions should be added asking whether access to knowledge has been obtained from R&D carried out by other (foreign) company divisions.

Furthermore, questions concerning financial flows at present include donations and other transfers. It is recommended that these questions are subdivided into questions about actual sales/purchases, donations and other transfers separately. Finally, R&D purchases (including import) of enterprises that do not produce R&D should be explicitly observed.

For the time being, due to lack of sources, we have assumed for the case of the Netherlands that the underreporting of R&D export and import on balance do not affect domestic use and knowledge capital formation.

4 Capitalising R&D

4.1 Conceptual issues

In the process of capitalisation, it should be made clear first under what conditions R&D genuinely leads to the creation of an asset in the SNA sense. In this discussion different positions are taken. For example, Harrison (2002) wonders whether all university research should really be treated as leading to the creation of an asset. Aspden (2003) mentions that potentially all research provides, one way or another, a service over longer periods of time, either through higher levels of productivity or simply by satisfying people's curiosity. Therefore he advocates a generic capitalisation of R&D, including both private and public performed R&D (basic research).

There is however one major obstacle. Knowledge created in the public domain misses any form of ownership. Although the government can be identified as the financer and performer of R&D, it is not necessarily true that the government is also the owner of this public knowledge. The comparison, made by some, with museums and public libraries is unjustified. Museums and libraries are access devices to knowledge which are clearly subject to ownership. They are (legally) owned by the government or by any other a private institute. The owner could at any point in time decide to sell the asset or to levy access fees. This is simply impossible for knowledge once it has been made freely accessible to the public.

In addition, museums and libraries are subject to wear and tear. Their owners (e.g. the government) face value losses as a result of aging and of library and museum visits. Freely accessible knowledge is not necessarily subject to wear and tear. As long as access devises are being maintained, knowledge itself has principally an infinite service life. For example, ancient knowledge may satisfy people's curiosity in a same way as more recently gained knowledge. Therefore, the life length of knowledge with respect to satisfying people's curiosity is a priori uncertain.

As explained by Aspden (2003, §34), innovations usually result from newly gained knowledge but also from preceding research that may have been carried out many years ago. Also from this point of view, it is not obvious on the basis of what principles the service lives of knowledge should be determined. Generally, the creation of new knowledge is impossible without using existing knowledge. From this perspective, it would simply not make any sense to write off knowledge while it may continue to contribute to future innovations.

There is in our opinion one important reason why R&D may lead to the creation of an asset in the SNA sense. Due to the exclusive access to knowledge obtained by R&D, the owner may exert a certain level of market power. The service of a knowledge asset decays together with the inevitable loss in monopolistic power the owner experiences over time. Quite logically, this loss in market power determines the service life of a knowledge asset. Also, the sharing of this knowledge incurs an opportunity cost since it delimits the monopolistic power of the initial owner. This opportunity cost is not present in the use of freely accessible knowledge. In other words, exclusive ownership maintains to be a decisive precondition for knowledge to be accepted as an asset in the SNA sense.

As stated in the 1993 SNA, "…the System's accounts and balance sheets are compiled for institutional units or groups of units and can only refer to the values of assets that belong to the units in question" (§10.10). Certain naturally occurring assets, such as air and (fish in) oceans, are mentioned by the 1993 SNA as examples of entities not satisfying this criterion. Another example in this context would be generally accessible knowledge that can be freely used by all agents.[5]

Obviously, the discussion then boils down to how the exclusive ownership of knowledge assets should be defined. We do not consider the existence of legal enforcement of ownership by way of patenting as a necessary condition. Exclusive ownership can also be obtained by way of secrecy or by the exclusive access to the complementary tacit knowledge.

The R&D account for the Netherlands presented in this paper defines three types of R&D: market R&D, own-account R&D and non-market R&D. As a first SNA rule, it could be recommended to place all market and own-account R&D within the SNA asset boundary. Non-market R&D should be excluded from capitalisation, unless the resulting knowledge is either being patented or explicitly being used in the course of government production (e.g. defence). This R&D asset boundary does not rely on the, in this context, less relevant Frascati categorisation *i.e.* basic research, applied research and experimental development. The delineation proposed here is based on the assumption that any kind of company R&D is principally conducted with the ultimate goal of increasing competitiveness, whether this comprises basic research, applied research or experimental development.

