Measuring the unmeasurable: a country's non-R and D expenditure on product and service innovation

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by

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Abstract:
Knowledge about non-R&D expenditure on innovation activities such as patenting and licensing, design, trial production, tooling-up, manpower training, market research and investment in fixed assets, is stil1 extremely sparse. Questions about the latter were very poorly answered in the recent Community Innovation Survey (CIS). With the aid of information regarding the quality of replies, we estimate missing values and then reach a national estimate of 1992 innovation expenditure in the manufacturing and service industries of the Netherlands. For policy discussions as well as for modelling, it is interesting to note that expenditure on product-related R&D (6,24 billion guilders) represents about 26% of total product (and service) innovation expenditure, the latter including 12,5 billion guilders for investment in fixed assets.

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In the past, innovation measurement tended to be confined to R&D. This is frequently unsatisfactory since the innovation process also requires a number of non-R&D activities such as the acquisition of patents and licences, design, trial production and tooling up, training of personnel, market research and, last but not least, investment in new production capacity. While such non-R&D expenditure may be of considerable quantitative importance, innovation policy as well as theorizing and modelling stil1 have to rely on R&D statistics as the major source of information systematically collected over time and across all OECD countries. In many of these countries, information about non-R&D expenditure on innovation is virtually non-existent .

The recent pilot innovation survey organized by the European Commission and Eurostat was a first attempt at capturing non-R&D innovation expenditure on a European scale. Smal1 sample pre-testing of the harmonized European innovation survey questionnaire in five countries suggested that roughly half of the sample firms were unable to answer to the question about innovation expenditures adequately (see Kleinknecht 1993). Obviously, firms are not yet accustomed to collect such information and to report it in postal surveys. As we expected firms to have difficulties in answering, we included the following additional question in the survey in the Netherlands (in brackets: percentages of answers):

Your answers to the above questions (on innovation expenditure) consisted of:

- o ***fairly accurate figures (manufacturing: 23, 8%, services: 20,0 %)***
- o ***rough estimates (manufacturing: 46,6%, services: 32,1%)***
- o ***you were unable to answer (manufacturing: 29,6%, services: 47,8%).***

Given our stratified (net) sample of 7.784 firrns from all sectors of the manufacturing and service industries of the Netherlands and given a response rate of 52%, our database is in principle representative for firms with 10 and more employees on a national scale. Nonetheless, it is obvious that traditional methods of extrapolation are not feasible in this case. Not only the very high rates of missing values and 'rough estimates' are disturbing. There is also a bias problem. Our logit analysis of properties of firms revealed that those that had a missing value (or which gave a "rough estimate") can generally be characterized as somewhat 'weaker' irmovators (Brouwer & Kleinknecht, 1994: 121-125). The implication is that a simple extrapolation of data (assuming that firrns with missing values do not essentially differ from those that answered) would lead to a substantial over-estimation of national product (and service) innovation expenditure.

We have therefore used an altemative methodology. The basic idea behind this is that there must be a fairly close relationship between a firm's product innovation expenditure on the one hand, and, on the other hand, its product-related R&D expenditure (plus other firm characteristics such as branch, size, etc.). If this is valid, we could use R&D and other firm characteristics (which, in general, are quite well reported in other parts of the questionnaire) in order to simulate what should have been reported by those firms that were "unable to answer" or which gave only a "rough estimate" to the question on innovation expenditure.

We start from firms that indicated that they gave a "fairly accurate" answer. By means of OLS regressions, we try to explain a firm's innovation expenditure on product (and service) innovation as a function of its expenditure on product- (and service-) related R&D and some other factors. When using log specifications we obtained fairly good regression estimates: the equations are homoscedastic, tests on the functional form are positive, residues are normally distributed, and the R-squares look satisfactory.

In conclusion, the estimated OLS models provide a fairly good predictor of a firm's innovation expenditure. In Table 1 we document the OLS model which explains the log of a firm's expenditure on product (and service) innovations, *excluding* investments in fixed assets related to product innovations. Table 2 documents a similar estimate of innovation expenditures, *including* investments in fixed assets related to product innovation.

