Innovation, Formal vs. Informal R&D, and Firm Size: Some Evidence from Italian Manufacturing Firms*

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ABSTRACT. On the basis of data from two recent surveys on innovation diffusion in Italian manufacturing industry, this paper shows that informal R&D is an important part of the total R&D undertaken by small and medium sized firms. Nevertheless, when an output indicator such as the number and the nature of the innovations introduced by firms of different size is used, it emerges that small firms have introduced mainly incremental rather than major innovations. The paper therefore suggests that systematic R&D undertaken by large firms within structured laboratories is more effective (in terms of product innovations) than occasional R&D carried out by small firms.

I. Introduction

In spite of the overwhelming importance of large firms in innovation, it is widely acknowledged that traditional indicators of innovative activities (mainly R&D expenditures) fail to capture the innovative performance of small firms adequately.[1]

When small and medium size enterprises (henceforth SMEs) carry out their innovative activities they often do so without specific financial and managerial resources and, in particular, without formalised procedures. Thus SMEs tend to undertake a significant amount of innovative activities in their design, production and sales departments rather than in their R&D departments (which often do not exist at all).

The problem with the R&D figures provided by official surveys is that they do not include these *informal* R&D activities. Recently, in this *journal*, Alfred Kleinknecht (1989) has presented the results of a survey of 3,000 Dutch firms, and stressed the role of small firms in industrial R&D.[2] In his article, Kleinknecht shows that if informal R&D is taken into account the R&D commitment of SMEs (with less than 500 employees) is considerably higher than that reported by the official sources. The main difference between Kleinknecht's questionnaire and the official one is that the former includes a question on informal R&D (asking for man years of R&D instead of R&D expenditures) undertaken outside R&D laboratories.

In this paper we show that Kleinknecht's findings are quite consistent with those that have emerged from two very similar surveys carried out in Italy. In fact, informal R&D represents an important part of the total R&D carried out by Italian SMEs. However, if an output indicator such as the number and the nature of the innovations introduced by firms of different size is used, the Italian surveys show that small firms are able to develop incremental innovations rather than major innovations, whereas the most significant

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product innovations are more frequently achieved by large firms. This finding suggests that the systematic R&D activities carried out by large firms within structured laboratories are more effective than the occasional R&D activities undertaken by small firms.

II. Innovation and firm size

The first Italian survey on innovation diffusion (ISTAT-CNR, 1987) was conducted by interviewing 35,000 manufacturing firms with more than 20 employees: 24,104 firms returned the questionnaire. Table I shows that the share of those firms that introduced innovations during the period 1981–85 increased with firm size. However, this result cannot by itself lend support to the so-called Schumpeterian hypothesis since innovative activities did not increase faster than firm size. Moreover, as Acs and Audretsch (1988) have shown, a much more disaggregated analysis is needed for rigorous testing of the relationship between firm size and innovation. This is not possible with Italian data at this stage. Nevertheless, it should be stressed that according to the Italian survey the innovative capability of SMEs (with less than 500 employees) is not strikingly lower than that of firms having more than 500 employees.

TABLE I

Firm size (employees)	Firms responding to the questionnaire	Firms which have introduced innovations	
		Number	% of the class
20–49	14885	9419	63.3
50–99	4673	3490	74.7
100–199	2553	2090	81.9
200–499	1298	1084	83.5
500 and more	695	618	88.9
Total	24104	16701	69.3

Source of data: ISTAT-CNR (1987).