4.2 Time series construction in current prices

Generally there are substantial differences in how intangible capital is being administrated in company records. Therefore a complete economy-wide recording of knowledge capital stock is only possible on the basis of time series R&D expenditure data. The R&D supply-use accounts presented above are at the moment compiled for the years 1995-1999. Clearly, longer time series are needed when estimating R&D capital stock. GERD time series in the Netherlands covers the period 1970-2001. A transition matrix was constructed for the reference year 1995 to translate the GERD series 1970-1994 to the gross fixed capital formation figures by industry as recorded for the years 1995-1999, leading to a

[5] (re)quoted from Van de Ven (2000, p.4).

harmonised set of 1970-1999 R&D gross fixed capital formation time series in current prices at the level of 40 industries.

4.3 The R&D price index

Subsequently, the time series in current prices had to be translated into a time series in constant prices. Preferably the volume changes in R&D output should be estimated with the help of an output related price index adjusted for quality improvements. However, the uniqueness of R&D makes output price comparisons of R&D over time by definition impossible. When output prices are not available, an input based price measure is the only alternative. Such a composite input price index should preferably be constructed at the most detailed level possible.

Following the national accounts, the sum of production costs can be divided into:

- Compensation of employees (50.7%)
- Intermediate consumption (33.3%)
- Gross operating surplus (16.0%)

The percentages between brackets refer to the corresponding input shares in 1999. The price index used for each input component is discussed below.

The R&D survey provides information on the compensation of employees and full time equivalent jobs. This information is used for measuring changes in R&D wage rates over time. A breakdown between scientific staff and other R&D personnel is not possible. Although the data on full time equivalent jobs has such a breakdown, the data on compensation of employees has not.

For the years 1987-1999 we were able to use a specific deflator for R&D related intermediate consumption derived from the annual supply and use tables of the Dutch national accounts. On an annual basis these supply and use tables are being constructed at the level of approximately 800 commodities in current prices and in prices of the previous year. Due to lack of date, for earlier years we were forced to use the general GDP deflator.

For the gross operating surplus we also used the GDP price index for the whole 1971-1999 period.

