R&D Satellite Accounts in the Netherlands

A Progress Report

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Myriam van Rooijen-Horsten, Murat Tanriseven and Mark de Haan

Working paper

Statistics Netherlands

The Hague/Heerlen, 2008

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.

Publisher
Statistics Netherlands
Henri Faasdreef 312
2492 JP The Hague

Prepress
Statistics Netherlands - Facility Services

Cover
TelDesign, Rotterdam

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ISSN: 1876-9985

6018308002 X-41

R&D Satellite Accounts in the Netherlands

A progress Report

Myriam van Rooijen-Horsten, Murat Tanriseven and Mark de Haan*

Paper prepared for the OECD Working Party on National Accounts,
Paris, 3-5 October 2007
Session: Research and development (agenda item 11)

Summary: Anticipating the SNA revision (SNA 93 Rev.1) at Statistics Netherlands the capitalisation of R&D has been incorporated in a recently developed satellite account called the 'knowledge module'. This paper discusses a number of measurement issues, presents some of the main outcomes of capitalising R&D expenditure and provides suggestions for future work. In the paper special attention is given to problems related to measuring international R&D flows and the determination of service lives of R&D assets.

Keywords: Research and development, National Accounts, satellite accounting

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1. Introduction

One of the key changes of the SNA revision (SNA 93 Rev.1)[1] is the recording of R&D expenditure as gross fixed capital formation. As such R&D expenditure will directly add to GDP which increases the need of reliable data sources for R&D output and investment estimates. Anticipating this change in national accounting guidelines, the capitalisation of R&D at Statistics Netherlands has been incorporated in a recently developed satellite account called the ‘knowledge module’.

This paper briefly reports on work carried out at Statistics Netherlands to construct R&D capital stocks. The following section summarizes the most important conceptual and measurement issues encountered in the process of measuring R&D investment. Special attention is given to problems associated with the internationalisation of R&D activities. Section three illustrates the estimation of R&D capital stocks. Section four provides an overview of outcomes and section five provides suggestions for future work.

2. Measuring R&D investment

In this section three measurement issues are briefly highlighted. More extensive discussion of each of these issues can be found in Tanriseven et al. (2007) or De Haan and Van Rooijen-Horsten (2003, 2004 & 2007).

2.1 From R&D survey to national accounting conventions

The main sources used for the R&D investment data series as compiled in the knowledge module are the Frascati (OECD) 1993 and 2002) based surveys for three main groups of R&D performers: enterprises, research institutes and universities. Information on gross expenditure on R&D (GERD) and funding of R&D derived from these surveys is in the knowledge module translated to R&D supply and use following national accounting conventions. This translation process includes several steps. The two most important ones are:

- *Revaluation*: R&D expenditure from the R&D surveys must be revaluated in order to determine R&D output according to SNA guidelines. The estimation of own-account investment in R&D requires that capital expenditure on research equipment and buildings is replaced by their user costs of capital.
- *Overlaps with computer software*: The Frascati guidelines (cf. par’s 135 and further) indicate that certain software development projects may entirely fall under the Frascati definition of R&D. “For a software development to be classified as R&D, its completion must be dependent on a scientific and/or technological advance, and the aim of the project must be the systematic

[1] The new System of National Accounts is not finalized yet. However the registration of R&D as gross fixed capital formation has already been approved by the Statistical Commission.

resolution of a scientific and/or technological uncertainty", and, "The nature of software development is such as to make identifying its R&D component, if any, difficult". As such the capitalisation of R&D with the help of R&D statistics based on Frascati guidelines may lead to double counting parts of computer software investment.[2] In the Netherlands empirical evidence indicates that R&D connected to computer software development can be substantial. In the knowledge module corrections are made to prevent this double counting.

It is important to stress that the Dutch R&D survey does not explicitly ask for R&D sales and purchases of R&D services. This is a weakness since funding of R&D may also include donations or subsidies and these should be excluded from sales and purchases of R&D services. It is therefore recommendable to explicitly address purchases and sales of R&D services in future R&D survey questions. Further a well-established business survey for the R&D industry may help to better identify market and non-market producers. Fortunately, such a business survey was recently started up at Statistics Netherlands. However it has not yet been introduced as an additional source in the knowledge module.

