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Brouwer, E.; Kleinknecht, A.

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

Erik Brouwer [a], Alfred Kleinknecht [b,*]

[a] SEO, Foundation for Economic Research, Universiteit van Amsterdam, Amsterdam, Netherlands
[b] ESI, Economic and Social Institute, Vrije Universiteit, Room 4 A-14, De Boelelaan 1105, NL-1081 HV Amsterdam, Netherlands

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Abstract

Knowledge about non-R&D innovation expenditure, such as patenting and licensing, design, trial production, tooling-up, manpower training, market research and investment in fixed assets, is extremely sparse and questions about the latter were very poorly answered in the recent Community Innovation Survey (CIS). Using information regarding the quality of replies, we reach a tentative national estimate of 1992 innovation expenditure for all manufacturing and service industries in the Netherlands. Expenditure on product-related R&D represents about one quarter of total product (and service) innovation expenditure. Roughly half of the latter consists of investment in fixed assets, the latter being more important in services than in manufacturing.

1. Introduction

In the past, innovation measurement tended to be confined to R&D. This is frequently considered 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 still 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 nonexistent.

The recent pilot round of the Community Innovation Survey (CIS), organized by the European Commission and Eurostat, was a first attempt at capturing non-R&D innovation expenditure on a European scale. Small 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 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

* Corresponding author. Tel.: +31-20-4446138; fax: +31-20-4446127.

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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:
- fairly accurate figures (manufacturing: 23.8%, services: 20.0%)
- rough estimates (manufacturing: 46.6%, services: 32.1%)
- you were unable to answer (manufacturing: 29.6%, services: 47.8%).

Given our stratified (net) sample of 7784 firms 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. Other than the surveys in the other countries, the CIS for the Netherlands also covers the entire service sector. When applying the CIS questionnaire to services, only very small modifications needed to be made, and the experience was quite positive (Brouwer and Kleinknecht, 1995).

Nonetheless, given the high rates of item non-response (and of 'rough estimates') in the case of the innovation expenditure question, it is obvious that traditional methods of extrapolation are not feasible, notably since there may be a bias problem. Our logit analysis of properties of firms revealed that those that had a missing value (or that gave a 'rough estimate') can generally be characterized as somewhat 'weaker' innovators (see Appendix A). The implication is that a simple extrapolation of data (assuming that firms with missing values do not essentially differ from those that answered) would lead to a substantial overestimation of national product (and service) innovation expenditure.

We have therefore used an alternative 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.

2. Estimates

We start with firms that indicated that they gave a 'fairly accurate' answer. By means of ordinary least squares (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

Table 1
Factors that 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	Coefficient	*t*-value
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; numbers of observations deviate from those in Table 2 because of missing values); $R^2 = 0.71$; 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	Coefficient	t-values
Constant term	−1.32	−3.17
Continuous variables		
Log of product-related R & D expenditure (incl. 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 external technological knowledge	0.27	1.60
Sector dummy		
Chemical industry	0.34	1.22

Notes: $n = 215$ firms (i.e. firms that gave a 'fairly accurate' answer); $R^2 = 0.62$; all variables relate to the year 1992.

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 that 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.

In the above estimates, it is remarkable that the relationship between product-related R&D and total product innovation expenditure shows little variation across branches. We therefore use the coefficients of the model for simulation of innovation expenditures across the entire sample, rather than using branch-specific coefficients.

The simulation of expenditure on product and service innovation is done for those firms that had a missing value or 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 ticked 'unable to answer'. As is shown in our logit analysis in Appendix A, weaker innovators are more likely to give a 'rough estimate' or no answer. On the other hand, we see no a priori reason why the relationship of R&D to non-R&D innovation expenditure should differ systematically among stronger or weaker innovators. [1]

Our simulation of (R&D and non-R&D) expenditure on product and service innovation of Dutch manufacturing and service firms in 1992 is documented in Table 3 (split by size classes) and in Table 4 (split by branches). Innovation expenditure excluding investment in fixed assets is estimated at 11.1 billion guilders. The 95% confidence interval of this estimate is ± 1.47 billion guilders. [2] Tables 3 and 4 suggest that investment in fixed assets related to product and service innovation has considerable weight: innovation expenditure *including* investment is estimated to amount to 23.687 billion guilders. The 95% confidence interval is ± 2.296 billion guilders.

