ANALYSING LITERATURE-BASED INNOVATION OUTPUT INDICATORS: THE ITALIAN EXPERIENCE

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ANALYSING LITERATURE-BASED INNOVATION OUTPUT INDICATORS: THE ITALIAN EXPERIENCE*

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SUMMARY: This paper presents the results of a study on the product innovations introduced in the Italian market in 1989 and reported in a selected number of trade journals. The analysis of data collected by means of this literature-based counting procedure confirms that R&D oriented industries and large firms do not in Italy have a marked competitive advantage in innovation. The country appears to be instead characterized by a significant presence of consumer goods industries and small firms in innovation. Our data indicate a statistically significant association between trade competitiveness and strength in product innovation, and show the comparatively higher capacity for product innovation of some of the industries in which Italy achieves a positive performance in international trade. Moreover, the presence of spillovers at the regional level from both private and public R&D expenditures proves to be positively correlated with the development of product innovations. Finally, small firms with fewer than 50 employees appear to be more innovative than is usually believed to be the case.

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1. Introduction

The nature of the data available for analysis affects understanding of the technological structure and innovative capability of a country. For example, the input (R&D expenditures) and output (number of patents) indicators which, since the late 1950s and the early 1960s, have been conventionally employed in studies of the economic role of technological change do not provide a satisfactory account of this process. R&D expenditures are a proxy measure for the resources devoted to obtaining innovations, but they do not reflect the actual amount of innovative activity undertaken by firms and industries, since this also includes informal and occasional R&D not reported in official data (Santarelli - Sterlacchini, 1990). Patents, for their part, are a purely technological measure of new knowledge, but they do not explain the economic value of this knowledge (Acs - Audretsch, 1993).

In the light of these shortcomings of traditional indicators, the actual economic significance of new technology can be better understood by means of a direct measure of innovative output. Accordingly, this paper presents the results of an attempt to develop a measure of innovative output based on the new industrial products which were introduced in the Italian market in 1989 and reported in a selected number of trade journals spanning every industry in manufacturing. The paper is organized as follows.

Section 2 reviews innovation output indicators and discusses their points of strength and weakness. Section 3 outlines the procedure used to count and to distinguish, according to their degree of complexity and type of novelty, the new products placed on the Italian market by both national and foreign firms during 1989. Section 4 analyses the sectoral distribution of the innovations identified by this method and compares among the innovative outputs of industries with different commitments to R&D activities in terms of degree of complexity and type of novelty. Section 5.1 examines the distribution of foreign innovations by country of origin, in order to verify its consistency with the hypotheses of technology gap theory concerning the relation between technological strength and trade performance of countries in certain industries. In section 5.2 the new products introduced by Italian firms are divided according to region of origin. It thus becomes possible to compare the regional distribution of innovative output with that of R&D expenditures and patents. Section 6 takes account of the size distribution of the Italian firms included in the data base, in order to shed light on the relationship between market structure and innovative output in manufacturing. Finally, section 7 sets out some concluding remarks.

2. The measurement of innovative output

A direct measure of innovative output is the most reliable means to capture the economic significance of the innovation process. In effect, it indicates whether an idea for a new or improved product - represented, for example, by a patented invention - has a positive economic value. While a patent accounts for an invention exploiting a certain set of knowledge, the output from the overall innovation process acquires economic importance only if and when it results in the placement of a new product on the market. This product constitutes an innovation in the economic sense, i.e. what Freeman (1982, p. 7) has termed "the first commercial transaction involving the new product, process, system or device".

Their limited heuristic value notwithstanding, patents are widely employed in studies dealing with the output side of the innovation process. In addition to inter- and intra-industry studies of technology and productivity growth (for a survey, cf. Griliches, 1990), patent statistics have also been employed in international comparisons of technological capability (cf. Archibugi - Pianta, 1992a and 1992b) and in analyses of sectoral specialization in both international trade and technology by countries which display a marked preference for extending their patents abroad (Hughes, 1986; for the Italian case, cf. Archibugi - Santarelli, 1989). Nonetheless, concern is expressed in the innovation literature about the use of patents as reliable indicators of the output from innovative activities (for critical surveys, cf. Cohen - Levin, 1989; Archibugi, 1992). This concern stems from at least five considerations:

a) the technological level and the economic value of patents are highly heterogeneous;

b) the tendency to bundle claims together in one or more patents varies widely among countries;

c) not all innovations are patented;

d) not all patents become innovations (Griliches, 1990; Kleinknecht - Reijnen - Smits, 1993);

e) the propensity to patent varies greatly across firms belonging to different size classes.

The main implications of point a) are that the actual economic value of a patent is difficult to assess, and that cross-industry comparisons carried out with this indicator rely upon unrealistic assumptions concerning the homogeneous technological content and economic significance of patents in different industries.

As regards point b), a patent may plausibly consist of several related claims, each of which may be filed as a separate patent. It is therefore likely that in countries where inventors prefer to bundle a series of related claims together in one patent (e.g. the US) this indicator leads to underestimation of the output from innovative activity with respect to countries which typically file separate patents for each claim (e.g. Japan). A possible solution is the use of data bases comprising "high quality" patents, such as those of the European Patent Office (EPO) and the Office of Technology Assessment and Forecasts (OTAF) of the US Patent Office. Both of these sources represent a viable alternative to the data collected through the various national patent systems, especially because EPO and the US Patent Office offer better guarantees of protection and are highly selective in granting patents. Moreover, it is likely that innovations identified from these sources are more homogeneous in their economic value than those registered in the national patent systems, and this represents a partial solution to the problems identified in point a) above.

With respect to point c), it should be borne in mind that, when applying for patent, a patentee discloses the technical features of his/her invention to potential competitors and imitators. Thus in many cases patents are an inefficient means to protect the private returns from invention, and in certain industries (in particular micro-electronics and other high-tech industries) secrecy is favored.

Point d) highlights the importance of pre-emptive patents. These are used by incumbent monopolists or oligopolists in some industries to prevent competition by potential entrants when other non-technology-related barriers to entry are absent (cf. Gilbert - Newbery, 1982; Vickers, 1985). Thus patent holders sometimes do not follow a market-oriented behavior, and the invention is never commercialized[1] .

In the case of point e), it should be noted that firms of different size - although belonging to the same industry - have a different propensity to apply for either national or foreign patents. In particular, small firms usually present a larger number of applications for national patents.

Since the early 1980s at least five indicators alternative to patent data have been developed and used in empirical analyses (for a review, cf. Santarelli, 1993). These are:

1) the patent-based counting of innovations;

2) citation counts of patents;

3) the collection of innovation cases by means of interviews with experts and firm insiders;

4) self-assessment by managers of the number of innovations introduced by their firm;

5) the counting of innovations reported in trade journals.

The aim of the first two methods is to enrich the information gathered from patent data. In particular, the patent-based counting of innovations collects additional information on each patent by asking patent holders if their invention has led to commercialized innovations. The citation count of patents is also a method for the ex post evaluation of the economic value of a patent (cf., among

[1] In Italy, for example, only 50 per cent of national patents are actually utilized (cf. Napolitano - Sirilli, 1990).

others, Albert et al., 1991). In this case the indicator is constructed by counting the citations obtained by the relevant patent in subsequent patents. Nonetheless, irrespective of their endeavour to improve the validity and significance of patent data, these methods share a serious limitation with that source: they do not provide any information about those innovations which, although placed on the market, are not patented.

The third method consists in asking experts and firm insiders in each industry to describe innovations (either patented or not) of significant economic value introduced in their industries over a given period. This method was used at the Science Policy Research Unit (SPRU) in Sussex University to collect information on more than 4,000 innovations commercialized in the UK from 1945 to 1983 (cf. Pavitt - Robson - Townsend, 1987). The main criticism of this alternative concerns the heterogeneous economic value of the innovations thus identified, since the assembling of the data entails various unexamined biases (Cohen - Levin, 1989).

The fourth alternative has been widely employed in recent years and is based on the assessments of firm insiders with respect to the innovations developed by their company (cf. OECD, 1990; Smith, 1992). In this case, unless precise questions are asked which give unambiguous specification of the objective characteristics of new products[2], it may happen that firm insiders, in particular marketing personnel, define as "new" and technologically advanced almost everything they sell. As a consequence, this method is in most cases associated with over-estimation of the output of innovative activity.

The "counting of innovations" method employed in the present paper is based on the selection of innovations introduced during a given year and reported in the "product news" columns of trade journals. This procedure was used for the first time by The Futures Group (1984) - under contract by the US Small Business Administration - which examined more than one hundred technical and trade journals to develop a data base consisting of 8,074 innovations introduced in the United States in 1982. The same method was adopted by Kleinknecht - Reijnen - Smits (1993) who, by inspecting 35 trade journals, identified 6,325 innovations introduced in The Netherlands in 1989. A similar procedure was also used by Fleissner - Hofkircher - Pohl (1993), who counted 1,355 innovations presented in 400 Austrian periodicals during the same year. In this case, however, almost all Austrian periodicals containing technical information on the relevant branches were considered - included those which report such information only irregularly - and thus the counting procedure did not in all cases rely upon preliminary screening and selection of new products by specialized technical journals for all the innovations.