2.2 Internationalisation of R&D

In the Netherlands a large share of R&D carried out by private companies is concentrated in a restricted number of multinational companies. For these companies it appears very difficult to determine the exact amounts of intra-company R&D capital service flows from and to the rest of the world. This subsequently complicates the estimation of domestic R&D investment.

The annual R&D survey provides information on R&D funding. One may assume that R&D financed by foreign entities represents in most cases export. Reversely, financing by domestic entities of R&D carried out abroad will in most cases refer to import of R&D services. However, as already stressed, the Dutch R&D survey does not explicitly ask for R&D sales and purchases nor import or export of R&D services. In addition, the general focus of R&D surveys on solely R&D performers may lead to under reporting of R&D import.

Furthermore, it seems that R&D may be transferred within multinational companies without the presence of countervailing money flows. Even if an R&D survey would explicitly ask for R&D sales and purchases, it is questionable whether multinational enterprises would actually report all exchanges of R&D services with (foreign) affiliated enterprises. Especially for small and open economies such as the Netherlands, it therefore appears not straightforward to determine the amount of R&D services that actually accumulates as knowledge capital in the domestic economy.

[2] Computer software expenditure is already part of gross fixed capital formation in the National Accounts.

To further investigate the plausibility of the R&D survey data on R&D export, various additional data sources were examined. This study focussed on eight multinationals that together represented in the year 2005 46% of all Business Expenditure on R&D (BERD). Data for the entire multinational (worldwide) were collected from annual business reports. Data for only the Dutch establishments were obtained 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 share of company wide production carried out in the Netherlands.

Of these eight multinationals almost 13% of all their personnel worldwide was in 2005 employed in the Netherlands whereas for R&D personnel this share was 34%. These results indicate that R&D activities of these companies are to some extent concentrated in the Netherlands. Data on R&D expenditure in the Netherlands compared to R&D expenditure worldwide suggest a similar concentration. These results are not surprising. Each of these multinationals is of Dutch origin and have their headquarters located in the Netherlands. Historically, the strategic R&D activities of large companies are often located in the direct neighbourhood of their headquarters.

This concentration of R&D activities in the Netherlands suggests that these companies would export fair amounts of R&D services to foreign company divisions. However, according to the funding questions in the R&D survey, only one out of eight multinationals reported substantial amounts of R&D export (more than 90% of their BERD). The other multinationals reported no or very small amounts of R&D export. These results strongly suggest that the export of R&D services is being underreported in the Dutch R&D surveys. As a result, it appears quite difficult to determine the amount of gross fixed capital formation of R&D that should accumulate on the Netherlands´ national balance sheet.

To further investigate the measurement of intra company flows of R&D services, Statistics Netherlands invited a number of these large R&D performing multinational enterprises to discuss R&D capitalisation and the measurement problems involved. The conclusions based on discussions with these five multinationals, representing together almost one third of BERD, are the following.

The organisation of R&D activities appears to differ considerably between multinationals. In one company all R&D activity is concentrated in a separate R&D activity unit. This unit performs all R&D assignments from all other business units within the enterprise but may also take on assignments from outside the enterprise. All internal and external customers pay this R&D unit directly for the services provided. On occasion, the R&D unit also carries out (strategic) research not directly initiated by customers.

In contrast, in another company the performance of R&D is totally decentralised. The different business units carry out themselves all the R&D required for their own businesses. However, basic research is carried out at headquarters (corporate level).

Other models exist as well. In some companies R&D units can be found at various locations not necessarily in the neighbourhood of business units that profit from this R&D. Company wide R&D programs may be carried out on a world wide scale in close cooperation with various R&D units around the world. Especially for these fully globalized companies the recording of intra R&D flows becomes very problematic.