Our estimate of R&D expenditure on product and service innovation in manufacturing and service industries in 1992 amounts to 6.2 billion guilders (3.9 billion in manufacturing and 2.3 billion in services). From Table 3 one can calculate that the mean share of product-related R&D in total product and service innovation expenditures (excluding investments in

[1] However, when comparing Tables 3 and 5 below, we shall see that the share of R&D in total innovation expenditure among the stronger innovators (52.3% in manufacturing, 74,9% in services) deviates somewhat from the entire sample (56.8% in manufacturing, 54.3% in services).

[2] 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.

Table 3
Expenditure on product and service innovation in Dutch manufacturing and services [a] split by size classes (million guilders)

Size classes (numbers of employees)	Innovation expenditure, excluding investment [b]	Innovation expenditure including investment	
		Total [c]	Product-related R & D
Manufacturing			
10–49	515	1 616	220
50–199	645	1 480	424
200 and more	5733	8 433	3 272
Total manufacturing	6893	11 529	3916
Services			
10–49	1 432	5 407	314
50–199	1 267	3 310	1 030
200 and more	1 554	3 441	964
Total services	4253	12 158	2308
Total manufacturing and services	11 146	23 687	6224

[a] 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 figures have been raised to national totals.
[b] Product-related innovation expenditure includes 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.
[c] This column includes the same categories as the previous column, plus expenditure on investments in fixed assets related to product (and service) innovation.

Table 4
Expenditure on product and service innovation in Dutch manufacturing and services [a] split by branches (in million guilders)

Branches	Innovation expenditure excluding investment [b]	Innovation expenditure including investment	
		Total [c]	Product-related R & D
Manufacturing			
Food and beverages	704	1 412	195
Textiles and leather	74	225	22
Wood and building materials	137	432	40
Paper, printing and publishing	288	704	123
Chemicals, plastics	2 113	2968	1 043
Basic metal and metal goods	3286	5066	2335
Other industries	292	720	122
Total of manufacturing	6894	11 529	3 880 [d]
Services			
Public utility (gas, water)	105	228	54
Construction and installation	182	1 849	67
Trade	1 136	3478	416
Hotels, restaurants, repair	140	469	1
Transport, communications	477	1 293	78
Banking, insurance	408	1 101	137
Other commercial services	1 082	2724	874
Other non-commercial services [e]	724	1 015	680
Total services	4254	12 157	2308
Total manufacturing and services	11 148	23 686	6 188 [d]

[a,b,c] See notes under Table 3.
[d] This figure deviates from the corresponding figure in Table 3 because of missing values.
[e] Including public R & D laboratories.

fixed assets) 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 about 26% (34% in manufacturing and 19% in services).

It should be noted that our manufacturing estimate of a 34% share of R&D in total innovation expenditures (including fixed assets) in manufacturing comes quite close to the estimate of 35% for Italian manufacturing by Sterlacchini (1996, 28). Moreover, fixed assets (related to product innovation) are 40.3% of all innovation expenditure in manufacturing. This is not very distant from the 47.1% share of fixed assets estimated by Sterlacchini (1996, 28) in Italian manufacturing. One should note, however, that the two estimates are not fully comparable. Our estimate is confined to product and service innovation, while the Italian survey also tried to cover process innovation. It is remarkable that investment in fixed assets has more weight in services (taking 65% of all innovation expenditure) than in manufacturing which suggests that R&D is a less suitable innovation indicator in services.

Given that in 1992 Dutch gross domestic product (GDP, at market prices) amounted to 563.08 billion guilders and total investment was 114.24 billion (CBS, 1995, 377), we can conclude that total product and service innovation expenditure in 1992 amounted to 4.2% of GDP. Moreover, investment in fixed assets related to product and service innovation is about 11% of the country's total fixed asset investment.