The assumption behind the use of this literature-based counting of innovations is that firms prefer to disclose their products to the public - because, for instance, innovations signal technological competence to potential customers or even to suppliers of capital - and that journal editors make a thorough selection of products which are really new for the industry or at least the country.

This indicator has at least four merits: first, it provides information about commercially introduced innovations, and thus avoids the problems which typically arise with patent data; second, data collection can be carried out without any direct contact with the innovating firms, and this reduces the amount of unexamined biases in the data base; third, the whole procedure is relatively cheap compared with the others; fourth, the collection and use of data at the firm level is not hampered by secrecy problems.

The main shortcoming of the literature-based counting of innovations lies in the selection of the relevant journals and in the features of the new products section in each of them. It is probable that the number of innovations identified will be positively correlated with the number of journals selected or, in any case, with the total number of journals reporting this kind of information and the

[2] In this respect, the survey recently carried out by the National Statistical Office of Italy (ISTAT, 1993) represents an important progress.

length of the new product section in each of them. As regards the first point, one may contend that the adoption of a standardized procedure (like the one proposed in section 3 of the present paper) in the selection process should in any case reduce the effects of unavoidable sampling errors. The second point has implications for cross-country comparisons: in effect, the number and the characteristics of technical and trade journals vary greatly from one country to another, without displaying any precise pattern. Moreover, the usefulness of such publications is unevenly perceived by firms of different countries: for example, Italian firms apparently consider technical and trade journals to be less important than their counterparts in the US and The Netherlands normally do[3]. This implies that Italian firms have a lower propensity to submit their innovations for inclusion in the new product sections of national technical journals, whereas it is plausible that US, Dutch, and other foreign firms consider the inclusion of their new products in Italian trade journal as a way to boost their sales in Italy.

According to the above considerations, the number of domestic innovations that one would expect to identify by applying this counting method to Italy is smaller than in the case of US and The Netherlands[4], whereas that of foreign innovations placed on the Italian market would be even higher than expected.

Another weakness in the literature-based counting of innovations procedure relates to the distinction between product and process innovations. In effect, the choice of the classification procedure affects significantly the distinction between these two categories of innovation. For example, consistently with the "firm level approach" (cf. Archibugi - Evangelista - Simonetti, 1992), innovations may be classified from the perspective of the innovating firm. Thus each firm considers its new or improved products which can be sold on the market as product innovations, while changes in its production techniques are process innovations. At a sectoral level this approach identifies process innovations only when the sector of production coincides with the sector of use of the new product (cf. De Bresson - Townsend, 1978; Pavitt, 1984). Of course, the choice of this approach leads to identification of a small number of process innovations. Alternatively, one might use the "final demand approach" (cf. Archibugi - Evangelista - Simonetti, 1992). In this case, innovations which are directly beneficial to consumers are classified as product innovations, whereas those which are used as either capital or intermediate goods by other firms are classified as process innovations. At a sectoral level this approach always identifies process innovations when the sector of production is specialized in goods which are directed towards other firms. As a conseguence, this approach results in the definition as process innovations of a very large portion of those reported in trade journals.

A final drawback to this procedure is shared with the patent indicator and relates to the great variability of the propensity to submit innovations for inclusion in trade journals across industries and across size classes. It is possible that small firms - which have higher expectations of exploiting their innovations commercially in the domestic market - are more eager to have their novelties included in trade journals than large firms which are more integrated in international trade.

3. Methodology and classification scheme

The above shortcomings and problems notwithstanding, we experimented with the literature-based counting of innovations to create a data base on product innovations introduced in Italian industry in 1989. Whereas the aim of the experiment was mainly to test the consistency of the information thus obtained with that provided by official sources, 1989 was chosen because similar

[3] Furthermore, it is evident from the analysis of Fleissner - Hofkircher - Pohl (1993) that in Austria many journals offer technical information, but only a few (if any) of them contain a structured new products section.

[4] Serious doubts should instead be cast on the suitability of the whole procedure in cases like the Austrian one.

studies concerning other European countries have been carried out for this same year (cf. Kleinknecht - Bain, 1993). Accordingly, our data could be used for international comparisons.

The data base (called PRODIN89) comprises all innovations reported in the complete 1989 volume of 25 Italian technical and trade journals[5]. Product and process innovations have been distinguished on the basis of the "firm level approach" described in section 2. The journals considered contain technical information on 15 industrial sectors and were selected from a much larger number of similar Italian publications (most of which are listed in the Guida Monaci, a catalogue which enumerates Italian periodicals as well as providing a variety of business information) according to the following criteria:

i) the presence of a distinct "new products" column or section;

ii) the provision of detailed technical information about each innovation presented;

iii) the specification of the name and address of the innovating firm;

iv) continuity of publication and the ready availability of the journal throughout the country upon payment of a subscription[6].

In order to detect differences in the innovativeness of various industries, between small and large firms, and among geographical units, a classification scheme was adopted analogous to that introduced by Kleinknecht - Reijnen - Smits (1993). This scheme is useful for distinguishing innovations according to their degree of complexity and type of novelty.

'Degree of complexity' is a dimension of the knowledge base upon which the innovation relies. In effect, producing an innovation may involve the integration of different scientific disciplines and technologies, and it may require various skills, either internal or external to the innovating firm (cf. Malerba - Orsenigo, 1993). Accordingly, the idea of complexity referred to here does not entail any estimate of the difficulties connected to the innovation process.

'Type of novelty' is a measure, within a given technological regime, of the complementarities between a new innovation and the product that it is to replace (cf. Santarelli, 1994).

The degree of complexity of each innovation can be classified into three levels:

1) high complexity: this denotes a new system, i.e. an innovation consisting of several parts or components each of which relies upon a knowledge base deriving from a different discipline (e.g. a flexible manufacturing system, a new automobile, etc.);

2) medium complexity: in this case the innovation is a unit, although it consists of more than one part or component, and its development requires the integration of different disciplines (e.g. a new textile machine whose relevant knowledge base results from the integration of mechanical engineering and electronics);

3) low complexity: the innovation is a unit consisting of only one part and requiring a knowledge base which results from a single discipline (e.g. a new woollen fabric).

Five classes of type of novelty were identified:

I) a product which is totally new for the industry and which may involve a paradigmatic shift from a technological regime to a subsequent one (e.g. a hydraulic device which replaces the pneumatic hammer);

II) a modestly or slightly improved product (e.g. an energy saving production machine);

[5] The journals selected are the following: *Largo Consumo, Il Pesce, Industrie Alimentari, La Nuova Selezione Tessile, L'Informobili, LM - L'industria del Legno e del Mobile, L'Italia Grafica, Il Poligrafico Italiano, Annunciatore Poligrafico, Rassegna Grafica, Cellulosa e Carta, Rassegna Chimica, Il Farmacista Moderno, Il Giornale del Farmacista, Industria della Gomma, Il Mondo della Calzatura, L'Industria Meccanica, Management e Informatica, Bit, Rivista di Informatica, Tecniche dell'Automazione e Robotica, Automazione Oggi, Elettronica e Telecomunicazioni, L'Automobile*.

[6] This criterion determined the rejection of most journals which were not easily accessible, circulated only at a local level, or issued at irregular intervals.

III) a new or improved accessory for an existing product of medium or high complexity (e.g. a more reliable controlling device for a production machine);

IV) a product differentiation (this category comprises pseudo-innovations, i.e. incremental innovations such as a soap with a new perfume);

V) a process innovation identified from the prospective of the innovating firm (e.g. a new knitting machine developed by a firm belonging to the clothing industry).

This classification scheme - although not completely free from potential sampling errors - measures the economic value of innovations and, as such, is no less rigorous than the procedures used for the valuation of patents and innovative output in general surveyed in the previous section.

4. The sectoral distribution of innovations in Italian industry

The procedure described above was used to identify 1,602 innovations; and a data base consisting of innovations by two-digit standard industrial classification (SIC) industries was created (table 1). For the machinery and the office & professional equipment industries, which account for the highest number of innovations, table 1 presents more disaggregated data at the four-digit level, whereas for the chemical industry the disaggregation is at the three-digit level.

TABLE 1 - *Total innovations by Standard Industrial Classification code*

SIC CODE	INDUSTRIES	TOTAL INNOVATIONS absolute value	%
20 - 21	Food & beverages	38	2.37
22 - 23	Clothing & textiles	40	2.50
24 - 25	Wood & furniture	17	1.06
26 - 27	Paper, printing & publishing	43	2.68
28 - 29	Chemicals	146	9.11
	a) primary chemical products	*68*	*4.24*
283	*b) pharmaceutical products*	*37*	*2.31*
284	*c) soap, polishes & sanitation goods*	*41*	*2.56*
30	Rubber & plastics	41	2.56
31	Leather & footwear	9	0.56
33	Extractive	3	0.19
34	Metal products	38	2.37
35	Machinery	439	27.40
3551	*a) food & beverages mach.*	*93*	*5.81*
3552	*b) clothing & textiles mach.*	*82*	*5.12*
3553	*c) woodworking mach.*	*28*	*1.75*
3554 - 3555	*d) printing mach.*	*68*	*4.24*
	e) leatherworking mach.	*11*	*0.69*
	f) footwear mach.	*36*	*2.25*
	g) rubber & plastics mach.	*31*	*1.94*
	h) other mach.	*90*	*5.62*
357	Office & professional equipment	350	21.85
3572-3-4-9	*a) electronic-computing, etc.*	*214*	*13.36*
7372	*b) computer programm. & software ind.*	*136*	*8.49*
36	Electrotechnical & electronics industry	201	12.55
37	Motor vehicles, parts & accessories	67	4.18
38	Instruments	155	9.68
	Other manufacturing	15	0.94
	Total	1602	100.00

As regards machinery, the four-digit level of disaggregation allows identification of the main sector of use of each new machine. The reason for this disaggregation is straightforward: for many sectors, technology derives in a significant measure from R&D activities embodied in new machinery and capital equipment. Thus, with our data disaggregated at the four-digit level, it becomes possible to provide a rough measure of the links between *industry of origin* (i.e. the various branches of the machinery industry) and *industry of use* of the new capital goods identified (cf. Scherer, 1984).

