Firm Size and Innovation

Observations in Dutch Manufacturing Industries

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ABSTRACT. In an innovation survey in the Netherlands, we find considerably more SMEs which perform small scale R&D than are found in the official R&D surveys. Nonetheless, SMEs appear on average to be somewhat less R&D intensive than large firms. Only when we restrict our observations to firms which perform *some* R&D, there is no systematic relationship between size and R&D. Among the barriers to innovation the following are particularly important to SMEs: information deficits with respect to instruments of innovation policy; a lack of capital; a lack of management qualifications; problems in finding adequate technical information, and problems in finding qualified employees.

I. Introduction

This paper reports results from a mailing survey on industrial innovation in the Netherlands which was carried out in 1984 among some 3000 firms having 10 and more employees. It was intended to be a sample representative of all sectors of Dutch manufacturing. The response rate was 63.1% (1842 firms). The main incentive for doing such a survey was an apparent lack of good innovation indicators. It is a major problem for innovation research that the publication of innovation indicators collected by the Dutch Central Bureau of Statistics (such as e.g. on R&D) is restricted by severe confidentiality rules. In general, the Central Bureau is reluctant to deliver such indicators at sufficiently fine levels of sectoral and regional disaggregation for the purpose of economic research.

The data bank obtained by the survey has meanwhile been used for a number of purposes. For example, research has been carried out on industrial policy issues (Van Dijk and Kleinknecht, 1984; Kleinknecht, 1987b), on regional innovation patterns (Kleinknecht and Mouwen, 1985), on R&D effort and Dutch export performance (Kleinknecht and Verspagen, 1988), or on a re-investigation of the Schmookler hypothesis (Kleinknecht and Verspagen, 1989). Subsets taken from the data bank also proved to be useful for other researchers.

A notable by-product from the postal survey has been the outcomes reflecting on the relationship between firm size and innovation. With one exception (Kleinknecht, 1987a), the latter have been published until now exclusively in Dutch. This paper intends to report these results to the English-speaking public, concentrating on R&D efforts of SMEs, as well as on problems and barriers to innovation experienced by SMEs.

The official OECD data on R&D show a tremendous concentration of R&D in large firms. For example, according to the survey in the Netherlands about 70% of industrial R&D is performed by 5 large multinationals (Philips, Shell, AKZO, DSM and Unilever), and some 90% is concentrated in large firms, having 500 and more workers (see, e.g. Freeman, 1982, pp. 131—147).

On the other hand, there are indications in the literature that innovation in small and medium-sized firms appears to be much more important when looking at "direct" innovation indicators. For example, Pavitt, Robson and Townsend, judging from a survey of 4378 "significant innovations" argue that firms with fewer than 1000 employees commercialized a much larger share of innovations than is indicated by their share in R&D expenditures (1987, p. 297). Or Acs and Audretsch (1987, 1988), working on innovation data by the US Small Business Administration

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have indicated that SMEs may in a number of sectors be even more innovative than large firms.

Further below it will be argued that even when applying the R&D measure (according to the Frascati Manual), results can be different from the official surveys when using a somewhat simplified way of asking for R&D. But before making this point, some details of our mailing survey need to be mentioned.

II. Response rates and questionnaire design

Response rates to our postal survey seemed to vary positively with firm size. In the size class of firms having 10 to 19 employees the response rate was 49.1%, while the two classes of firms having 20 to 49 and 50 to 99 employees showed a response rate of 60.8% and 66.2% respectively. With increasing firm size, the response rate increased gradually, reaching 71.2% in the class of firms having $\geqslant 500$ employees. Moreover, in apparently less innovative sectors such as clothing, leather & shoes, or wood & furniture response rates proved to be slightly lower than average (Kleinknecht, 1987).

The above may imply that there is a relationship between the innovativeness of firms and their readiness to respond to a questionnaire on innovation. This suspicion is supported by the impression from inspection of individual questionnaires which suggests that more innovative firms seem to have filled in their questionnaires more carefully than less (or non-)innovative ones. If our speculation on the relationship between innovativeness and rates of response is realistic, we have to be cautious when making general statements on firm size and innovation. Notably, the innovation performance of SMEs, as compared with larger firms, may be over-estimated.