Table 1 Factors which explain a firm's (log of) expenditure on product and service innovation, ***excluding investments*** in fixed **assets** related to product or service innovations

exogenous variables	*coeff.:*	*t-values:*
constant term	-2,31	- 7,05
continuous variables:		
log of product-related R&D expenditure (incl. R&D contracted out)	0.57	11,37
firm size (log of number of employees)	0,55	7,49
dummy variables:		
R&D is a permanent (not occasional) activity	0,31	2,32
firm acquired external technological knowledge	0,42	3,30
sector dummies:		
chemical industry	0,34	2,01
construction or installation industry	-1,20	- 2,41

Notes:
* n = 292 firms (i.e. firms that gave a "fairly accurate" answer; n deviates from the n in Table 2, because of missing values);
** R-square: 0,71
*** all variables relate to the year 1992.

Table 2 Factors that explain a firm's (log of) expenditure on product and service innovation, ***including investments*** in fixed **assets** related to product or service innovations

exogenous variables	*coeff.:*	*t-values:*
constant term	-1,32	-3,17
continuous variables:		
log of product-related R&D expenditure (id. R&D contracted out)	0.45	7,70
firm size (log of number of employees)	0,61	6,85
dummy variables:		
R&D is a permanent (not occasional) activity	0,02	0,13
firm acquired extemal technological knowledge	0,27	1,60
sector dummies:		
chemical industry	0,34	1,22

Notes:
* n = 215 firms (i.e. firms that gave a "fairly accurate" answer; n deviates from the n in Table 1, because of missing values);
** R-square: 0,62
*** all variables relate to the year 1992.

Product-related R&D expenditure is an important explanatory variable of product innovation expenditure. The positive coefficients for firm size reveal that larger firms, with given R&D expenditures, have higher non-R&D innovation expenditure. The same holds for chemical firms and for those that bought extemal technological knowledge and, in the case of Table 1, for firms that consider R&D as a permanent (other than an occasional) activity.

Below, the coefftcients from Tables 1 and 2 are used for a simulation of expenditure on product and service innovation of those firms that had a missing value or which gave only a "rough estimate". With respect to the exogenous variables in the two tables, there are few problems with missing values. It should be noted that we make one crucial assumption in our simulation: The relationship between R&D and innovation expenditure measured among firms that gave "quite an accurate answer" also holds for firms that gave a "rough estimate" or no answer at all. Clearly, the realism of our simulation stands or falls with the realism of this assumption. As mentioned above, our logit analysis of properties of firms shows that weaker innovators are more likely to give a "rough estimate" or no answer (Brouwer & Kleinknecht 1994: 121-126). On the other hand, we see no apriori reason why the relationship of R&D to non-R&D innovation expenditure should differ systematically among stronger or weaker innovators.

Our simulation of (R&D and non-R&D) expenditure on product and service innovation of Dutch manufacturing and service firms in 1992 is given in Table 3 (split by size classes) and in Table 4 (split by branches). Innovation expenditure *excluding* investments in fixed assets is estimated at 11,1 billion guilders. The 95 % confidence interval of this estimate is +/- 1,47 billion guilders. [1] A comparison between the first and the second column in Tables 3 and 4 suggests that investments in fixed assets related to product and service innovation have considerable weight: innovation expenditure ***including*** investments is estimated to amount to 23.687 billion guilders. The 95 % confidence interval is +/- 2,296 billion guilders.

Our estimate of R&D expenditure related to product and service innovation in manufacturing and service industries in 1992 amounts to 6,24 billion guilders (3,93 billion in manufacturing and 2,31 billion in services).[2] From this it follows that the mean share of product-rela-

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[1] The limits of 80% and 90% confidence intervals are: +/- 0,963 billion and 1,236 billion guilders respectively; see Cramer (1986: 31-33) for the method of estimating these confidence intervals .

[2] Insiders will note that our estimates of R&D expenditure (just as our estimates of R&D man years or of numbers of firms engaging in R&D) are considerably higher than comparable figures by the Dutch Centra1 Statistical Office. This has to, do with our capturing of small-scale and often informal R&D-activities in smaller enterprises

ted R&D in total product and service innovation expenditures (*excluding* investments in fixed assets related to product and service innovation) is about 56% (57% in manufacturing and 54% in services). The share of product-related R&D in total product and service innovation expenditure (including investments in fixed assets) is 26% (34 % in manufacturing and 19% in services). It is remarkable that investment in fixed assets has more weight in services than in manufacturing .

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which tend to be under-counted in official surveys. For a detailed argument see Kleinknecht (1987) and Kleinknecht & Reijnen (1991).