In the case of chemicals, the three-digit level of disaggregation permits instead the distinction between primary chemical products and pharmaceuticals on the one hand, and soap, polishes & sanitation goods on the other. In this case the reason for dividing the overall two-digit industry into three branches is that, whereas a wide and heterogeneous range of active principles is employed in primary chemical products, pharmaceuticals and soap, polishes & sanitation goods employ two relatively smaller families of active principles: hence it follows that in each of these three branches the innovation process relies upon a different set of knowledge, and they can therefore be examined separately.

Immediately evident is the overwhelming importance of the machinery and the office & professional equipment industries, which account for 27.40 per cent and 21.85 per cent of total innovations respectively. Ranking third is the electrotechnical & electronics industry (12.55%), fourth the instruments industry (9.68%) and fifth the chemical industry (9.11%).

The result for the machinery industry is consistent with previous research (Scherer, 1982; Robson - Townsend - Pavitt, 1988; Santarelli - Sterlacchini, 1990, 1994b), and it demonstrates the importance of the capital goods industry in general (i.e. machinery and capital equipment) as the main source of innovations for the entire production system and, in particular, for supplier dominated firms (as defined by Pavitt, 1984) belonging to traditional consumer goods industries (clothing & textiles, wood & furniture, leather & footwear), which usually account for a significant share of total industrial employment and value added. These firms are relatively weak in terms of autonomous innovative capability and derive most of their innovations from suppliers of equipment and intermediate inputs, whereas in-house R&D is almost irrelevant (cf. Santarelli - Sterlacchini, 1990; Kleinknecht - Poot - Reijnen, 1991). In this respect, of great significance are the branches specialized in the production of machinery for the food & beverages and the clothing & textiles industries, which account for 5.81 per cent and 5.12 per cent of total innovations respectively. Inserted in a hypothetical input-output matrix of invention flows analogous to the one first proposed by Schmookler (1966), this finding confirms that the total amount of technology *used* by the consumer goods industries mentioned above is probably much higher than one would expect on the basis of their autonomous innovative capability alone. Accordingly, the new products introduced by firms belonging to these industries embody an amount of R&D which is much higher than that resulting from their autonomous innovative activity.

The figures for the office & professional equipment, electrotechnical & electronics, and instruments industries show that these microelectronics-based productions underwent major innovations during the year in question, punctuated by a significant flow of new products (cf. Antonelli, 1988). For analytical convenience, the office & professional equipment group of products includes the software industry, which by the second half of the 1980s had overtaken hardware in terms of total sales within the overall data processing industry (cf. Datamation, various years). In our data base, in fact, software accounts for almost 39 per cent of the new products identified in the office & professional equipment industry, thereby confirming the strategic function of the suppliers of standard and customized software packages in the development of that industry. In the case of the office & professional equipment, electrotechnical & electronics, and instruments industries the high number of innovations reflects the propensity of firms belonging to these industries to invest heavily in R&D, and to rely upon autonomous innovative capability as their main source of technological knowledge. In fact, within these high-tech industries, an important function is played by *science* *based* firms in Pavitt's sense, which produce internally most of the technology they use.

As regards chemicals, in Italy during the relevant year the demand for primary chemical products and for soap & polishes grew significantly with respect to the previous year[7], whereas that for pharmaceuticals remained substantially unchanged. These differences in the dynamics of internal demand are presumably responsible for the relatively low share (25.33%) of new pharmaceuticals in all new chemicals placed on the Italian market in 1989.

Between-industry comparisons of the distribution of innovations by degree of complexity support the findings of studies on the features of innovative activities by firms belonging to the traditional consumer goods industries[8]. As shown in table 2, innovations which denote a low degree of complexity - representing in most cases the result of innovative activities undertaken outside a formal R&D department - account for 97.50 per cent of total innovations commercialized in the clothing &textiles industry, 88.24 per cent of those counted for the wood & furniture industry, 77.78 per cent of those identified for the leather & footwear industry[9].

TABLE 2 - *Distribution of innovations by degree of complexity and industry*

INDUSTRIES	HIGH		MEDIUM		LOW		TOTAL
	abs.v.	%	abs.v.	%	abs.v.	%	abs.v.
Food & beverages			1	2.63	37	97.37	38
Clothing & textiles			1	2.50	39	97.50	40
Wood & furniture			2	11.76	15	88.24	17
Paper, printing & publishing			9	20.93	34	79.07	43
Chemicals	1	0.68	17	11.64	128	87.67	146
a) primary chemical products			*15*	*22.06*	*53*	*77.94*	*68*
b) pharmaceutical products	*1*	*2.70*	*2*	*5.41*	*34*	*91.89*	*37*
c) soap, polishes & sanitation goods					*41*	*100.0*	*41*
Rubber & plastics			3	7.32	38	92.68	41
Leather & footwear			2	22.22	7	77.78	9
Extractive			2	66.67	1	33.33	3
Metal products			1	2.63	37	97.37	38
Machinery	2	0.46	336	76.54	101	23.01	439
a) food & beverages mach.			*81*	*87.10*	*12*	*12.90*	*93*
b) clothing & textiles mach.			*69*	*84.15*	*13*	*15.85*	*82*
c) woodworking mach.			*19*	*67.86*	*9*	*32.14*	*28*
d) printing mach.			*55*	*80.88*	*13*	*19.12*	*68*
e) leatherworking mach.			*9*	*81.82*	*2*	*18.18*	*11*
f) footwear mach.	*1*	*2.78*	*29*	*80.56*	*6*	*16.67*	*36*
g) rubber & plastics mach.			*23*	*74.19*	*8*	*25.81*	*31*
h) other mach.	*1*	*1.11*	*51*	*56.67*	*38*	*42.22*	*90*
Office & professional equipment	2	0.57	172	49.14	176	50.29	350
a) electronic-computing, etc.	*1*	*0.47*	*159*	*74.30*	*54*	*25.23*	*214*
b) computer programm. & software ind.	*1*	*0.74*	*13*	*9.56*	*122*	*89.71*	*136*
Electrotechnical & electronics industry	3	1.49	62	30.85	136	67.66	201
Motor vehicles, parts & accessories	64	95.52			3	4.48	67
Instruments			76	49.03	79	50.97	155
Other manufacturing					15	100.0	15
Total	72	4.49	684	42.70	846	52.81	1602

[7] Conversely, in 1989 the market performance of sanitation goods was not particularly positive.

[8] Cf. among others, Acs - Audretsch (1993), Kleinknecht - Poot - Reijnen (1991), Pratten (1991), and, for Italy, Santarelli - Sterlacchini (1990).

[9] In the food & beverages industry, which also is characterised by a low commitment to R&D activities, innovations with a low level of complexity represent 97.37% of the total.

Conversely, the share of these simple innovations is significantly lower in industries characterized by a higher commitment to formal R&D, such as machinery (23.01%), electronic-computing (25.23%), and, in particular, motor vehicles, parts & accessories (4.48%).

Different considerations apply to chemicals. In this case - irrespective of the branch considered - the innovation is usually a unit consisting of only one part and relying upon a very specific and mono-disciplinary (in the broad sense) knowledge base. As a consequence, it is not surprising that new products with a low degree of complexity represent 77.94 per cent of the total in primary chemical products, 91.89 per cent in pharmaceuticals, and 100 per cent in soap, polishes & sanitation goods.

Further support for the above findings is provided by analysis of the distribution of innovations according to their type of novelty (table 3).