With regard to R&D funding questions the following conclusions can be drawn. The decision on how much to spend on R&D is in most cases taken at the corporate level. These decisions are regarded as being of a strategic nature for the entire company. They are periodically re-evaluated but usually not every year. Surprisingly, estimations of returns to R&D do not seem to play a key role in decisions about the company wide R&D programs. R&D is simply considered fundamental for the continuation of the business on the longer term.

The funding of basic research differs from funding of experimental development and applied research. At least for the Research component of R&D, the main responsibility for R&D budgets seems to lie at the corporate level. Different business units of the multinational are invoiced by headquarters for certain amounts of R&D costs. Applied R&D cost redistribution systems differ considerably between multinationals:

I. *On the basis of (expected) benefits:* those business units that benefit from the R&D are paying for concomitant R&D costs;

II. *More or less related to (expected) benefits*: the R&D intensity of different products per business unit is used as a measure for intra company cost redistributions;

III. *Unrelated to (expected) benefits*: sometimes simply a fixed percentage of turnover or profit of each business unit is invoiced to cover company wide R&D costs.

Only when multinationals employ a direct invoice principle, in which R&D costs are shared by the beneficiary company units, surveying intra company R&D service flows on a country by country basis seems to make sense. This information can be used to estimate an R&D trade balance on the national economy level. Unfortunately, other cost accounting methods (II and III) do not provide these possibilities. Therefore the figures that multinational enterprises are providing in response to questions in the R&D survey on funds received from abroad do not necessarily address all cross-border transfers of R&D services.

Regarding the use of licenses, the outcome of the interviews was rather unambiguous. Payments via licences and royalties are unusual within an enterprise group. In general the legal ownership of all R&D seems to lie at the corporate level. From the interviews a tentative conclusion can be drawn that the multinational enterprises subscribe the point of view that in fact the business units that gain the benefits are usually the economic owners of this R&D. Generally one may therefore conclude that import and export of R&D services should address the transfers of

R&D investments rather than R&D capital services (being the service flows derived from R&D capital).

A last finding is that each of the five interviewed multinationals does not include R&D as assets on their company's balance sheet unless it is purchased from other parties. The same holds for ownership of patents. A few companies experimented with capitalisation of R&D in their company records but according to their opinions this led to unsatisfying results.

In conclusion, survey questions on foreign R&D funding may result in sometimes considerable underreporting of R&D export. Again, a first recommendation is to explicitly address R&D purchases and sales in R&D survey questions. The measurement of intra-concern flows of R&D requires special attention. Multinational companies are often unable to provide information on the use of R&D services at the national level. From a statistical point of view it would be very helpful if direct invoice methods would be implemented in much more multinational companies. Also from a company's perspective there seems to be a need to bring R&D costs in close relationship to the benefits of R&D.

For companies following indirect R&D funding mechanisms funding questions in surveys will not lead to satisfying results. In these cases the only way out is to ask which part of domestic R&D expenditure is expected to benefit foreign affiliates. This will provide an indication of the amount of R&D that is being transferred to foreign affiliates. Reversely, in these cases surveys should include questions on the domestic appliances of R&D carried out by foreign affiliating R&D units. This may provide an indication of the R&D transferred from abroad to the domestic economy.

Generally, due to ongoing globalisation many national statistical offices are implementing special monitoring systems to coordinate all surveying of the largest, usually multinational, companies. The goal of those special monitoring systems is to make sure that all statistical surveys are mutually consistent and deliver comprehensive results at the national economy level. This may in most instances require custom-made surveying methods. It seems highly desirable to make the observation of R&D flows part of these custom made observation systems for the largest companies.

3. Measuring R&D capital stocks

3.1 Introduction

The OECD (2001) handbook on Measuring Capital provides the methodological underpinnings of measuring consumption of fixed capital, net capital stocks and capital services. The handbook shows that these statistics are interrelated and should be constructed preferably on the basis of one conceptual framework. The Perpetual Inventory Method (PIM) applied at Statistics Netherlands is based on these OECD guidelines.[3] This system can also be used to calculate R&D stocks and consumption of fixed capital.