Besides the question of how to interpret the non-response, we faced the problem that in recent years Dutch firms have been inundated by all types of questionnaires and interviewers, and have become reluctant to respond. Notably, postal surveys from Universities often end up with deceptive response rates. We realized from the beginning that a satisfactory response rate would only be possible if we succeeded in minimizing the time and effort required to fill in our questionnaire. As a consequence, we decided to only ask questions which a manager in a central function of the enterprise could answer spontaneously without having to go to the firm's archives.

Consequently, our question on R&D referred to the most crude indicator possible, i.e. R&D man years. Information about R&D budgets would certainly have been more desirable, since the latter also includes investment in R&D facilities. On the other hand, there is a growing number of field studies which suggest that R&D work in SMEs can take place in rather informal ways, often taking place without a formal R&D department or a formal budget and often even outside regular working hours (see, e.g. Van Dijk, 1987). We therefore asked first whether the firm had a formal R&D department. When the answer was "no", we continued with the following question:

> If your enterprise does *not* have an R&D department, R&D activities might be carried out by other departments within your enterprise. For example: the sales department might develop a new product, or the production department might introduce improvements to a production process.
>
> Have any R&D activities been carried out within your enterprise during 1983 even though you do not have a formal R&D department?
>
> o No
>
> o Yes. If so, can you give an estimate of the number of man years that were devoted to such activities in 1983 (if necessary, give a *rough* estimate)?
>
> Man years devoted to R&D in 1983: . . . .

For the definition of R&D, we referred to the Dutch version of the Frascati Manual which was reproduced on the back flap of the questionnaire (the text being identical to that used in the survey by the Central Bureau of Statistics).

It is conceivable that much of the small scale and informal R&D work in SMEs cannot be captured adequately by the official surveys: a good many firms having small amounts of R&D may fill in zero R&D, just in order to get rid of the complicated questionnaire. But even those willing to respond correctly may experience difficulties due to their inadequate internal accounting for R&D. So far, the relatively complicated questionnaire in the official survey may be counterproductive.

III. Results on R&D performance

Table I illustrates the differences between our estimate of numbers of manufacturing firms in the

TABLE I
Numbers of firms having R&D (our results compared with the data from the official survey)

Firm size (employees)	Firms having R&D in 1981 according to official survey		Our most cautious estimate (with downward bias)[c] of	
	Q[a]	F[b]	Firms having R&D in 1983	Firms having an R&D department in 1983
10 to 19	n.a.	n.a.	544	85
20 to 49	n.a.	n.a.	736	144
50 to 99	155	119	435	117
100 to 199	158	142	345	178
200 to 499	138	145	248	128
⩾ 500	141	133	155	107

[a] "Q" refers to numbers of questionnaires returned; this probably is most directly comparable to our address list which covers company headquarters ("hoofdvestigingen").
[b] "F" refers to numbers of firms responding (according to legal definition). There can be differences between Q and F because a holding company may sometimes return several questionnaires, and/or one questionnaire may cover information from several firms of the holding.
[c] Firms which did not respond are assumed to have no R&D.

Netherlands performing any R&D and that from the official survey by the Central Bureau of Statistics (CBS). It can be added that the calculations which refer to man years of R&D show similar differences (Kleinknecht, 1987, p. 254). Table I shows no essential differences in the category of firms having ⩾ 500 employees. But there are considerable and growing differences as firm size diminishes.

Taking into account the above-mentioned possibility of a relationship between innovativeness and response rates, the data in Table I have been extrapolated in the most cautious way by assuming that firms which did not respond have *no* R&D. This extreme assumption certainly implies a downward biased estimate, notably of numbers of small firms having R&D. Nonetheless, we still arrive at estimates which considerably exceed those of the official survey. To be fair, four possible reasons need to be mentioned why our estimates may be upward biased.

First, our address list is not fully compatible with that of the Central Bureau of Statistics (the latter being kept secret). We may have counted slightly more firms having R&D because our address list stated the headquarters ("hoofdvestigingen") of firms which may be owned by a holding company. The Central Bureau in several cases has an agreement with holding companies that only one questionnaire be returned for all companies of the holding company. This is likely to explain slight differences, notably in numbers of medium-sized and large firms having R&D. Secondly, the Ministry of Economic Affairs was mentioned in our questionnaire as having financially sponsored our survey, and a letter of recommendation by the Minister was included. Although the companies were assured that no information concerning individual respondents would be given to the Ministry, the possibility can not be excluded that there have been companies that overestimated their innovative activities in order to make a good impression on the Ministry, which is a source of subsidies on R&D. Third, in doubtful cases, the Central Bureau sometimes phones companies in order to check their interpretation of the definition of R&D. This occasionally leads them to disregard the R&D reported. No such control was built into our survey. Fourth, our data refer to the year 1983, while the official survey covers the year 1981, and there has been a slight increase of aggregate R&D in recent years.