When the sources of innovations are considered, however, significant differences between SMEs and large firms emerge. In the first survey, innovating firms were asked to identify the sources of their innovations: in Table II these are divided between internal sources of innovation ("R&D," "Design and industrialization," and "Patents") and one of its major external sources ("Intermediate & capital goods"), which can be taken as a measure of embodied technical progress. As far as internal sources are concerned, SMEs appeared to be relatively more engaged in innovative activities carried out in the design and industrialization stages than within R&D departments; only large firms with more than 500 employees instead assigned a high priority to formal R&D activities. On the other hand, SMEs resorted to intermediate and capital goods more frequently than to internal sources.[3]

By applying the Z-test to the differences in means between SMEs and large firms we found that the significance level of such differences was 99% for all internal sources of innovation; by contrast, they were not significant for the major external source considered (i.e., "Intermediate & capital goods"). In conclusion, therefore, this first

TABLE II
Recourse to different sources of innovation*

Firm sizes (employees)	R&D		Design and industrialization		Patents		Intermediate & capital goods	
	Number	% of the class	Number	% of the class	Number	% of the class	Number	% of the class
20 to 49	1073	11.39	3354	35.61	1085	11.52	6519	69.21
50 to 99	564	16.16	1533	43.93	602	17.25	2402	68.82
100 to 199	449	21.48	1101	52.68	416	19.90	1444	69.09
200 to 499	358	33.03	622	57.38	248	22.88	770	71.03
500 and more	270	43.69	429	68.93	233	37.70	419	67.80

Source of data: ISTAT-CNR (1987).
* Percentages are calculated on the total of innovating firms. Firms could indicate more than one source of innovation.

survey of innovation diffusion showed a considerable degree of innovativeness among Italian SMEs: one higher, for instance, than that revealed by the official R&D figures (Archibugi, Cesaratto, and Sirilli, 1988; Santarelli and Sterlacchini, 1989).

Moreover, SMEs gave R&D activity relatively low priority as a source of innovation. In this regard, it should be pointed out that the question on R&D in the first survey was too generical, so that the above result can only serve as a rough approximation of the R&D effort made by Italian manufacturing firms. As we shall see in the next section, the different extent of R&D commitment between size classes emerges much more clearly when both *formal* and *informal* R&D activities are taken into account.

A second weakness of the first survey lay in its failure to provide any information concerning the number of innovations adopted by each firm. This obviously gave rise to an overestimation of the role of firms that had introduced only one or a few innovations during the relevant period.

III. R&D activities and types of innovation

The second survey was based on a more detailed questionnaire sent or administered by interview to the 16,701 manufacturing firms which, according to the first survey, had introduced innovations during the period 1981—1985: 8,220 firms returned the questionnaire. In particular, both R&D activities and the number and type of innovation were analyzed, with a variety of comprehensive information.

As far as R&D is concerned, Table III shows that the share of firms possessing an R&D department in 1985 was very low in the class with less than 50 employees (4.39%) and markedly higher for the class with more than 500 employees (56.75%). The figures change significantly if only the R&D performed in other departments is considered. Such *informal* R&D was performed in 1985 by 11.5% of firms with less than 50 employees and by 18.42% of those with more than 500 employees; the share of *informal* R&D was higher than that of *formal* R&D for the classes of firms with between 50 and 199 employees. When total (*formal* plus *informal*) R&D is considered, the share of firms undertaking R&D still increased with firm size, but the commitment of SMEs was higher than the figure obtained when only *formal* R&D was examined. The Z-test yields a 99% significance level for the differences in means between SMEs and large firms in the category "Firms having an R&D department" while such differences are not significant in the case of "Firms performing R&D in other departments only."

This finding is consistent with the results of Kleinknecht's study, since it shows that a significant number of small and medium sized firms are indeed active in R&D, even though, quite often, such innovative efforts are not captured by the official surveys. Cesaratto, Mangano, and Sirilli (1988) report that in the Italian case 1,100 firms

TABLE III
Formal and informal R&D by size of innovating firms (1985)

Firm sizes (employees)	Firms responding to the questionnaire	Firms performing R&D (total)		Firms having an R&D department[a]		Firms performing R&D in other departments only[b]	
		Number	% of the class	Number	% of the class	Number	% of the class
20 to 49	3939	626	15.89	173	4.39	453	11.50
50 to 99	1789	581	32.48	194	10.84	387	21.63
100 to 199	1210	503	41.57	207	17.11	296	24.46
200 to 499	815	477	58.53	261	32.02	216	26.50
500 and more	467	351	75.16	265	56.75	86	18.42

Source of data: ISTAT-CNR (1988).
[a] Which can carry out R&D even in other departments.
[b] Design, production, and other departments.

were included in the 1985 official R&D survey while, for the same year, the ISTAT-CNR survey revealed some 2,874 firms engaged in R&D activities (*formal* and *informal*).[4] Although it is not possible, at this stage, to make accurate comparisons in terms of R&D expenditures or equivalent man years, this survey shows that the official figures concerning Italian manufacturing firms are probably seriously underestimated.