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 from the R&D survey by Statistics Netherlands. This has to do with our capturing of small-scale and often informal R&D activities in smaller enterprises which tend to be undercounted in traditional R&D surveys (see Kleinknecht, 1987). Similar findings have meanwhile been reported in other countries, e.g. in Italy (Santarelli and Sterlacchini, 1990; Cesaratto and Sirilli, 1992) and in Germany (Felder et al., 1996). It should be added that records on R&D subsidies in the Netherlands that have meanwhile become available give support to our argument that there must be much more R&D in smaller firms than is suggested by the standard R&D survey (see Kleinknecht and Reijnen, 1991). The difference between the two surveys can be illustrated by taking R&D as a percentage of GDP. According to our data, the amount of 6.2 billion guilders of *product-related* R&D is about 1.1% of GDP, while *total* R&D (product *and* process R&D) according to the standard R&D survey is about 1% of GDP (the share of product R&D in total R&D being 67.1% according to our survey).

Finally, Table 5 provides an indication of the importance of other components of product and service innovation expenditure. Other than the figures in Tables 3 and 4, percentages in Table 5 are not based on simulations but on means of the answers given by 322 firms that indicated that they gave a

Table 5
Shares of various types of product innovation expenditure by size class (%)

Type of expenditure	Manufacturing				Services			
	10–50 employees	50–199 employees	200 and more employees	Total	10–50 employees	50–199 employees	200 and more employees	Total
Product-related R&D	40.4	59.5	51.7	52.3	50.9	80.4	80.8	74.9
Patents and licences	6.4	3.5	21.7	18.1	14.9	1.3	5.5	4.8
Design	10.6	4.8	1.6	2.6	3.5	1.1	0.9	1.5
Trial production, tooling-up, manpower training	20.1	18.4	14.9	15.7	21.6	5.9	8.1	9.3
Market research	3.9	4.6	2.3	2.7	4.0	1. 0	3.7	2.2
Other expenditure	18.6	9.2	7.8	8.6	5.2	10.3	1.1	7.3
Total	100	100	100	100	100	100	100	100

Note: the figures are based on 322 firms that gave a 'fairly accurate answer'. They are biased in favour of 'strong' innovators (see Appendix A) and *cannot* be interpreted as *national* totals.

'fairly accurate answer'. Table 5 shows the share of R&D in innovation expenditure excluding investment in fixed assets. As has already been mentioned, the latter group is biased towards firms with an above-average degree of innovation (see Appendix A), and the figures 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 still be interpreted as showing that factors such as design and market research form only a minor fraction. The major part of innovation expenditure is due to trial production, tooling-up and training, and, in some categories, to patents and licences. It should be noted that our estimates not only exclude process innovation expenditures, but also undercount 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 for pragmatic reasons: in earlier trial surveys, respondents were usually unable to separate routine advertisements from new product advertisements.

In spite of the unavoidable caveats mentioned, our estimates on the amount and structure of innovation expenditure do shed some light on an hitherto sparsely explored field. The outcomes 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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Appendix A. Properties of firms which answered the question about innovation expenditures

The Community Innovation Survey (CIS) covered a number of questions never before asked in a large-scale postal survey. The pre-test of the harmonized questionnaire suggested that many firms would not be able to report their total innovation expenditure, and many firms would give a 'rough estimate', rather than a 'fairly accurate' figure (Kleinknecht, 1993, 153–188). Indeed, in the Netherlands, 29.6% of the manufacturing firms (and 47.8% of the service firms) reported that they could not answer the question about their innovation expenditure. Moreover, 46.6% of the manufacturing firms (32.1% of the service firms) reported that they could give only a 'rough estimate'.

In principle, a certain rate of item non-response does not need to be a problem. However, if the rate of item non-response is high and if there are reasons to expect a selectivity bias, our attempt to estimate national figures by applying raising factors can encounter serious problems. One cannot exclude the possibility that innovative firms are more motivated to respond to an innovation survey. Highly innovative firms tend to employ highly educated people and are likely to keep better records about their innovation activities. They are therefore more likely to give a 'fairly accurate answer'.