For calculating R&D capital stocks the following information is needed:

- Time series of data on R&D gross fixed capital formation;
- An initial R&D capital stock;
- R&D prices;
- Average service lives of R&D and their distribution;
- Age-efficiency patterns of R&D.

Despite all complexities discussed in the former section, R&D investment time series were calculated using the R&D survey time series (1970-2004). An initial capital stock for the year 1952 and estimates for R&D investments from 1953-1969 were estimated with the help of historical R&D survey data covering the years 1959 and 1964. For the period 1953-1969 it is assumed that the R&D expenditure growth rates are constant.

Output based prices of R&D services are at this moment not available at Statistics Netherlands. Alternatively, the annual price changes of R&D services are derived from price changes of production costs. The production costs of R&D services have three components: compensation of employees, intermediate consumption and user costs of capital. Their cost shares, obtained from R&D survey data, are used as weights. The price changes of each of these cost components are obtained from National Accounts time series.[4]

The knowledge capital stock is indirectly measured using the PIM. Two additional pieces of information are needed to determine the annual R&D wealth stocks: the distribution of service lives of R&D assets (i.e. amortisation patterns) and the decay in the efficiency of R&D as a result of expected declining market advantages due to obsolescence.

3.2 Service lives

Knowledge is not subject to wear and tear. The reason why knowledge asset values decline over time is because their contribution to company profits will inevitably fall in time. Eventually knowledge will be shared by others or may simply become obsolete due to new knowledge creation.

Unless patented there is almost no empirical evidence on the service lives of knowledge capital. However, the amortisation of patents gives a useful impression of the service lives of knowledge capital. 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,

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[3] See Van den Bergen, De Haan, De Heij and Horsten (2005) for a detailed description.

[4] Due to a lack of data, for the period 1970-1986 the GDP price index is used for the intermediate consumption cost component.

2004). However it is uncertain whether patent lives are representative for the service lives of all (patented and unpatented) R&D assets. This needs further investigation.

One may assume expensive patents to have on average longer service lives than cheaper patents. An unweighted average service life of patents is therefore expected to be downwards distorted. The unweighted average service life should therefore be seen as a lower bound.[5] The *unweighted* average service life of patents is determined by using information on the age distribution of patents as obtained from the Dutch Patent Registry. This register provides annual information on the number of patents granted from the year 1968 onwards. For all granted patents information is further provided about the number of patents expiring at a certain age. The maximum age allowed in the analyses is 21 years, after which all patents have expired.

Table 1 shows information on the distribution of patent values, derived from the PatVal report (2005). This information can be used to estimate the service lives per value category of patents[6]. To obtain a measure of the expected value of the patent, inventors are asked to give their best estimate of the value of the innovations that they contribute to develop. This information can be used to calculate *weighted* average patent service lives by taking these patent values explicitly into consideration. In Table 2, the information on patent values is combined with information on the age distribution of patents. This latter information is used to estimate an asset's probability of reaching a certain age. Table 2 shows for example that 8.9% of all patents have an expected service life of 2 years while 14.1% of all patents have an expected service life of 3 years and so on. The connection of average patent values to mortality probabilities is based on an assumed perfect correlation between patent age and values.

Table 1
Distribution of patent values

Value Intervals	Average value	Europe	Netherlands
1,000 €	*1,000 €*	*%*	*%*
0-30	15	8	8
30-100	65	17	16
100-300	200	21	18
300-1000	650	22	20
1,000-3,000	2,000	15	17
3,000-10,000	6,500	10	13
10,000-30,000	20,000	4	5
30,000-100,000	65,000	2	3
100,000-300,000	200,000	1	1
>300,000	300,000	1	1
Total		100	100

Source: PatVal Report (2005)

[5] Unweighted averages suggest that patent values are totally uncorrelated with service lives.

[6] In the PatVal report (2005) information on patent values is provided for a number of European countries.

However, it is also unlikely that patent values and service lives are fully correlated. Therefore the weighted average service life should be regarded as the upper bound. One may expect the correct average patent service life to be somewhere between this lower and upper bound.