TABLE 3 - *Distribution of innovations by type of novelty and industry*

INDUSTRIES	(1) %	(2) %	(3) %	(4) %	(5) %	TOTAL abs.val.
Food & beverages	5.26	7.89	13.16	65.79	7.89	38
Clothing & textiles	17.50	22.50	5.00	52.50	2.50	40
Wood & furniture	5.88		29.41	58.82	5.88	17
Paper, printing & publishing	25.58	4.65	20.93	44.19	4.65	43
Chemicals	7.53	8.22	17.81	61.64	4.79	146
a) primary chemical products	*11.76*	*16.18*	*35.29*	*26.47*	*10.29*	*68*
b) pharmaceutical products	*10.81*	*2.70*	*5.41*	*81.08*		*37*
c) soap, polishes & sanitation goods				*100.00*		*41*
Rubber & plastics	19.51	39.02	9.76	31.71		41
Leather & footwear	22.22	11.11		55.56	11.11	9
Extractive	33.33	33.33			33.33	3
Metal products	13.16	15.79	18.42	52.63		38
Machinery	12.30	34.62	17.77	34.85	0.46	439
a) food & beverages mach.	*16.13*	*26.88*	*6.45*	*50.54*		*93*
b) clothing & textiles mach.	*9.76*	*34.15*	*19.51*	*36.59*		*82*
c) woodworking mach.	*10.71*	*28.57*	*46.43*	*14.29*		*28*
d) printing mach.	*10.29*	*20.59*	*23.53*	*45.59*		*68*
e) leatherworking mach.	*18.18*	*72.73*	*9.09*			*11*
f) footwear mach.	*11.11*	*50.00*	*13.89*	*19.44*	*5.56*	*36*
g) rubber & plastics mach.	*19.35*	*38.71*	*22.58*	*19.35*		*31*
h) other mach.	*10.00*	*43.33*	*15.56*	*31.11*		*90*
Office & professional equipment	11.14	21.43	20.00	47.43		350
a) electronic-computing, etc.	*11.68*	*25.23*	*17.29*	*45.79*		*214*
b) computer programm. & software ind.	*10.29*	*15.44*	*24.26*	*50.00*		*136*
Electrotechnical & electronics industry	9.95	24.38	34.33	30.85	0.50	201
Motor vehicles, parts & accessories	28.36	29.85	1.49	38.81	1.49	67
Instruments	10.97	22.58	27.10	39.35		155
Other manufacturing	6.67	13.33	33.33	46.67		15
Total	198	383	323	678	20	1602
%	12.36	23.91	20.16	42.32	1.25	100.00

Notes: (1) product totally new for the industry; (2) modestly improved product; (3) new or improved accessory product; (4) product differentiation; (5) process innovation.

"Product differentiations" account for 52.50 per cent of total innovations introduced in clothing & textiles, 58.82 per cent of those identified in wood & furniture, and 55.56 per cent of those singled out in leather & footwear[10]. These pseudo-innovations, however, represent only 38.81 per cent of the total in motor vehicles, parts & accessories, 34.85 per cent in machinery, 45.79 per cent in electronic-computing, and 26.47 per cent in primary chemical products. Once again, consumer goods industries appear to have undergone an innovation process which is more incremental in nature than that in knowledge-intensive industries.

These results become even more significant if one restricts the focus to the 536 innovations developed and marketed by Italian firms, which represent 33.46 per cent of the total. In this case (table 4) all the innovations introduced in the clothing & textiles industry have a low degree of complexity, whereas this share drops to 91.67 per cent in the case of wood & furniture and 75 per cent in that of leather & footwear.

TABLE 4 - *Distribution of Italian innovations by degree of complexity and industry*

INDUSTRIES	HIGH		MEDIUM		LOW		TOTAL
	abs.v.	%	abs.v.	%	abs.v.	%	abs.v.
Food & beverages			1	5.26	18	94.74	19
Clothing & textiles					18	100.0	18
Wood & furniture			1	8.33	11	91.67	12
Paper, printing & publishing					8	100.0	8
Chemicals	1	2.86			34	97.14	35
a) primary chemical products					*11*	*100.0*	*11*
b) pharmaceutical products	*1*	*7.14*			*13*	*92.86*	*14*
c) soap, polishes & sanitation goods					*10*	*100.0*	*10*
Rubber & plastics			2	11.11	16	88.89	18
Leather & footwear			2	25.00	6	75.00	8
Extractive			1	100.0			1
Metal products					20	100.0	20
Machinery	2	0.83	189	78.42	50	20.75	241
a) food & beverages mach.			*50*	*92.59*	*4*	*7.41*	*54*
b) clothing & textiles mach.			*37*	*78.72*	*10*	*21.28*	*47*
c) wood workingmach.			*8*	*66.67*	*4*	*33.33*	*12*
d) printing mach.			*13*	*92.86*	*1*	*7.14*	*14*
e) leatherworking mach.			*9*	*81.82*	*2*	*18.18*	*11*
f) footwear mach.	*1*	*3.03*	*26*	*78.79*	*6*	*18.18*	*33*
g) rubber & plastics mach.			*16*	*80.00*	*4*	*20.00*	*20*
h) other mach.	*1*	*2.00*	*30*	*60.00*	*19*	*38.00*	*50*
Office & professional equipment			23	42.59	31	57.41	54
a) electronic-computing, etc.			*19*	*79.17*	*5*	*20.83*	*24*
b) computer programm. & software ind.			*4*	*13.33*	*26*	*86.67*	*30*
Electrotechnical & electronics industry	1	2.04	15	30.61	33	67.35	49
Motor vehicles, parts & accessories	19	95.0			1	5.00	20
Instruments			18	64.29	10	35.71	28
Other manufacturing					5	100.0	5
Total	23	4.29	252	47.01	261	48.69	536

Conversely, the technological strength of the Italian suppliers of specialized machinery - as evidenced by several studies (cf., for example, Cainarca - Colombo - Mariotti, 1989) - is confirmed by the fact that only 20.75 per cent of the new products identified for this industry display a low degree of complexity, with the category "medium degree of complexity" representing 78.42 per cent of the total.

[10] In the case of this attribute too, the food & beverages industry presents a very high frequency (65.79%).

More controversial is the case of electronic-computing: Italian producers (in particular Olivetti) are more specialized in the production of complex, although not necessarily advanced from a technological viewpoint, equipment (with the exception of photocopy machines) than they are in simple parts, accessories, and peripherals. This peculiarity provides a plausible explanation for the small (20.83%) share of domestic innovations with a low degree of complexity identified for this industry, which apparently contrasts with its relatively low R&D intensity in Italy.

Inspection of the type of novelty reveals that the attribute "product differentiation" applies to 61.11 per cent of total Italian innovations in clothing & textiles, 75 per cent of those introduced in wood & furniture, and 62.50 per cent of those identified for leather & footwear (table 5).

TABLE 5 - *Distribution of Italian innovations by type of novelty and industry*

INDUSTRIES	(1) %	(2) %	(3) %	(4) %	(5) %	TOTAL abs.val.
Food & beverages		5.26		78.95	15.79	19
Clothing & textiles	16.67	16.67	5.56	61.11		18
Wood & furniture			16.67	75.00	8.33	12
Paper, printing & publishing	25.00	12.50	25.00	37.50		8
Chemicals	2.86	2.86	11.43	82.86		35
a) primarychemical products		*9.09*	*36.36*	*54.55*		*11*
b) pharmaceutical products	*14.29*			*85.71*		*14*
c) soap, polishes & sanitation goods				*100.00*		*10*
Rubber & plastics	11.11	50.00		38.89		18
Leather & footwear	25.00			62.50	12.50	8
Extractive	100.0					1
Metal products	15.00	10.00	20.00	55.00		20
Machinery	10.37	40.66	14.11	34.02	0.83	241
a) food & beverages mach.	*12.96*	*27.78*	*5.56*	*53.70*		*54*
b) clothing & textiles mach.	*10.64*	*31.91*	*23.40*	*34.04*		*47*
c) woodworking mach.	*8.33*	*50.00*	*25.00*	*16.67*		*12*
d) printing mach.	*7.14*	*14.29*	*14.29*	*64.29*		*14*
e) leatherworking mach.	*18.18*	*72.73*	*9.09*			*11*
f) footwear mach.	*6.06*	*54.55*	*12.12*	*21.21*	*6.06*	*33*
g) rubber & plastics mach.	*15.00*	*50.00*	*15.00*	*20.00*		*20*
h) other mach.	*8.00*	*48.00*	*14.00*	*30.00*		*50*
Office & professional equipment	5.56	27.78	22.22	44.44		54
a) electronic-computing, etc.	*4.17*	*45.83*	*16.67*	*33.33*		*24*
b) computer programm. & software ind.	*6.67*	*13.33*	*26.67*	*53.33*		*30*
Electrotechnical & electronics industry	4.08	24.49	40.82	30.61		49
Motor vehicles, parts & accessories	30.00	30.00		35.00	5.00	20
Instruments	3.57	25.00	25.00	46.43		28
Other manufacturing		20.00	20.00	60.00		5
Total	51	156	87	234	8	536
%	9.51	29.10	16.23	43.66	1.49	100.00

Notes: (1) product totally new for the industry; (2) modestly improved product; (3) new or improved accessory product; (4) product differentiation; (5) process innovation.

The incremental nature of innovations developed by Italian firms belonging to traditional consumer goods industries is therefore confirmed.However, table 6 also shows that these industries introduced 7.69 per cent of Italian innovations identified for the relevant year, although in 1989 they were responsible for only 0.33 per cent of total R&D expenditures in Italian manufacturing. This finding yields better understanding of the features of the innovative process in Italian traditional industries. In effect, it confirms the results obtained by Santarelli - Sterlacchini (1990) using official data from the first Italian survey on innovation diffusion (ISTAT-CNR, 1987); namely, that not only are innovations implemented by firms belonging to traditional consumer goods industries of the incremental type, they also result from a production process which does not require any particular commitment to structured R&D activities. Thus, in terms of innovation output, these industries appear to be more innovative than is usually believed to be the case when only their commitment to formal R&D is considered.