Figure 1
A comparison of the R&D price index with the GDP price index

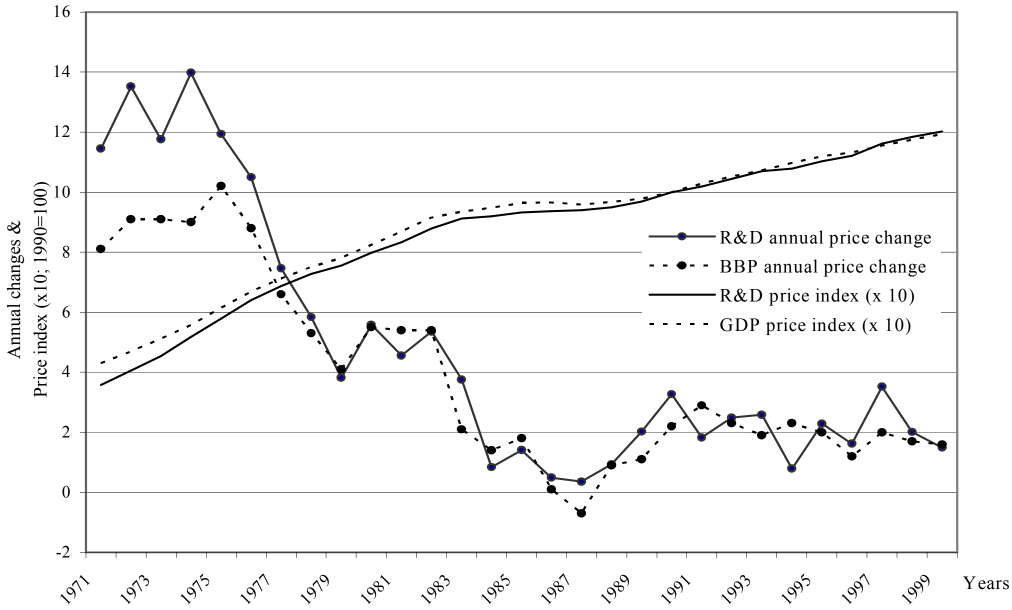


Figure 1 provides a comparison between our newly constructed R&D price index and the GDP price index. The Frascati manual (§35) recommends using the GDP price index for constant price comparisons, although this is being acknowledged a second best solution. Figure 1 shows that the specific R&D price index does not differ very much from the GDP price index. The most substantial differences show up in the early seventies, a period characterized by substantial wage increases and high inflation rates. Although in later years incidental differences in annual price changes do occur, the R&D and GDP price indexes follow almost similar patterns. In the case of the Netherlands, the GDP price index does not seem a very bad approximation for measuring R&D in constant prices.

4.4 Service lives and depreciation patterns

The indirect measurement of knowledge capital stocks based on cumulated R&D expenditure requires tackling several issues. Firstly, assumptions must be made concerning the expected services lives and the development of knowledge capital services over time. Secondly, it may take some time before R&D projects lead to the creation of knowledge assets ready for use in new, or renewed, modes of production. Finally, one may argue whether unsuccessful R&D should, or should not, accumulate to the knowledge capital stock. These three issues are discussed below.

Service lives

The service life of codified knowledge is principally infinite as long as the knowledge carrier (*e.g.* book, CD-rom) is well maintained. However, the service life of a knowledge *asset* is another point of concern. As for example indicated by Pakes & Schankerman (1984, p.75), "...the rate of decay in the revenues accruing to the producer of the innovation derives not from any decay in the productivity of knowledge but rather from two related points regarding its market valuation, namely, that it is difficult to maintain the ability to appropriate the benefits from knowledge and that new innovations are developed which partly or entirely displace the original innovation". In other words, the capital services derived from R&D related knowledge are determined by the monopolistic market power a manufacturer obtains from knowledge over a certain period of time. The periodic change in the value of the knowledge asset is influenced by the adoption of similar innovations by competitive firms or by alternative innovations i.e. replacement investments in R&D. As a result, Pakes & Schankerman (p.75) argue that "one may expect that the rate of decay of appropriable revenues would be quite high, and certainly considerably greater than the rate of deterioration in the physical productivity of traditional capital". In conclusion, R&D related knowledge capital is not subject to wear and tear as tangible capital is. The only reason why knowledge assets loose their value in time is because of the decay in excess revenues its owner is able to appropriate compared to other market competitors.

Empirical evidence on the life lengths of knowledge capital is scarce. Annual depreciation rates used in the literature for building up knowledge capital stock on the basis of R&D investment series range from 11 to 25%. This corresponds to an average service life of about 5 to 10 years. It is sometimes argued that output elasticities with respect to R&D related capital are not very much influenced by the choice of a R&D depreciation rate (cf. Guellec & van Pottelsberghe, 2001). Yet, balance sheet positions and capital service levels are substantially affected by the choice of a depreciation rate.

In the Netherlands, the R&D survey is combined with the innovations survey every second year. For the year 2002, this combined survey includes questions about the expected service life of technology adopted in product innovations of the current year. This information can be used as a proxy of the amortisation patterns of knowledge capital. Unfortunately, many respondents are reluctant to indicate their expectations about the life length of new technology they have been implementing. One problem is that especially the larger companies may be involved in several innovation projects and as a consequence they are simply unable to give univocal answers. This problem becomes particularly apparent when looking at the electronics industry. In the Netherlands this industry branch is dominated by a small number of very big companies.

Evidence from Australia (ABS, 2004) indicates that the median life for patents is around nine years. 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.