It turns out that the unweighted patent average age (the lower bound) is a little bit longer than 7 years. A weighted patent average (the upper bound) amounts to almost 18 years. As a result 12.5 years is taken as the average service life of patents and subsequently for all R&D assets. For two industries an exception is made. The average value of patents in the chemical manufacturing industry appears to be above average while in the electro technical manufacturing industry it seems to be below the average. Therefore average service lives of the chemical and electro technical manufacturing industries are set at 15.5 and 9.5 years respectively.

Table 2
Patent values and mortality rates

Age	Average patent value	Mortality probability
years	*1,000 €*	*%*
0	15	0.0
1	15	0.2
2	25	8.7
3	65	14.1
4	200	11.4
5	430	12.4
6	650	9.8
7	1,508	11.4
8	2,000	4.5
9	2,000	3.8
10	6,442	3.2
11	6,500	2.8
12	6,500	2.4
13	6,500	2.0
14	6,500	1.7
15	6,500	1.5
16	20,000	1.4
17	20,000	1.3
18	20,000	1.2
19	20,000	1.2
20	104,791	4.9
21	300,000	0.1

Sources: Dutch Patent Registry and the PatVal Report (2005)

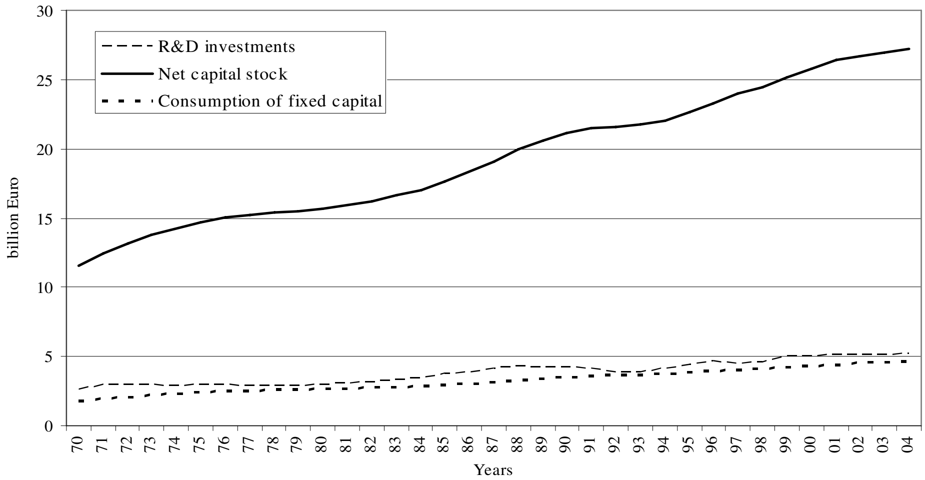
3.3 Age-efficiency patterns

Besides service lives the age-efficiency (profit) patterns of knowledge assets must be determined as well. It is unlikely that R&D assets generate constant revenue flows over their entire service lives. One may expect the competitive edge of knowledge capital to decline in time, indicating declining age-efficiencies or asset profitability. Generally so-called age-efficiency profiles are used to postulate the asset efficiency changes over time. At Statistics Netherlands hyperbolic age-efficiency profiles are used.[7] Hyperbolic profiles suggest that efficiency losses increase progressively over the asset´s service lives.[8] The shape of these profiles may differ between the various asset categories. For R&D assets a shape parameter of 0.75 is applied to define their age-efficiency pattern. This choice, however, is difficult to support with empirical evidence.

4. Results

This section briefly presents some results of introducing the concept of R&D capital in the Dutch National Accounts. Figure 1 shows the annual volume changes in R&D wealth stocks, R&D investment and consumption of fixed capital. The total value of the R&D capital stock, measured in constant prices, shows a rather gradual increase. It seems that the widespread and rapid introduction of ICT capital in the nineties did not affect R&D investments very much.