TABLE 6 - *R&D expenditures and innovations in Italian industry*

INDUSTRIES	R&D EXPENDITURES '89 millions of liras	R&D EXPENDITURES '89 per cent	INNOVATIONS '89 per cent
Food & beverages	70,432	1.06	3.85
Clothing & textiles; Leather & footwear	11,964	0.18	5.26
Wood & furniture	9,784	0.15	2.43
Paper, printing & publishing	2,302	0.03	1.62
Chemicals	1,713,497	25.73	7.09
a) primary chemical products	*456,570*	*6.86*	*2.23*
b) pharmaceutical products	*1,200,613*	*18.03*	*2.83*
c) soap, polishes & sanitation goods	*56,314*	*0.85*	*2.02*
Rubber & plastics	176,186	2.65	3.64
Extractive	205,719	3.09	1.62
Metal products	227,249	3.41	0.20
Machinery[a]	558,419	8.38	48.79
food & bever., rubber & plastics mach.	*107,020*	*1.61*	*14.98*
clothing & textiles, leather work. mach.	*54,598*	*0.82*	*11.74*
woodwork., printing and footwear mach.	*94,327*	*1.42*	*11.94*
other mach.	*119,263*	*1.79*	*10.12*
Office & professional equipment[b]	532,572	8.00	4.86
Electrotechnical & electronics industry	1,755,983	26.37	9.92
Motor vehicles, parts & accessory	1,307,768	19.64	4.05
Instruments	83,552	1.25	5.67
Other manufacturing	4,528	0.07	1.01
Total	6,659,955	100.00	100.00

[a] the amount of R&D expenditures refers to the sector as a whole, according to the ISTAT classification (SIC code 35).

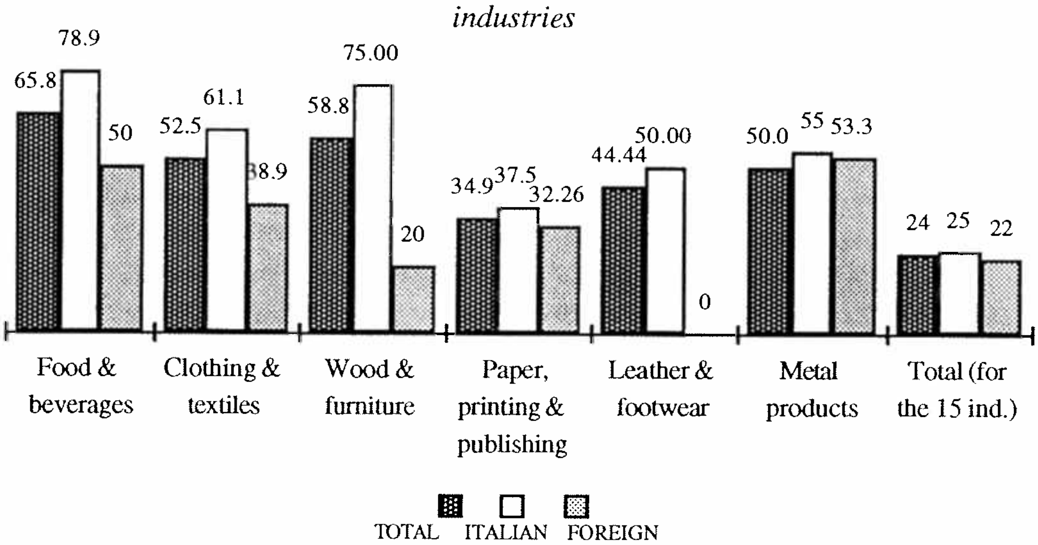
[b] computer programming & software industry not included.

Source: ISTAT (1992) and PRODIN89

"Modestly improved products" represent 40.66 per cent of the novelties developed by Italian firms in the machinery industry, whereas the category "products totally new for the industry" accounts in this case for 10.37 per cent of the total. The machinery industry therefore has a competitive advantage also in relation to the type of novelty of its innovations. The fact that 33.33 per cent of the new products marketed by the Italian electronic-computing industry are "pseudo-innovations" and that only 4.17 per cent are "products totally new for the industry" confirms instead that, in this strategic production, Italian firms are technologically backward. In fact, tables 3 and 5 show that 11.68 per cent of the new electronic-computing products marketed in Italy are "totally new for the industry", and that most of the Italian ones (45.83%) are modestly improved products.

A simple cross-tabulation of degree of complexity and type of novelty shows even more incontrovertibly that traditional consumer goods industries and other industries with scant commitment to coordinated R&D activities (food & beverages, metal products, and paper, printing & publishing) account for a proportion of incremental innovations (i.e. product differentiations with a low degree of complexity) which is much higher than in the sample as a whole (fig.1).

Fig. 1 - Share of incremental innovations in some selected industries



As was to be expected, among Italian innovations alone (fig. 1), this feature of traditional consumer goods and other non R&D-oriented industries is even more marked, thereby confirming the peculiarity of innovative activity in firms belonging to those industries. In particular, the results for the clothing & textiles and the wood & furniture industries are highly significant: in the former 61.11 per cent of Italian innovations are product differentiations with a low degree of complexity, whereas only 38.89 per cent of foreign ones combine these attributes; in the latter the proportion is 75 per cent and 20 per cent respectively.

Moreover, the proportion of incremental innovations of this kind in total Italian innovations (25.4%) is higher than that for foreign innovations (22.2%), and this provides even stronger support for the interpretation that technological innovation in Italian manufacturing is mostly of the incremental type.

5. The geography of innovative output

The output data reported in PRODIN89 also shed light on the spatial dimension of innovative output. In effect, they allow foreign innovations to be distinguished by country of origin, and domestic ones by the region in which the innovating firm is located. It is thus possible to compare the figures arising from our data with the general hypothesis of technology gap theory concerning the positive relation at the industry level between a country's technological strength and its trade performance. And our data also enable comparison between the regional distribution of Italian innovations and that of R&D expenditures and patents. Such comparisons serve to test the reliability of our literature-based indicator as a proxy for the innovative capability of Italian firms.

5.1. The sectoral distribution of foreign innovations

Among the 1,602 innovations listed in PRODIN89, 1,066 (corresponding to more than 66%) are new products introduced on the Italian market by foreign firms (table 7). On aggregate, the EC countries and the US are the most important suppliers of new products, although a significant share is also accounted for by Japan.

At the sectoral level, the EC countries as a whole emerge as the main foreign suppliers of product innovations, with the sole exception of the office & professional equipment industry. In effect, of the 296 foreign innovations identified for this industry, 114 (more than 38%) have been developed by US firms, and only 67 (22.64%) by EC ones, with the Japanese firms ranking third (8.45%). These results confirm that technological change in the office & professional equipment industry originates mainly from US companies and then spreads to other countries through exports of new products (cf. Santarelli, 1995).

TABLE 7 - *Foreign innovations by industry and country of origin*

INDUSTRIES	not allocable	EUROPE EC	EUROPE non EC	US	JAPAN	other States	foreign not allocable	TOTAL
Food & beverages	1	16		2				19
Clothing & textiles	4	8	5	3		2		22
Wood & furniture		5						5
Paper, printing & publishing	4	16	2	4	2	1	6	35
Chemicals	27	46	2	14			22	111
a) primary chemical products	*10*	*25*	*1*	*11*			*10*	*57*
b) pharmaceutical products	*9*	*9*	*1*				*4*	*23*
c) soap, polishes & sanitation goods	*8*	*12*		*3*			*8*	*31*
Rubber & plastics	4	9	2	5			3	23
Leather & footwear		1						1
Extractive		2						2
Metal products	3	2	6				7	18
Machinery	31	95	21	14	7	6	24	198
a) food & beverages mach.	*8*	*21*	*5*	*1*	*1*		*3*	*39*
b) clothing & textiles mach.		*22*	*7*	*2*	*4*			*35*
c) woodworking mach.	*1*	*13*	*2*					*16*
d) printing mach.	*13*	*12*	*5*	*6*		*6*	*12*	*54*
e) leatherworking mach.								
f) footwear mach.	*1*	*2*						*3*
g) rubber & plastics mach.	*3*	*4*		*1*	*1*		*2*	*11*
h) other machinery	*5*	*21*	*2*	*4*	*1*		*7*	*40*
Office & professional equipment	65	67	8	114	25	3	14	296
a) electronic-computing, etc.	*40*	*38*	*5*	*71*	*25*	*3*	*8*	*190*
b) computer programm. & software ind.	*25*	*29*	*3*	*43*			*6*	*106*
Electrotechnical & electronics industry	45	50	12	22	7	1	15	152
Motor vehicles, parts & accessories		31	2	8	6			47
Instruments	44	49	3	10	5		16	127
Other manufacturing	2	3	1	1			3	10
Total	230	400	64	197	52	13	110	1066
%	21.58	37.52	6.00	18.48	4.88	1.22	10.32	100.00

The share of US firms is very significant in the primary chemical products (19.30%) and rubber & plastics (21.74%) industries as well, whereas it proves to be almost irrelevant in traditional consumer goods industries[11].