We believe that these four qualifications can explain only a small part of the observed differences in Table I. As already suggested above, the principal reason for the differences may lie in the simplicity of our questionnaire and in our restriction to the most simple indicator possible, i.e. R&D man years. This may have led many small firms to report small-scale and informal R&D work which they would (and often could) not have reported in the official surveys. The official survey asks for money spent on R&D which implies that a firm can only give a correct answer if its internal budgeting and accounting procedures are sufficiently detailed.

While in Table I, the numbers of firms reporting intramural R&D differ considerably, our figures in the right hand column of Table I, covering the numbers of firms having a *formal* R&D department, come much closer to the official estimates of numbers of firms having R&D (left hand columns). This is another indication that the reach of the official surveys is mainly restricted to *formal* R&D. Figure 1 provides an illustration of the

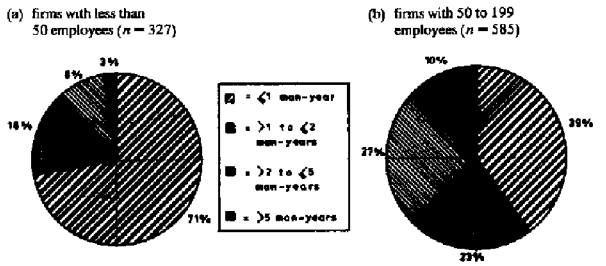

Fig. 1. Amounts of R&D in small firms.

amounts of small scale R&D captured by our survey.

Our attempt to identify the rather informal R&D work leads to a notable shift in the observed concentration of R&D in large firms. According to the official survey, about 90% of private R&D in Dutch manufacturing firms is done by large firms ($\geqslant 500$ employees). According to our estimate, this percentage would fall to 82.4% (when considering only the firms having more than 50 employees); the percentage falls to 77.3% when adding the R&D work done by firms having 10 to 49 employees which are not usually surveyed by the Central Bureau of Statistics (for calculations see Kleinknecht 1987, p. 33).

Table II gives an overview of percentages of firms in our sample which have R&D and/or an R&D department, as well as a measure of R&D intensities by size class.

It needs to be emphasized that the figures in Table II are likely to overestimate the R&D activities of SMEs, since they relate to enterprises in our sample which returned a questionnaire. As already mentioned above, response rates varied positively with firm size, and a positive relationship between innovativeness and response rates can not be excluded. Notably the relative innovativeness of the smallest firms can be exaggerated because of a response rate of 49.1% (as compared with 71.2% in the largest size class).

Having these qualifications in mind, we can conclude that the above R&D intensities do not give an unambiguous picture pertaining to R&D effort and firm size. Considering *all* firms, it seems that large firms ($\geqslant 500$ employees) on average are somewhat more R&D intensive than SMEs. However, such a measure of mean R&D intensity is somehow problematic for it includes a high percentage of SMEs which perform *no* R&D at all. This holds in particular for the smallest size class and is also reflected in a tremendously high

TABLE II
R&D performance by size class

	Size classes (employees): 10—19 $n=183$	20—49 $n=550$	50—99 $n=451$	100—199 $n=326$	200—499 $n=213$	$\geqslant 500$ $n=119$
Firms having intramural R&D but no R&D department	23.5%	40.4%	52.8%	38.3%	42.3%	30.3%
Firms having an R&D department	4.4%	9.8%	19.5%	41.1%	45.1%	67.2%
mean R&D intensity of all firms[a]	1.99	2.10	2.15	2.32	2.04	[6.5] 3.01[c]
standard errors[d]	(0.51)	(0.18)	(0.17)	(0.21)	(0.33)	(0.40)
mean R&D intensity of firms having R&D[b]	6.95	4.05	2.93	2.90	2.32	[6.5] 3.05[c]
standard errors[d]	(1.38)	(0.27)	(0.20)	(0.24)	(0.36)	(0.40)

[a] R&D man years as a percentage of employees in *all* firms in the size class.
[b] R&D man years as a percentage of employees in firms *which have some R&D* in the size class.
[c] This is a serious underestimation, because 2 out of 5 large Dutch multinationals did not participate in our survey. Tentative inclusion of their employees and R&D employees leads us to an R&D intensity of 6.5% (in hooked brackets), which comes close to the results of the official survey.
[d] These are standard errors of non-weighted means of R&D intensities.

standard error. On the other hand, taking only firms *which have some R&D*, the figures appear to be consistent with the conclusion from the classical survey by Kamien and Schwartz, that "... inventive activity does not typically increase faster than firm size ..." (1982, p. 103). However, this conclusion cannot be confirmed by applying tests on the significance of differences in mean R&D intensities, since the Kolmogorov—Smirnov test indicates that the assumption of normal distribution is far from realistic.