Figure 1
R&D capital stock, investment and consumption of fixed capital in constant prices of the year 2000, the Netherlands, 1970-2004



7 There are however some exceptions. For software and mineral exploration a constant efficiency over the service life is used.
8 Geometric profiles assume, in contrast, the largest absolute efficiency losses at the beginning of an asset´s service life.

Table 3 summarizes the effect of R&D capitalisation on a number of National Accounts aggregates. Capitalisation of R&D leads to an upwards adjustment of gross fixed capital formation of approximately five percent.[9] This share increases in recent years. The effects of R&D capitalisation on gross domestic product (GDP) are rather modest. Total GDP is adjusted upwards by approximately 1.2 %.

In the period 1998-2004 the cumulated volume growth of R&D gross fixed capital formation was about 14%. R&D investments do not seem to be very much influenced by business cycles. In contrast, the volume growth of (total) gross fixed capital formation was considerably lower in the same period. In the years 2002-2004 the volume growth of gross fixed capital formation was even negative.

Table 3
Adjustment in National Accounts aggregates as a result of R&D capitalisation, the Netherlands, 1998-2004

		1998	1999	2000	2001	2002	2003	2004
Gross fixed capital formation in R&D	*bln €*	4.2	4.8	5.0	5.4	5.6	5.7	6.0
Gross fixed capital formation (GFCF)	*bln €*	80.5	88.4	91.7	94.7	92.9	92.8	92.4
Adjusted GFCF	*bln €*	84.7	93.2	96.7	100.1	98.4	98.6	98.4
Adjustment in %	*%*	5.3	5.4	5.5	5.7	6.0	6.2	6.4
Share R&D in adjusted GFCF	*%-share*	5.0	5.2	5.2	5.4	5.6	5.8	6.1
Gross domestic product (GDP), market prices	*bln €*	362.5	386.2	418.0	447.7	465.2	476.9	491.2
Adjusted GDP, market prices	*bln €*	366.7	391.0	423.0	453.1	470.8	482.7	497.1
Adjustment in %	*%*	1.17	1.24	1.20	1.21	1.19	1.20	1.21
Share R&D in adjusted GDP	*%-share*	1.16	1.23	1.18	1.19	1.18	1.19	1.20
	Volume-index (1998=100)							
Gross fixed capital formation in R&D		100.0	110.5	109.7	112.7	111.3	111.7	114.0
Adjusted Gross fixed capital formation		100.0	108.8	109.3	109.7	104.9	103.4	101.9
Gross domestic product		100.0	104.8	108.8	110.9	111.0	111.4	113.9

5. Future work

As mentioned in this paper the ongoing process of globalisation is expected to cause more and more difficulties in surveying large multinational companies. It becomes increasingly problematic to demarcate their domestic economic activities. Coordination is needed to ensure that all statistical surveys are mutually consistent and deliver comprehensive results at the national economy level.

Recently a ‘top 250’ project was started at Statistics Netherlands to achieve this consistency. This project aims to scrutinize data from the largest 250 enterprises in the Netherlands. It is expected that a complete and consistent statistical description of these enterprises requires custom-made surveying methods. It seems desirable to make the observation of intra-company R&D flows part of this custom-made surveying approach. One advantage is that intra-concern R&D flows seem to exist for only a restricted number of multinationals.

[9] The values in figure 4.2 are given in current prices

R&D import and export estimates can also be improved by introducing specific questions in R&D surveys. Different ways to strengthen the usefulness of R&D surveys for national account purposes are currently investigated at Statistics Netherlands.

This year the National Accounts publication of the Netherlands included for the first time a set of tables on multi factor productivity. At this moment capital inputs do not include knowledge (R&D) capital. In the near future it is expected that the knowledge module will provide information on a wider range of intangible business investments including spending on innovative property (e.g. R&D) and economic competencies as well as software and other computerized information. Although R&D capital may be easier to measure than most economic competencies (e.g. brand equity and market research), conceptually these intangibles do not seem to differ much from R&D. In future work on growth accounting we aim to address issues as what is the contribution of this broader range of intangible capital to output growth and how does the inclusion of these intangibles affect the allocation of output growth between capital formation and multifactor productivity growth.

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