Disaggregation of EC innovations by country of origin (table 8), shows that Germany contributed 48.50 per cent and France 21.75 per cent of these new products marketed in Italy, with the other member countries accounting for a less significant share[12]. This result is consistent with the fact that Germany is by far the most important commercial partner for Italy, whereas France is ranked second: in 1989 imports from Germany and France amounted (in value) to 37.36 per cent and 25.90 per cent respectively of total Italian imports from EC countries.

[11] With the partial exception of the clothing & textiles industry, where US firms account for 13.64% of foreign innovations.

[12] The UK, ranked third, was responsible for 16.5% of the new products.

TABLE 8 - *European (EC) innovations by country of origin*

INDUSTRIES	EC abs.v.	EC %	B	F	L	NL	D	UK	IRL	DK	GR	E	P
Food & beverages	16	4.00	1	2			5	4	2	2			
Clothing & textiles	8	2.00		1			3	4					
Wood & furniture	5	1.25					5						
Paper, printing & publishing	16	4.00		3		7	5	1					
Chemicals	46	11.50	1	9		1	23	11		1			
a) primary chemical products	*25*	*6.25*		*2*		*1*	*15*	*7*					
b) pharmaceutical products	*9*	*2.25*	*1*	*2*			*1*	*4*		*1*			
c) soap, polishes & sanitation goods	*12*	*3.00*		*5*			*7*						
Rubber & plastics	9	2.25		5			1	3					
Leather & footwear	1	0.25					1						
Extractive	2	0.50		1				1					
Metal products	2	0.50		2									
Machinery	95	23.75	2	16		6	58	9		2		2	
a) food & beverages mach.	*21*	*5.25*		*2*		*2*	*10*	*5*		*1*		*1*	
b) clothing & textiles mach.	*22*	*5.50*	*2*	*4*		*1*	*13*	*1*				*1*	
c) woodworking mach.	*13*	*3.25*		*2*			*10*			*1*			
d) printing mach.	*12*	*3.00*		*3*		*3*	*6*						
e) leatherworking mach.	*0*	*0.00*											
f) footwear mach.	*2*	*0.50*		*2*									
g) rubber & plastics mach.	*4*	*1.00*		*1*			*2*	*1*					
h) other machinery	*21*	*5.25*		*2*			*17*	*2*					
Office & professional equipment	67	16.75	1	21		5	29	8		3			
a) electronic-computing, etc.	*38*	*9.50*		*12*		*4*	*18*	*3*		*1*			
b) computer programm. & software ind.	*29*	*7.25*	*1*	*9*		*1*	*11*	*5*		*2*			
Electrotechnical & electronics industry	50	12.50	1	9		9	18	12				1	
Motor vehicles, parts & accessories	31	7.75		10			19	2					
Instruments	49	12.25		6		6	26	11					
Other manufacturing	3	0.75		2			1						
Total	400	100.00	6	87		34	194	66	2	8		3	
%	100,00		1.50	21.75		8.50	48.50	16.50	0.50	2.00		0.75	

To test the reliability of our data as a proxy for the technological capability of Italy a simple index of the relative strength of each industry in product innovation (SPIN) can be constructed using the formula:

The index is greater than 1 for those industries in which Italian firms have a share of product

$$SPIN_j = \frac{Inn_{Ij}/InnW_j}{Inn_I/InnW}$$

where:
Inn_{Ij} = Italian innovations in industry j;
$InnW_j$ = total innovations in industry j;
Inn_I = Italian innovations in all industries;
$InnW$ = total innovations in all industries.

innovations on total innovations higher than the industry aggregate, lower than 1 for the other industries.

In table 9, the SPIN index computed for the various industries in our data base is compared with an index of revealed technological comparative advantage (RTCA) constructed from data on Italian patents extended to the US during the period 1982-85[13]. This indicator is based on the well-known Balassa (1965) specialization index and assumes values greater than 1 when a country's share of

[13] This indicator is widely employed in studies of technological competitiveness (cf. for Italy, Archibugi, 1988;

US patents in a given industry is greater than its share in total US patents. The aim of the comparison between SPIN and RTCA is to identify whether industries characterized by a significant presence of national firms in product *innovations* are equally strong in developing *inventions* of a technological level sufficiently high to suggest the extension of the patent to the US.

TABLE 9 - *Strength in product innovation, revealed technological comparative advantage, and contribution to trade balance indicators*

INDUSTRIES	SPIN	RTCA	CTB
Food & beverages	1.49	1.006	- 4.04
Clothing & textiles	1.34	1.943	6.91
Wood & furniture	2.11	n.a.	1.59
Paper, printing & publishing	0.56	n.a.	- 0.85
Chemicals	0.72	n.a.	- 4.35
a) primary chemical products	*0.48*	*0.979*	*n.a.*
b) pharmaceutical products	*1.13*	*2.734*	*0.52*
c) soap, polishes & sanitation goods	*0.73*	*0.275*	*- 0.18*
Rubber & plastics	1.31	1.167	0.44
Leather & footwear	2.66	n.a.	4.48
Extractive	1.00	0.402	-9,66
Metal products	1.57	0.669	3.07
Machinery	1.64	2.159	9.33
a) food & beverages mach.	*1.74*	*n.a.*	*0.13*
b) clothing & textiles mach.	*1.71*	*n.a.*	*0.75*
c) woodworking mach.	*1.28*	*n.a.*	*n.a.*
d) printing mach.	*0.62*	*n.a.*	*-0.04*
e) leatherworking mach.	*2.99*	*n.a.*	*n.a.*
f) footwear mach.	*2.74*	*n.a.*	*n.a.*
g) rubber & plastics mach.	*1.93*	*n.a.*	*n.a.*
h) other mach.	*1.66*	*n.a.*	*n.a.*
Office & professional equipment	0.46	n.a.	n.a.
a) electronic-computing, etc.	*0.34*	*0.744*	*-0.77*
b) computer programm. & software ind.	*0.66*	*n.a.*	*n.a.*
Electrotechnical & electronics industry	0.73	1.159	- 0.69
Motor vehicles, parts & accessories	0.89	1.081	- 1.73
Instruments	0.54	0.661	n.a.
Other manufacturing	1.00	n.a.	n.a.

The two indicators provide contrasting figures for only three industries: the electrotechnical & electronics and the motor vehicles industries reveal significant technological strength only with the RTCA indicator, whereas the opposite result emerges for the metal products industry. As regards the first two industries, one may argue that the nature and the scale of product innovation within them is such that (small) innovations presented in trade journals do not have any connection with (big) innovations for which patent protection is requested and extended to the US. Exactly the opposite result is obtained for the metal products industry: in this case the contrasting figures provided by the SPIN and the RTCA indicators indicate that most of the innovations developed in Italy do not have a technological level sufficiently high to suggest the extension of patent protection to the US. Most of the innovations identified for this industry are in effect of the incremental type (cf. fig. 1 above).

The SPIN index is higher than 1 for all the traditional consumer goods industries and all the-branches of the machinery industry, with the sole exception of printing machinery[14]. Unfortunately,

[14] Our data show this branch to be heavily dependent on imported of innovations from Germany and Israel.

the patent data used to construct the RTCA index are not available for these industries, and thus no comparisons between the two indicators can be made.

The reliability of our data can be tested by checking whether the strength in product innovation (SPIN) emerged for particular industries is associated, for those same industries, with a favourable trade performance. Data from the National Statistical Office of Italy (ISTAT, 1990) were used to compute the indicator of contribution to the trade balance (CTB) for the relevant industries:

$$CTB_j = \left\{ \frac{X_j - M_j}{(X - M)/2} - \left[\frac{X - M}{(X - M)/2} \cdot \frac{X_j + M_j}{X + M} \right] \right\} \cdot 100$$

where:
X_j = exports in industry j;
M_j = imports in industry j;
X = total exports in all industries;
M = total imports in all industries.

This indicator yields values greater than 0 (less than 0) when the relevant industry makes a contribution to the overall trade balance of the country which is higher (lower) than its percentage share in the country's total trade (cf. Amendola - Guerrieri - Padoan, 1991). It is therefore helpful to identify industries of specialization and industries of despecialization.

In fact, in 1989 the CTB index (table 9) was 6.91 for the clothing & textiles industry, 1.59 for wood & furniture, 4.48 for leather & footwear, and 9.33 for the aggregate machinery industry. These findings and the results provided by computation of the SPIN index suggest a further explanation of the relation between strength in product innovation and trade specialization for certain industries. One can in fact argue that - consistently with the "technology gap" approach (cf., among others, Soete, 1987; Fagerberg, 1987, 1988; Amendola - Dosi - Papagni, 1993) - there is a positive relation between strength in innovation and trade performance for most industries. A formal test for this relation can be carried out by calculating the Spearman rank correlation. This test shows a strong (0.648) positive correlation between SPIN and CTB, significant at a 1 per cent level at a one-tailed test, and seems therefore to support the general hypothesis of technology gap theory.

5.2. Innovative output, patents, and the spillovers from R&D activities in Italian regions

530 of the 536 Italian innovations contained in PRODIN89 were broken down according to the region of the innovating firms. Only 13 out of 20 Italian regions recorded at least one resident firm introducing new products in 1989.