Service patterns

Annual changes in the wealth of knowledge capital are determined by two (interrelated) factors: the distribution of live lengths of knowledge assets (i.e. amortisation patterns) and the decay in the value of knowledge as a result of declining market advantage received from knowledge capital (i.e. age efficiency patterns). Evidence on patent amortisation patterns (cf. ABS, 2004) indicate a bell-shaped mortality distribution of R&D capital, quite similar to those found and applied for other types of assets in the Netherlands (cf. Meinen et al., 1998). There is much less information about the age efficiency profiles of R&D capital. However one may expect the competitive edge of knowledge capital to decline over time, indicating declining age efficiency.

The assumptions underlying the depreciation calculations presented here are reflected by figure 2. Due to lack of evidence no differentiation is at this time being made between industries. For all industries we apply a mortality function reflecting on average the patent amortisation patterns presented by the ABS (2004). This bell shaped mortality distribution is approximated with the help of a Weibull function (α = 2.0; λ = 0,1, cf. OECD, 2002a, p.53-54) with an average life expectancy of about nine years. Secondly, we assume a declining average age-efficiency pattern modelled with the help of a Winfrey curve (maximum age at which rentals equal to zero, i.e. parameter *a*, is assumed 30 years; while the skewness parameter, *m*, is assumed 2, cf. OECD, 2002a, p.51-52). As such we assume that the decline in age-efficiency, i.e. the competitive advantage obtained from the knowledge asset, decreases on average progressively over time.

The value of the sum of assets *W* of the vintage *m* at time *t* is determined as follows (cf. van den Bergen, 2004):

$$W_{m,t} = \sum_{\tau=0}^{n-t} \frac{S_{t+\tau} N_m K_{t+\tau}}{(1+r)^{\tau}}$$

where:

$S_{t+\tau}$ = the average capital service of an asset at age $t+\tau$;

N_m = the initial number of assets of the vintage *m*;

$K_{t+\tau}$ = the fraction N_m that is still in operation;

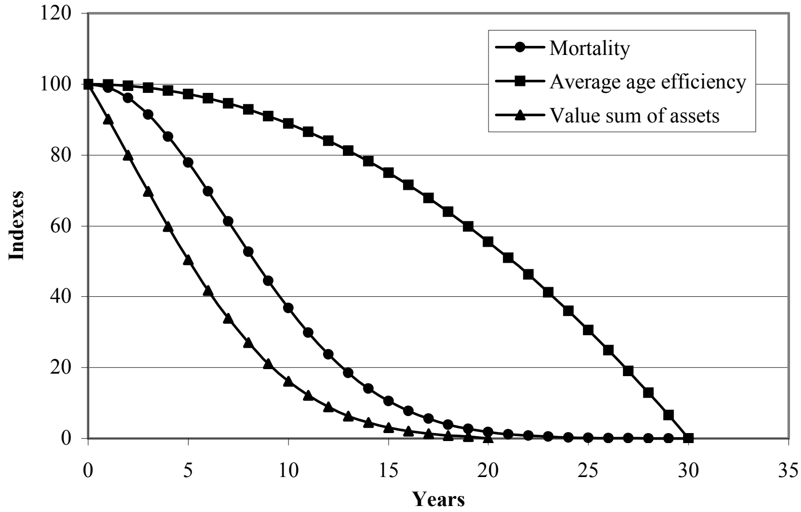
n = maximum service life of the asset;

r = discount rate.[6]

Summation over vintages leads to the total value of knowledge capital at time t.

When following the above presented model, the decline in the value sum of assets of a particular vintage follows an almost linear pattern over the first 5 years and after that period a geometric decay pattern.

Figure 2
Mortality function, age-efficiency function and the resulting value decline in the value of knowledge assets of a particular vintage



Gestation lags

Pakes & Schankerman (1994, p.82) indicate the presence of two types of *time lags*: gestation lags and application lags. Gestation lags refer to the time needed to complete R&D projects. Application lags refer to the time between completion of the R&D project and its initial commercial use. Pakes & Schankerman indicate that the sum of gestation and application lags may range from 1.5 to 2.5 years. Peleg (2003) indicates that the adoption of new innovations may be accelerated under the pressure of increasing competitiveness. As a preliminary approximation, we use a time lag of 1 year. The presence of such a time lag implies that R&D output is at first instance recorded as work in progress, *i.e.* changes in inventories. The complete project expenditure is recorded as gross fixed capital formation at the moment of finalisation in the subsequent year, counterbalanced by negative withdrawals form inventories.