Table IV gives two measures of total R&D intensity by size class: the first being the ratio of R&D man years (in 1985) to the number of employees in all firms, the second the same ratio to the number of employees of the firms performing some R&D. The first indicator increases with size class, thus confirming that the number of SMEs which perform no R&D at all is higher than that of large firms; by contrast, the second indicator decreases. As Kleinknecht (1989) points out, this latter measure probably overestimates the R&D activities of SMEs, since those which returned the questionnaire can be assumed to be the most innovative firms within the class.

This, however, is not the whole point. In fact, if within the firms with less than 50 employees the mean R&D intensity is 9.6%, this means that they have, on average, between 2 and 4 R&D employees. Analogously, the number of R&D personnel ranges between 3 and 6 units in firms with 50 to 99 employees, and between 4 and 9 units for the class with 100 to 199 employees.[5] This casts some doubt on whether firms with less than 200 employees can undertake R&D in a systematic way. Conversely, in firms with 200 to 499 employees, the number of R&D personnel fall between 8 and 20 units, while in the class with more than 500 employees there are, on average, at least 21 R&D employees per firm. Such numbers are large enough to indicate the presence of an R&D laboratory or, at any rate, the existence of structured R&D activities in firms with more than 200 employees.

In other words, the average number of R&D employees in small firms is very low when considered in absolute terms. This suggests that the R&D carried out by small firms is more often organized on an occasional, unstructured and less systematic basis than it is in medium and large firms. Accordingly, even if the ISTAT-CNR survey reveals that there is more R&D undertaken by small firms than that measured by the official R&D survey, it must be stressed that this R&D is less significant (in both a technological and an economic sense) than the R&D carried out by medium and large firms. In our view, it is the level of systematic R&D, both *formal* and *informal*, that constitutes the crucial indicator of innovative capability. In fact, systematic R&D enables major innovations to be introduced, and it is around these that incremental innovations are developed. These latter may also be implemented by firms which do not have structured R&D, but they often cannot occur without the former.[6]

Support for this assertion is provided when we examine the number and type of technological innovations introduced by Italian manufacturing firms during the period 1981—85. Table V shows the average number of product innovations per firm in each size class. Product innovations are divided into three groups on the basis of their

TABLE IV
R&D performance by size class (1985)

Firm sizes (employees)	Mean R&D intensity of all firms[a]	Mean R&D intensity of firms having R&D[b]
20 to 49	1.72	9.64
50 to 99	2.16	6.70
100 to 199	1.94	4.61
200 to 499	2.48	4.10
500 and more	3.87	4.30

Source of data: ISTAT-CNR (1988).
[a] Man years of R&D on the number of employees of all firms.
[b] Man years of R&D on the number of employees of firms having R&D.

TABLE V
Type of product innovations by size of innovating firms (average number per firm)

Firm size (employees)	Products new for the sector or for Italy	Products new for the firm	Improvements of existing products
20 to 49	1.24	3.02	2.74
50 to 99	1.75	3.68	2.92
100 to 199	2.40	3.53	3.32
200 to 499	2.53	3.52	4.82
500 and more	6.55	5.48	6.62

Source of data: ISTAT-CNR (1988).

technological and economic importance. The most significant innovations are identified as products that are new either for Italy or for the sector of activity of the firm. According to this indicator, the significance of innovations increases with firm size. In particular, whereas there are small differences between the size classes from 20 to 499 employees, firms with more than 500 employees introduced an average number of significant product innovations (6.55) which was far higher than the figure for SMEs (ranging between 1.24 and 2.53).[7]

SMEs instead perform comparatively better when products new for the firm and improvements of the existing products are considered.[8] When Table V is used as a matrix for the analysis of variance (Spiegel, 1975), the differences in the row means are not significant (according to the F test at 99% level) if only the last two columns are considered ("Products new for the firm" and "Improvements of existing products"), although they turn out to be significant when all the three columns are taken into account. This suggests that when the products new for the sector or for Italy are considered, the differences in innovativeness of Italian firms are significantly associated with firm size.