Table 10 shows the overwhelming importance of the Lombardia region in terms of product innovations in almost all industries. The principal exceptions are in the leather & footwear industry (where the Marche region performs particularly well), the industry producing food & beverages machinery (cf. Emilia Romagna), and motor vehicles (cf. Piemonte). These regional portions of product innovations reflect the industrial specialization of the above-mentioned regions, and therefore support the reliability of the literature-based indicator.

For all regions, it was possible to compare our innovation output data with R&D expenditures and the number of patents extended to the US in 1986 (table 11)[15]. In order to control for the relative size of the various Italian regions, each measure is divided by resident population[16].

[15] We are grateful to Marco Vivarelli for allowing us to use the data on patents employed in Audretsch - Vivarelli (1993). The data source for patents is the SPRU data base at Sussex University and is based on the US OTAF Patent Office. 1986 has been chosen because more recent data are not yet available. Conversely R&D data refer to 1986 because the returns from R&D undertaken in a given year can be identified in new products placed on the market after a significant time-lag (usually two or three years).

[16] The measure for the resident population is obtained as the mean of the values at the beginning and the end of the year.

TABLE 10 - *Distribution of Italian innovations by industry and region*

	Lombardia	Emilia Romagna	Piemonte	Veneto	Toscana	Marche	Friuli Venezia Giulia	Trentino Alto Adige	Umbria	Abruzzo	Campania	Liguria	Puglia	total	not allocable	TOTAL
1	8	5	1	1	1						1	1		18	1	19
2	11	1	3	1						1				17	1	18
3	6		3	1		2								12		12
4	3		1	1	1									6	2	8
5	22	5	3	4	1									35		35
5a	*7*	*1*	*1*	*2*										*11*		*11*
5b	*6*	*4*	*2*	*1*	*1*									*14*		*14*
5c	*9*			*1*										*10*		*10*
6	14	1		1		2								18		18
7	4				1	3								8		8
8													1	1		1
9	12	5	2	1										20		20
10	139	45	16	13	15	3	3	3	2	1		1		241		241
10a	*24*	*20*	*3*	*3*	*1*		*1*	*1*	*1*					*54*		*54*
10b	*29*	*5*	*4*	*1*	*5*		*2*					*1*		*47*		*47*
10c	*3*	*6*			*2*	*1*								*12*		*12*
10d	*8*		*3*		*2*				*1*					*14*		*14*
10e	*2*	*2*		*5*	*2*									*11*		*11*
10f	*26*	*1*		*3*	*3*									*33*		*33*
10g	*17*	*2*	*1*											*20*		*20*
10h	*30*	*9*	*5*	*1*		*2*		*2*		*1*				*50*		*50*
11	26	4	19	1		1			1					52	2	54
11a	*11*	*2*	*9*			*1*			*1*					*24*		*24*
11b	*15*	*2*	*10*	*1*										*28*	*2*	*30*
12	40	1	5				2				1			49		49
13	2	4	13	1										20		20
14	17	6	1	1	2							1		28		28
15	3			1			1							5		5
tot	307	77	67	27	21	11	6	3	3	2	2	3	1	530	6	536
%	57.92	14.53	12.64	5.09	3.96	2.08	1.13	0.57	0.57	0.38	0.38	0.57	0.19	100.00		

Notes:

1. Food & beverages
2. Clothing & textiles
3. Wood & furniture
4. Paper, printing & publishing
5. Chemicals
   a) primary chemical products
   b) pharmaceutical products
   c) soap, polishes, etc.
6. Rubber & plastics
7. Leather & footwear
8. Extractive
9. Metal products
10. Machinery
    a) food & beverages mach.
    b) clothing & textiles mach.
    c) wood mach.
    d) printing mach.
    e) leather mach.
    f) footwear mach.
    g) rubber & plastics mach.
    h) other mach.
11. Office & professional equipment
    a) electronicc-computing, etc.
    b) computer program. & software ind.
12. Electrotechnical & electronics industry
13. Motor vehicles, parts & accessories
14. Instruments
15. Other manufacturing

Immediately evident from the correlation matrix presented in table 12 is the high coefficient of linear correlation (0.876) between product innovations (INN) and patents (PAT). This finding confirms that innovative output in Italy, irrespective of the measurement procedure adopted, concentrates in a well defined group of regions, with some significant exceptions. In fact, regions where traditional consumer goods industries predominate (Veneto, Emilia Romagna, Toscana, Marche) appear to be more innovative when the PRODIN89 indicator is used, whereas the opposite result is obtained for those regions (like Piemonte and Liguria) in which scale intensive industries are more developed.

TABLE 11 - *R&D expenditures, innovations, and patents extended to the US by region*

REGIONS	R&D exp. in 1986		INNOVATIONS '89		PATENTS '86	
	millions of liras	%	abs. val.	%	abs. val.	%
Piemonte	1,805,390	30.36	67	12.64	124	18.67
Valle d'Aosta	1,472	0.02				
Lombardia	2,045,855	34.41	307	57.92	274	41.27
Trentino Alto Adige	18,239	0.31	3	0.57		
Veneto	190,415	3.20	27	5.09	29	4.37
Friuli Venezia Giulia	83,331	1.40	6	1.13	20	3.01
Liguria	293,558	4.94	3	0.57	11	1.66
Emilia Romagna	254,355	4.28	77	14.53	89	13.40
Toscana	254,277	4.28	21	3.96	23	3.46
Umbria	26,098	0.44	3	0.57	2	0.30
Marche	19,064	0.32	11	2.08	5	0.75
Lazio	607,460	10.22			50	7.53
Abruzzo	47,424	0.80	2	0.38	5	0.75
Molise						
Campania	176,898	2.98	2	0.38	12	1.81
Puglia	34,418	0.58	1	0.19	1	0.15
Basilicata	5,334	0.09				
Calabria	8,652	0.15			1	0.15
Sicilia	45,961	0.77			18	2.71
Sardegna	27,456	0.46				
ITALY	5,945,657	100.00	530	100.00	664	100.00

Sources: R&D expenditures (ISTAT, 1989); patents (SPRU data base).

The case of Lombardia and Lazio is curious. In Italy, Lombardia is by far the most technologically advanced region, both in traditional and scale intensive productions. As a consequence, irrespective of their size, firms resident in this region benefit from a number of technological spillovers which engender incremental innovations which are not patented and can therefore be identified only by resorting to a direct measure of innovative output. In the case of Lazio, previous studies (Sirilli, 1986; Santarelli - Sterlacchini, 1989) have instead shown that firms with their legal offices in the Rome metropolitan area but with their production facilities located in other regions account for a very large share of the total patents attributed to this region by official sources. The actual contribution of Lazio to overall innovative output is therefore less significant than one would deduce from patent data, although the literature-based procedure (with which no innovations were identified) would probably have underestimated product innovations developed by firms with their production facilities in this region.

In table 12, the linear correlation coefficient between patents and R&D expenditures (0.805) is higher than that between product innovations and R&D expenditures (0.603). These results indicate that there is a close linkage between formal research activities (carried out by firms) and innovations whatever indicator of innovative output is used. Nevertheless, the differences between the patent and the innovative output correlation coefficients suggest that, when a direct measure of innovative output is employed, the innovative activity of industrial firms seems also to be based on both external or internal sources of informal knowledge which are not captured by traditional input indicators.

TABLE 12 - *Correlation matrix*

	INN	R&D	PAT
INN	1.00	...	...
R&D	0.603	1.00	...
PAT	0.876	0.805	1.00

6. The size distribution of Italian innovating firms

The Italian firms responsible for the development of the 536 "national" innovations contained in PRODIN89 were interviewed in order to obtain information about their size (in terms of number of employees) in 1989. Unfortunately, data were forthcoming for only 291 innovations, due to the firms' reluctance to disclose information concerning their employees. As a consequence, the results of the following analysis of the size distribution of innovative firms registered in PRODIN89 must be treated with a certain caution.

Tables 13a and 13b show the distribution of innovations by size class and industry of the innovating firm.

In particular, table 13a presents for each industry the percentage distribution of innovative firms in any size class as a share of total firms identified in the class for all industries, whereas table 13b shows the percentage distribution of innovative firms by size class within each industry. Analysis of these data shows (table 13a) that firms with fewer than 50 employees account for the largest number of innovations (104, corresponding to more than 35% of the total), and that firms with 50 to 199 employees introduced 27 per cent of total innovations; but the largest firms with more than 500 employees are responsible for only 67 innovations, corresponding to 23 per cent of those contained in PRODIN89. These results acquire significance when compared with a measure of the presence of firms belonging to each size class in any given industry.