It is obvious that much (if not all) of the informal and small scale R&D activities measured in our survey refer to the "D" rather than to the "R" component of R&D, and one may wonder whether this is worth measuring. There are two other results from our survey which suggest that the answer should be yes.

First, we asked firms whether they had been busy with an innovation project in 1983. The innovation was defined as incorporating a new or at least a considerably improved product, production process, or a combination of both which was "new to the enterprise".[2] It is worth reporting that 87.6% of the SMEs (< 500 employees) who reported having intramural R&D also reported that they had worked on one or more innovation projects according to the above definition.

Secondly, as will become obvious further below, there is evidence from our survey that shortages of capital weigh much heavier on SMEs than for larger firms as a barrier to innovation. This suggests that if SMEs (are able to) do any R&D, they might be forced to apply more restrictive project selection criteria as compared with larger firms. Consequently, the small amounts of R&D work which they can afford to undertake might be allocated to projects with above average pay-offs.

IV. Barriers to innovation

Our questionnaire covered a list of possible problems firms might experience in the innovation process. Table III summarizes the eight topics which received the highest score in terms of importance. It turns out that three out of these eight problems are significantly related to firm size. Most important to SMEs as opposed to large firms is capital scarcity. The problem: "costs of an ongoing innovation project are hard to control" (No. 5) was intended as an indirect test of management qualification. Table III suggests that the latter weighs heavier for SMEs than for large firms. The same holds for difficulties to obtain technical information and know how required for innovation projects (No. 6).

TABLE III
Percentages of innovating firms by size which find a certain problem important

Problems	Size classes (employees) 10—19 $n = 75$	20—49 $n = 294$	50—99 $n = 330$	100—199 $n = 264$	200—499 $n = 176$	⩾500 $n = 112$	Signif.[a]
1. Lack of capital	58.7	47.3	38.8	33.7	29.0	26.8	+++
2. Difficulties in forecasting market demand	57.3	47.6	49.7	59.1	48.3	50.9	o
3. Expected costs of an innovation project are too high	37.3	36.1	32.7	33.3	35.8	30.4	o
4. Problems in adapting marketing function	25.3	25.5	27.6	26.5	25.0	25.9	o
5. Costs of ongoing projects hard to control	29.3	26.9	27.9	20.5	19.3	11.6	+
6. Technical information and know-how difficult to find	24.0	20.4	26.1	18.2	22.2	8.9	+
7. Problems to find employees with certain qualifications	24.0	20.7	21.2	20.1	12.5	12.5	o
8. Problems with government regulations	13.3	8.8	11.2	10.6	13.6	13.4	o

[a] According to the CHI^2 one-sample test (Siegel, 1956, 42—47), differences between size classes are:
o = insignificant,
+ = significant at 90% level,
+++ = significant at 99% level.

The overall variation between size classes of the answers to point 7 ("problems to find employees with certain qualifications") proves to be insignificant. It should nonetheless be noted that this problem appears to be important to 20 to 25% of the firms having less than 200 workers, whereas it is important to only 12.5% of the firms having more than 200 workers.

V. The reach of public policy instruments

In the Netherlands, a number of public policy instruments have been designed in recent years in order to alleviate problems of innovating firms. Our questionnaire covered a list of institutions and public policy measures, which the Ministry of Economic Affairs considered to be the most important at the time. We asked whether the firms knew at all about the existence of these policy instruments and whether they had made use of them. In Table IV, results are split by classes of firm size, referring to answers by firms which reported having done any R&D work in 1983.

Table IV shows that for half of the policy instruments knowledge varies significantly with firm size, i.e. smaller firms are systematically less informed about the existence of such instruments than their larger counterparts.