[6] We use a discount rate of 5%.

Unsuccessful R&D

One may question whether unsuccessful R&D contributes to the R&D capital stock. Bos *et al*. (1992) recommend that at the moment it becomes clear that certain R&D projects are unsuccessful the R&D should be instantly written of for the full amount. In contrast, Carson (1994) compares R&D projects with mineral exploration. The nature of both types of 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.

5 Results

An overview of this alternative recording of R&D services is represented in the supply and use table for 1999 presented in table 6. These tables distinguish the three types of R&D product groups: market R&D (including R&D transferred between affiliated companies), own-account produced R&D and non-market R&D. Not surprisingly, universities and the R&D industry are the largest R&D producers. In the Netherlands, the ICT hardware manufacturing industry is also an important R&D producer.

By convention, all non-market R&D ends up as government consumption while all other R&D is accounted for as work in progress, gross fixed capital formation or export. Due to the assumed gestation lag of one year, initially all R&D output is recorded as work in progress. Gross fixed capital formation corresponds to the domestic expenditure on market and own account R&D at time (*t*-1) recorded at current prices (and not at *t*-1 prices). Obviously, this gross fixed capital formation is compensated by a similar but negative recording of work in progress.

Table 7 shows the gross fixed capital formation by industry of destination. The biggest investors in knowledge capital are found within the chemical industry, the ICT hardware manufacturing industry and the R&D services industry.

Table 8 summarizes the effect of R&D capitalisation on the major aggregates of the national accounts. When market and own-account R&D are capitalised according to above specified method, gross fixed capital formation is adjusted upwards by approximately five percent for all years. This share seems to decline in more recent years, indicating that total investment in the Netherlands is not increasingly directed towards knowledge capital.

The effects of R&D capitalisation on gross domestic product are rather modest. Total gross domestic product is adjusted upwards by 1.1 to 1.2 %. Equally, economic growth, measured by the volume increase of gross domestic product, is hardly affected. Obviously, adjustments of net national income are also quite modest since upward adjustments of gross fixed capital formation are counterbalanced by negative adjustments from consumption of fixed capital.

Finally, table 9 shows the effects of R&D capitalisation on the net stocks of fixed capital. Although the upward adjustment of the net fixed capital stock is quite modest, compared to the total sum of intangible fixed capital this adjustment is rather substantial. This specifically results from the relatively longer service lives assumed for R&D as compared to for example software, which in the Dutch national accounts is written of in three years time on average.

Table 6
Supply-use tables for R&D, the Netherlands, 1999

Supply table, mln € (basic prices = purchasers' prices)

	Manufacture of chemical products	Manufacture of ICT hardware	R&D industry[2)]	University education	Public admini-stration & social security	Other industries	Rest of the world, import	Total supply
Market R&D[1)]	40	220	1724	415	-	574	441	3413
Own-account R&D	138	776	-	-	-	952		1866
Non-market R&D	-	-	1089	1580	264	-		2933
Total supply	178	996	2813	1995	264	1526	441	8212

[1)] including 'intra-enterprise R&D'.

[2)] A totally satisfying demarcation of the R&D industry is currently not possible.