Table 3 Expenditure on product and service innovation in Dutch manufacturing and services@ split by size classes

size classes (numbers of employees)	innov . expenditure, excl. investment (million guilders)#	innov. expenditure incl. investment (million guilders)*	n
manufacturing :			
10-19	134	545	235
20-49	381	1.162	451
50-99	273	680	594
100-199	372	800	391
200-499	478	1.201	273
500 and more	5.255	7.232	138
total manufacturing	6.893	11.529	2.082
services :			
10-19	491	1.831	488
20-49	941	3.576	479
50-99	663	1.802	325
100-199	604	1.508	251
200-499	411	851	270
500 and more	1.143	2.590	197
total services	4.253	12.158	2.012
total manuf. and services	11.146	23.687	4.094

@ the values in this table were obtained by simulating missing values and 'rough estimates' by means of the equations given in Tables 1 and 2, adding the figures from firms that gave 'quite an accurate answer'. The fígures have been raised to national totals.

product-related innovation expenditure include expenditure such as: R&D, patents and licences, design, trial production, tooling-up, manpower training, market research (not market introduction), but *not* investments in fixed assets.

* this column includes the same categories as the previous column, *plus* expenditure on investments in fíxed assets related to product (and service) irmovation.

Table 4 Expenditure on product and service innovation in Dutch manufacturing and services split by branches

branches:	innovation expenditure *including* investment (in million guilders)	innovation expenditure *excluding* investment (in million guilders)	n
food and beverages	704	1.412	228
textiles and leather	74	225	135
wood and building materials	137	432	219
paper, printing & publishg.	288	704	272
chemicals, plastics	2.113	2.968	251
basic metal and metal goods	3.286	5.066	889
other industries	106	386	81
branch unknown	186	334	7
total of manufacturing	6.894	11.529	2.082
services :			
public utility (gas, water)	105	228	67
construction & installation	182	1.849	248
trade	1.136	3.478	417
hotels, restaurants, repair	140	469	144
transport, communication	477	1.293	273
banks, insurance	408	1.101	172
other commercial services	1.082	2.724	516
other non-comm. services	724	1.015	175
total services:	4.254	12.157	2.012
total manuf. and services	11.148	23.686	4.094

Notes: see Table 3

Finally, Table 5 provides an indication of the structure of product and service innovation expenditure. Other than the figures in Tables 3 and 4, percentages in Table 5 are <u>not</u> based on simulations but on (weighted) arithmetic means of the answers given by 322 firms that indicated that they gave a 'fairly accurate answer'. Table 5 shows the share of **R&D** in **innova-tion** expenditure ***excluding*** investment in fixed **assets**. As has **already** been mentioned, the **latter** group is biased towards 'strong' innovators. This explains why the share of **R&D** in **innovation** expenditure is **higher** in this group than according to **Tables** 3 and 4.

Table 5 Percentage shares of various types of product innovation expenditure

type of innovation expenditure:	manufg.	services:	total:
product-related **R&D**	64%	75%	69%
patents and licences	2%	5%	4%
design	3%	1%	2%
trial production, tooling-up, manpower training	17%	9%	13%
market research (excluding market introduction)	3%	2%	3%
other expenditure	11%	7%	9%
totals	100%	100%	100%

Note: The figures are weighted arithmetic **means,** based on 322 **firms** that gave a 'fairly accurate answer'. They are biased in favour of 'strong' innovators and ***cannot*** be interpreted as ***national*** **totals**.

When investment in fixed **assets** is excluded from product innovation expenditure, **product-**related **R&D** takes the lion's share of product innovation expenditure. Although the results in Table 5 are biased towards 'strong' innovators, they **can** stil1 be interpreted as showing that **factors such** as patenting, licensing, design and market research form only a minor **frac-tion.** The major part of innovation expenditure is due to trial production, tooling-up and trai-ning, as **well** as 'other **costs'** . It should be noted that our estimates not only exclude **process** innovation expenditures, but **also** under-count product (and service) innovation expenditures to the extent that expenditures on advertising related to new product introduction are not **covered.** They have been deliberately omitted from the CIS questionnaire by **pragmatic** reasons: in earlier trial surveys, marketeers were usually unable to separate routine **adver-**tisements from new product advertisements.

In spite of the unavoidable caveats mentioned, our estimates on the amount and **structure** of irmovation expenditure do shed some light on an hitherto sparsely explored field. The **out-comes may** be of interest to policy makers as **well** to model builders **who,** sooner or later, **will** have to integrate product innovation into their macro-models.

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