These findings are consistent with our above assumption concerning the non-systematic nature of R&D activities carried out by small firms. The innovations implemented by small firms are often of incremental type, and their introduction and development generally do not require any particular commitment to structured R&D.

However, this does not entitle us to conclude that there is a close cause-effect relationship between the "quality" of R&D activities and the "quality" of innovations. In effect, no direct comparison between innovations and R&D data is possible, because the former represent innovations introduced in the period 1981—1985 while the latter relate to 1985 only. Nevertheless, it is reasonable to assume that the total R&D commitment among firms of different sizes did not change during the relevant period.

IV. Conclusion

The paper has shown that the innovative capability of firms of different sizes does not necessarily increase faster than firm size. In particular, firms with less than 500 employees appear to be more innovative than is usually believed to be the case. This finding has emerged from the two ISTAT-CNR surveys on innovation diffusion in Italian manufacturing firms; surveys which give a more reassuring profile of the technological level of Italian industry than that provided by the official survey.

However, there is still a significant difference between Italian SMEs and large firms, since the former are likely to undertake R&D activities which are less systematic than those carried out by the latter. The corresponding innovations reflect a similar difference in terms of "quality" of R&D activities, and the contribution of large firms to the development of major innovations is more significant than that of SMEs.

In conclusion, whilst the commitment of Italian SMEs to *informal* R&D is evidence that they devote considerable effort to improving their internal levels of innovative activity, such firms do not seem to have engaged in a systematic research process. Conversely, large firms engage in institutionalized search for innovation which, in the Italian case, is associated with higher innovative performance.

Notes

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[1] See, among others, Freeman (1982) and Pavitt (1982).

[2] See also Kleinknecht (1987) for a short note on the same subject.

[3] This is not to say that small firms have a purely passive role in the process of technological change. Indeed the speed and the effectiveness of innovation diffusion is based upon a close interaction between producers and users of innovative intermediate and capital goods. Moreover, without further changes in the area of organizational procedures, for instance, it is difficult for small "supplier-dominated" firms (Pavitt, 1984) to make significant improvements in their products or processes simply by introducing new machinery.

[4] These figures also include firms belonging to the service sector. They therefore are higher than those reported in Table III, which refers only to manufacturing firms. As Cesaratto *et al.* (1988, p. 24) point out: "This large difference is mainly due to the different survey systems used: in the survey on R&D a complex questionnaire is used which requires a considerable amount of effort to fill in; although referring to

the same definitions as the previous ones, the innovation questionnnaire asked a few simple questions which can easily be answered by the firm's management. The respondent's task is thus much simplified."

[5] In the case of small firms it is likely that the actual average number of R&D employees (in terms of man years) is closer to the lower rather than to the upper value. Kleinknecht (1989) shows that in Dutch industry the average number of R&D employees is 1.5 for the firms with less than 50 employees and about 3 for the firms with 50 to 199 employees.

[6] This is not to imply that incremental innovations do not deserve an important (sometimes autonomous) role, both in the process of diffusion and in terms of feedbacks on the major innovations they originate from.

[7] Medium sized firms with 200 to 499 employees perform significantly better than small firms only in the case of incremental innovations.

[8] The average number of process innovations introduced by SMEs is even higher, but it must be noticed that this is the most frequent type of innovation introduced by firms in all the size classes. In effect, process innovations, on average, account for 38.9% of total innovations introduced by firms with less than 50 employees and, for instance, 34.3% of those introduced by firms with more than 500 employees.

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