In the following we test whether the degree of innovation of a firm has an impact on the quality of answers given to the question on innovation expenditures. We use a multivariate logit probability model. This model compares systematically the properties of firms which were able to give 'a fairly accurate answer' or which gave 'a rough estimate' to those firms which were 'unable to answer' (reference group). In other words, the logit model investigates which factors influence the probability that a firm will tick one of the following possibilities:
1. the firm gave a 'fairly accurate answer';
2. the firm gave a 'rough estimate';
3. the firm was unable to answer.

We are particularly interested to see whether the probability of giving no answer is systematically related to factors such as a firm's R&D intensity, firm size or the firm's sector of principal activity. The outcomes are documented in Table 6. As in a regression model, we consider effects which have a t-value of about 2 or larger as significant.

Interpreting Table 6, three important points emerge: first, differences in firm size do not matter for the quality of answers; second, a high R&D intensity increases the probability that a firm will give a fairly accurate answer, rather than give no answer; the same holds if the firm's R&D is a permanent (other than an occasional) function; third, service sector firms tend to have higher probabilities of giving no answer (rather than giving a rough estimate). The second and third points suggest that notably highly R&D intensive firms in the manufacturing sector that have a permanent innovation function have lower probabilities of being unable to answer. This implies that a naive use of raising factors would lead us to arrive at national figures

Table 6
Factors that influence the probability that a firm will give 'a fairly accurate answer', a 'rough estimate' or will be 'unable to answer' the question about its total product innovation expenditure (summary of multivariate logit estimates)

Exogenous variables	Fairly accurate figure [a]		Rough estimate [a]	
	Effect	t-value	Effect	t-value
R&D intensity	0.01	2.69 **	0.01	1.81 *
Firm size (log of workers)	−0.01	1.03	0.01	0.33
Dummy for independent firms (not part of a group)	−6.30	3.97 **	−1.08	2.37 **
Dummy for firms that are strongly dependent on mother company when taking decisions about innovation	−1.35	1.77 **	−5.90	2.37 **
Dummy for firms that underwent structural change (e.g. merger) during last three years	−2.20	0.21	6.69	2.14 **
Dummies (for sectors of principal activity)				
Textiles industry	1.68	0.62	−13.17	1.83 *
Wood processing and furniture	7.97	1.32	−5.57	0.01
Paper industry	10.01	0.70	−18.75	2.22 **
Chemicals and fibres	9.12	1.58	−7.41	0.20
Basic metals, metal goods	6.67	0.85	−9.79	1.15
Other manufacturing industries	7.96	0.25	−17.25	1.59
Public utility enterprises	21.19	0.11	−53.55	4.75 **
Construction and installation	1.59	0.98	−17.29	2.63 **
Wholesale and retail trade	5.06	0.35	−9.38	1.10
Hotels, restaurants, etc.	11.06	0.11	−30.29	3.02 **
Transport, communications	1.61	0.99	−16.97	2.68 **
Banking, insurance	2.58	1.41	−24.69	3.86 **
Other commercial services	1.60	0.83	−12.72	2.34 **
Non-commercial services	−4.07	1.81 *	−15.49	2.95 **
R&D is a permanent function	2.60	2.07 **	3.13	1.91 *
Firm consulted a regional innovation centre	−1.68	0.28	5.80	1.69 *
Firm participated in national R&D programme (PBTS)	3.24	0.98	−1.70	0.14
Firm received a technical development credit (TOK)	7.42	0.65	−9.48	0.46
Firm participated in an EU R&D programme	−2.23	1.42	−8.58	1.86 *
Firm collaborated on R&D	2.61	2.89 **	7.24	3.43 **
Firm acquired external technical knowledge	1.44	1.77 *	3.38	2.12 **

[a] Effects are to be interpreted with respect to the reference group ('unable to answer'); in the case of dummy variables, the coefficients are 'derivatives' which give the change of the probability (in percentage points) if the independent variable shifts from zero to one. In the case of continuous variables, the coefficients are 'pseudo elasticities' which reflect the change of the probability (in percentage points) if the independent variable changes by 1%.

* Effect is significant at 90% level; ** effect is significant at 95% level.

that exaggerate the innovation level of firms. This is why the estimation procedure documented in Tables 1 and 2 has been chosen.

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