Use table, mln € (basic prices = purchasers' prices)

	Government consumption	Changes in inventories	Gross fixed capital formation	Rest of the world, export	Total use
Market R&D		233	2487	694	3413
Own-account R&D		317	1549		1866
Non-market R&D	2933				2933
Total use	2933			694	8212

Table 7
Gross fixed capital formation of knowledge capital by industry branch of destination, 1995-1999 (million €)

	1995	1996	1997	1998	1999
Agriculture, forestry and fishing	46	47	33	37	56
Mining and quarrying	60	64	23	54	94
Manufacture of food products, beverages and tobacco	206	266	250	258	255
Manufacture of textile and leather products	12	12	9	9	8
Manufacture of paper and paper products	16	16	13	10	15
Printing	2	4	3	2	3
Manufacture of petroleum products	0	0	22	20	38
Manufacture of basic chemicals and man-made fibres	588	576	211	135	165
Manufacture of chemical products	336	329	647	671	728
Manufacture of rubber and plastic products	27	24	38	40	30
Manufacture of basic metals	28	33	31	20	24
Manufacture of fabricated metal products	54	58	35	44	33
Manufacture of machinery and equipment n.e.c.	135	155	187	208	251
Manufacture of transport equipment	107	133	85	108	92
Manufacture of building material	19	21	17	11	9
Manufacture of ICT Hardware	689	745	879	862	877
Manufacture of (other) electronic equipment	54	59	72	73	74
Other manufacturing	10	11	14	31	20
Electricity, gas and water supply	28	50	53	78	85
Construction	12	19	19	16	25
Trade, hotels, restaurants and repair	129	119	132	133	160
Transport and storage	25	25	24	26	25
Telecommunications and post	45	46	47	44	38
Content: entertainment and art	0	0	0	0	0
Content: publishing, press and broadcasting	2	2	3	2	3
Banking, insurance & pension funding	20	20	78	106	115
Computer and related activities	4	6	35	44	41
Research and development	532	542	527	549	593
Legal and economic activities	1	2	5	13	8
Architectural and engineering activities	14	17	113	160	135
Advertising	0	0	0	0	0
Other business activities	39	33	35	29	9
Primary education	0	0	0	0	0
Secondary education	0	0	0	0	0
Higher education	0	0	0	0	0
University education	10	10	4	12	11
Other education	0	0	0	0	0
Health and social work activities	0	0	0	0	0
Other service activities n.e.c.	0	0	17	17	16
	3250	3444	3657	3824	4035

Table 8
Changes in the main national accounts aggregates as a result of R&D capitalisation, the Netherlands, 1995-1999

		1995	1996	1997	1998	1999
Gross fixed capital formation in R&D	mln €	3 250	3 444	3 657	3 824	4 035
Changes in inventories	mln €	139	89	92	152	550
Consumption of fixed capital	mln €	3 086	3 171	3 329	3 445	3 552
Gross fixed capital formation	mln €	61 347	66 381	71 680	76 230	84 186
Adjusted gross fixed capital formation	mln €	64 597	69 825	75 337	80 054	88 221
Adustment in %	%-share	5,3	5,2	5,1	5,0	4,8
Gross domestic product, market prices	mln €	302 233	315 059	333 725	354 194	374 070
Adjusted gross domestic product, market prices	mln €	305 622	318 592	337 474	358 170	378 655
Adustment in %	%-share	1,1	1,1	1,1	1,1	1,2
Gross domestic product, market prices	%-volume change	3,0	3,0	3,8	4,3	4,0
Adjusted Gross domestic product, market prices	%-volume change	3,1	3,0	3,8	4,3	4,1
Net national income, market prices	mln €	260 178	269 064	287 624	295 441	318 239
Adjusted net national income, market prices	mln €	260 481	269 426	288 044	295 972	319 272
Adustment in %	%-share	0,1	0,1	0,1	0,2	0,3

Table 9
Net capital stock of fixed assets, the Netherlands, 1995-1999 (million €)

	1995	1996	1997	1998	1999
Dwellings, buildings and structures	1 280 056	1 353 012	1 418 843	1 497 961	1 600 389
Machinery and equipment	314 688	324 514	337 771	353 233	371 222
Transport equipment	71 540	74 405	77 400	83 264	90 594
Other tangible fixed assets	16 937	17 413	18 421	20 506	21 876
Intangible fixed assets	10 491	11 346	13 288	16 146	18 468
Total net capital stock	1 693 712	1 780 691	1 865 723	1 971 110	2 102 549
Knowledge capital	19 877	20 471	21 519	22 333	23 150
Adjusted total net capital stock	1 713 589	1 801 162	1 887 242	1 993 443	2 125 699
Adustment in %	1,2	1,1	1,2	1,1	1,1