Not surprisingly, knowledge among SMEs which perform *no* R&D work is considerably less, and, of course, the actual use of policy instruments shows a similar picture (see Kleinknecht, 1987, 22). It can be added that some of these instruments have been primarily designed for aiding small and medium-sized firms (e.g. subsidies on management training. Rijksnijverheidsdienst, transfer points). But even in these cases, smaller firms are not systematically better informed than larger ones.

VI. Summary and conclusions

Judging about the innovativeness of SMEs, we are

TABLE IV

Percentages of firms by size which are informed about policy instruments and institutions for innovation support

Instrument or institution	Classes of firm size (employees) 10—19 $n = 58$	20—49 $n = 299$	50—99 $n = 338$	100—199 $n = 270$	200—499 $n = 190$	⩾500 $n = 117$	Signif.[a]
— technical development credit	65.5	70.6	71.6	80.4	82.1	88.0	o
— subsidies and credits on energy saving pilot projects	65.5	64.5	68.3	75.9	88.9	94.9	+
— subsidies for management training	60.3	53.2	66.0	66.7	70.5	63.2	o
— stimulation of environmentally favorable technology	43.1	44.5	50.0	58.5	67.4	81.2	+++
— subsidies on contract research	24.1	24.1	30.5	39.6	37.4	46.2	++
— TNO (National Labs for Applied Research)	75.9	78.6	92.9	91.1	93.7	94.9	o
— Inventors' Center at Rotterdam	22.4	24.7	24.0	26.3	24.7	41.0	o
— Industrial Guarantee Fund	36.2	33.4	39.3	47.0	52.1	57.3	+
— Universities' Transfer Points	46.6	45.5	55.0	64.8	68.9	77.8	++
— Rijksnijverheidsdienst	75.9	71.2	77.5	75.2	75.3	74.4	o
— Company for Industrial Projects (MIP)	41.4	52.5	62.1	68.5	83.7	83.8	+++
— Private Venture Company (PPM)	48.3	45.5	59.8	61.9	72.1	71.8	+
— Regional Development Companies (ROM)	61.1	64.9	74.9	80.0	88.4	89.7	o
— National Investment Bank	63.8	70.9	82.5	87.8	93.7	91.5	o

[a] According to the CHI^2 one-sample test (Siegel, 1956, 42—47), differences between size classes are:
o = insignificant,
+ = significant at 90% level,
++ = significant at 95% level,
+++ = significant at 99% level.

confronted with serious measurement problems. First, smaller firms responded somewhat less than larger firms. Secondly, and more importantly, there are indications that in small enterprises R&D work often is not sufficiently formalized such as to allow to give adequate answers to questions about R&D budgets. This might be a reason of why considerable amounts of small scale R&D are not captured in the official surveys. Using a radically simplified way of asking for R&D activities, we tried to take into account rather informal R&D efforts in SMEs. Numbers of SMEs having any R&D as well as man years of R&D found in our survey tremendously exceed comparable figures from the official surveys.

Nonetheless, according to our survey, a large percentage of SMEs (probably underestimated in Table II above) does not have any R&D, and the average R&D intensity of *all* SMEs turns out to be somewhat lower than the R&D intensity of larger firms. However, the R&D intensity of SMEs *which have some R&D* appears to be not less than that of large firms.

Among the barriers to innovation in SMEs, capital scarcity ranked the highest. Moreover, there are indications of a lack of management qualifications, of problems to find technical information and of a lack of adequately trained personnel. These findings suggest that policy instruments such as subsidies on R&D for SMEs (the Dutch INSTIR), technical development credits, subsidies for management training, government backing for increased manpower training, or the recent installation of innovation advice centers are appropriate. However, as compared with large enterprises, SMEs are generally less informed about the mere existence of such instruments. For SMEs, the "incubation" period for new government measures may be longer than for large firms. Hence the frequent changes of policy instruments in recent years may have worked to the disadvantage of SMEs.

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Notes

[1] The questionnaire was addressed to the top management of the firm. In the case of small firms (up to a hundred workers) the questionnaire was answered in most cases by the director or by the director's assistant or secretary. In the medium-sized and large firms, there was some more variation in the functions of respondents, covering as the most important categories R&D directors, marketing people, controllers and bookkeepers.

[2] While this definition excluded small, incremental improvement innovations, the notion of "new to the firm" implied that the innovation was already known in the branch of industry in the Netherlands. Hence from the national viewpoint, these are imitative innovations. Numbers of innovations characterized in another question as "new to the branch of industry in the Netherlands" were considerably lower.

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