6 Conclusions

There is a solid case to capitalise R&D and to change the SNA accordingly. R&D lead to the creation of knowledge. This knowledge may carry the main properties of assets as defined in the SNA:

- Knowledge may lead to market power and subsequently to added profits;
- Exclusive ownership can be enforced by way of patenting or other means.

An exception to this rule should be made for most non-market R&D. Once the resulting knowledge of (non-market) R&D is made freely accessible to the public, there is no ownership what so ever, no market advantage of one agent over others, and as a result this knowledge cannot be regarded as an asset in the SNA sense.

R&D statistics according to Frascati guidelines are generally a very useful source for national accounting purposes. However, in this paper it is argued that improvements of the Frascati guidelines in the direction of measuring R&D import and export flows would be very helpful. The paper shows that especially in open economies, the measurement of knowledge capital is only possible on the basis of R&D production data in combination with sound R&D import and export data.

Although, the capitalisation of R&D substantially extents the coverage of fixed intangible capital in the national accounts, in the case of the Netherlands, capitalising R&D has generally a limited effect on the main national accounting aggregates.

Finally, it would be very useful to test the use of R&D expenditure data in knowledge capital stock estimates also for other countries. The experience with software shows that an internationally harmonised implementation of new accounting standards regarding the coverage of intangible capital should be given sufficient thought. Compared to software, the starting position with respect to R&D is however much better since national accountants in many countries have access to internationally harmonised R&D statistics. This was, and perhaps still is, not the case with respect to software.

References

Aspden, C. (2003) The capitalization of R&D in the national accounts – boundary and measurement issues, paper presented at the second meeting of the Canberra II Group, OECD (Paris).

Astralian Bureau of Statistics (ABS) (2004) Capitalising research and development, paper presented at the third Canberra II Group meeting, 17-19 march, Washington D.C.

Bergen, D. van den (2004) Measuring capital, mimeo, Statistics Netherlands (Voorburg/Heerlen).

Commission of the European Communities (1996) European System of Accounts – ESA 1995, Eurostat (Luxemburg).

Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations & World Bank (1993) System of National Accounts 1993, Series F, No. 2, Rev. 4, United Nations (New York).

Guellec, D. & B. van Pottelsberghe de la Potterie (2001) R&D and productivity growth: panel data analysis of 16 OECD countries, OECD (Paris).

Harrison, A. (2002) R&D in the national accounts, paper presented at the 12th Statistical Days, Slovenia.

Mandler, P. & S. Peleg (2003) R&D and software, paper presented at the second meeting of the Canberra II Group, OECD (Paris).

Meinen, G., P. Verbiest & Peter-Paul de Wolf (1998) Perpetual Inventory Method, Service lives, Discard patterns and depreciation methods, Statistics Netherlands (Voorburg/Heerlen).

OECD (2002) Frascati Manual 2002, OECD (Paris).

OECD (2002a) Measuring capital, a manual of capital stock, consumption of fixed capital and capital services, OECD (Paris).

Pakes A. & M. Schankerman (1984) The rate of obsolescence of patents, research gestation lags, and the private rate of return to research resources, in: Z. Griliches (ed.) R&D, patents and productivity, The University of Chicago Press (Chicago).

Peleg (2003) Stocks of R&D – service lives of R&D, obsolescence, depreciation, paper presented at the second meeting of the Canberra II Group, 13-15 October, OECD (Paris).

Statistics Netherlands (2001) Kennis en economie 2001, Statistics Netherlands (Voorburg/Heerlen).

Ven, P. van de (2000) Intangibles: Invaluable? – Should the asset boundary in the 1993 SNA be extended?, paper presented at the 26th General Conference of the International Association for Research on Income and Wealth (Krakow).