The innovative capability of small firms emerges even more clearly, in fact, if one focuses on specific branches of the machinery industry (table 13b): 72.73 per cent of the total innovations identified for the industry producing footwear machinery were introduced by firms with fewer than 50 employees, which account for 39.11 per cent of the employees in the firms identified for this industry. Significantly, the share of innovations introduced by firms with fewer than 50 employees was 70 per cent in the case of leather machinery, and 60.71 per cent in that of food & beverages machinery, whereas these firms represented 34.55 per cent and 9.34 per cent of total employment in their industry respectively. Different results emerge in the case of the clothing & textiles *filiere*. In effect, 45 per cent of new machines were introduced by firms with fewer than 200 employees - and this share drops to 5 per cent for firms with fewer than 50 employees - whereas 61.54 per cent of total new clothing & textiles products may be attributed to large firms with more than 1,000 employees. Firms with fewer than 200 employees accounted for only 23.08 per cent of the total. As regards the industry producing machinery for these traditional consumer goods, firms having less than 200 employees were responsible for more than 8 per cent of total employment. Firms with more than 1,000 employees accounted instead for almost 92 per cent of total employment in the clothing & textiles industry. The explanation for this apparently surprising prevalence of larger firms is that most of the innovations identified within this relatively low R&D spending *filiere* regard the textile industry in a strict sense[17]. This is a "scale intensive" industry (in Pavitt's sense) where the production process takes place in large plants: accordingly, large firms are also responsible for most of the innovations introduced in this industry.

According to the "Schumpeterian hypothesis", within industries strongly committed to autonomous R&D activities the contribution of larger firms to innovation should be more marked. In fact, 75 per cent of the new products identified for the electronic-computing industry were introduced by firms with more than 500 employees, which represented more than 97 per cent of the industry total in terms of employment. This share rose to 60 per cent in the rubber & plastics industry and to 100 per cent in the motor vehicles, parts & accessories industry, where these size class accounted for more than 97 per cent and 100 per cent of the industry total employment respectively.

TABLE 13a - *Distribution of innovations and employment by size class and industry*[a]

INDUSTRIES	1 - 19		20 - 49		50 - 199		200 - 499		500 - 999		1000 & more	
per cent by column	INN	EMP	INN	EMP	INN	EMP	INN	EMP	INN	EMP	INN	EMP
Food & beverages					2.53	3.92	2.44	2.35	25.00	22.13	3.92	2.00
Clothing & text.			4.84	4.27			4.88	9.13			15.69	7.29
Wood & furniture	4.76	3.85	1.61	1.58	5.06	6.86						
Paper, printing ...	2.38	0.27							6.25	12.54		
Chemicals			1.61	1.75	8.86	12.30	12.20	6.00	6.25	10.76	3.92	1.66
a) primary chem.			*1.61*	*1.75*	*6.33*	*7.90*						
b) pharmaceutical					*1.27*	*1.98*	*12.20*	*6.00*			*1.96*	*0.89*
c) soap, polishes .					*1.27*	*2.42*			*6.25*	*10.76*	*1.96*	*0.77*
Rubber & plastics			1.61	1.69	6.33	5.13					17.65	11.49
Leather & footwear	2.38	4.67			2.53	3.08						
Extractive					1.27	1.09						
Metal products	4.76	1.65	6.45	4.50	3.80	3.95	4.88	4.84				
Machinery	76.19	79.40	56.45	61.08	49.37	48.67	53.66	57.06	31.25	42.97	3.92	4.52
a) food & bev. ...	*19.05*	*12.09*	*14.52*	*14.61*	*7.59*	*9.28*	*9.76*	*12.68*			*1.96*	*0.74*
b) clothing & ...	*2.38*	*4.12*			*10.13*	*10.95*	*14.63*	*19.40*	*25.00*	*34.51*	*1.96*	*3.78*
c) woodw. mach.			*4.84*	*5.96*	*3.80*	*2.73*	*12.20*	*2.97*				
d) printing mach.	*11.90*	*9.62*	*1.61*	*1.46*			*2.44*	*3.96*				
e) leatherw. mach.	*11.90*	*14.84*	*3.23*	*3.51*	*3.80*	*2.95*						
f) footwear mach.	*19.05*	*24.18*	*12.90*	*15.43*	*6.33*	*4.61*	*2.44*	*2.32*				
g) rubber & ...	*9.52*	*10.16*	*6.45*	*5.49*	*5.06*	*7.18*	*4.88*	*7.55*				
h) other mach.	*2.38*	*4.40*	*12.90*	*14.61*	*12.66*	*10.97*	*7.32*	*8.16*	*6.25*	*8.47*		
Office & prof ...	2.38	3.85	9.68	12.97	3.80	4.06	2.44	5.19	31.25	11.59	19.61	8.35
a) electronic-co...	*2.38*	*3.85*	*1.61*	*2.81*	*2.53*	*2.97*			*31.25*	*11.59*	*13.73*	*7.48*
b) computer pr...			*8.06*	*10.17*	*1.27*	*1.09*	*2.44*	*5.19*			*5.88*	*0.87*
Electrotechnical ...	7.14	6.32	11.29	6.66	12.66	6.67	17.07	12.71			9.80	8.55
Motor vehicles ...											25.49	56.13
Instruments			6.45	5.49	3.80	4.28	2.44	2.73				
Total (abs. values)	42	364	62	1,711	79	7,317	41	9,082	16	6,141	51	138,646
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] all values, unless otherwise spcified, are percentages.

[17] Of course, articles of clothing differ in terms of design. None of them can therefore be considered as a product innovation. Innovations are instead the new fabrics and accessories utilized for either ready-made or tailor-made clothes.

TABLE 13b - *Distribution of innovations and employment by size class and industry*[a]

	1 - 19		20 - 49		50 - 199		200 - 499		500 - 999		1000 & more		TOTAL	
	INN	EMP	INN	EMP	INN	EMP	INN	EMP	INN	EMP	INN	EMP	INN	EMP
Food...					22.22	6.20	11.11	4.60	44.44	29.36	22.22	59.84	9	4,629
Cloth...			23.08	0.66			15.38	7.53			61.54	91.81	13	11,015
Wood...	28.57	2.58	14.29	4.97	57.14	92.45							7	543
Paper...	50.00	0.13							50.00	99.87			2	771
Chem...			6.25	0.68	43.75	20.26	31.25	12.27	6.25	14.88	12.50	51.91	16	4,442
a) prim.			*16.67*	*4.93*	*83.33*	*95.07*							*6*	*608*
b) phar.					*14.29*	*7.52*	*71.43*	*28.27*			*14.29*	*64.21*	*7*	*1,928*
c) soap					*33.33*	*9.29*			*33.33*	*34.68*	*33.33*	*56.03*	*3*	*1,906*
Rubber..			6.67	0.18	33.33	2.30					60.00	97.53	15	16,337
Leath...	33.33	7.02			66.67	92.98							3	242
Extrac..					100.0	100.0							1	80
Met. pro.	18.18	0.74	36.36	9.48	27.27	35.59	18.18	54.19					11	812
Mach...	24.06	1.52	26.32	5.51	29.32	18.76	16.54	27.30	3.76	13.90	1.50	33.00	135	18,979
a) food..	*28.57*	*1.40*	*32.14*	*7.94*	*21.43*	*21.57*	*14.29*	*36.59*			*3.57*	*32.50*	*28*	*3,148*
b) cloth.	*5.00*	*0.15*			*40.00*	*8.06*	*30.00*	*17.73*	*20.00*	*21.32*	*5.00*	*52.73*	*20*	*9,937*
c) wood...			*27.27*	*17.83*	*27.27*	*34.97*	*45.45*	*47.20*					*11*	*572*
d) print..	*71.43*	*8.33*	*14.29*	*5.95*			*14.29*	*85.71*					*7*	*420*
e) leath..	*50.00*	*16.36*	*20.00*	*18.18*	*30.00*	*65.45*							*10*	*330*
f) foot...	*36.36*	*9.78*	*36.36*	*29.33*	*22.73*	*37.44*	*4.55*	*23.44*					*22*	*900*
g) rubb..	*28.57*	*2.76*	*28.57*	*7.00*	*28.57*	*39.12*	*14.29*	*51.12*					*14*	*1,342*
h) other	*4.35*	*0.69*	*34.78*	*10.73*	*43.48*	*34.46*	*13.04*	*31.80*	*4.35*	*22.32*			*23*	*2,330*
Office...	3.85	0.11	23.08	1.67	11.54	2.23	3.85	3.54	19.23	5.36	38.46	87.09	26	13,293
a) elct..	*6.25*	*0.12*	*6.25*	*0.42*	*12.50*	*1.91*			*31.25*	*6.27*	*43.75*	*91.28*	*16*	*11,359*
b) cmpu..			*50.00*	*9.00*	*10.00*	*4.14*	*10.00*	*24.35*			*30.00*	*62.51*	*10*	*1,934*
Electrot..	9.38	0.17	21.88	0.84	31.25	3.58	21.88	8.46			15.63	86.95	32	13,635
Motor...											100.0	100.0	13	77,828
Instrum..			50.00	14.35	37.50	47.79	12.50	37.86					8	655
Total	14.43	0.22	21.31	1.05	27.15	4.48	14.09	5.56	5.50	3.76	17.53	84.92	291	163,261

[a] totals are absolute values, all the others are percentages.

Conversely, our data do not support the Schumpeterian hypothesis in the electrotechnical & electronics industry, where the share of innovations introduced by firms with more than 500 employees represents only 15.63 per cent of the total, with this size class responsible for almost 87 per cent of the industry employment. In fact, in explaining the low innovative contribution of large firms belonging to this industry, it should be stressed that it is characterized more by *specialized suppliers* of intermediate goods - usually medium sized firms[18] - than by large scale producers of standardized goods.

Although the above comparisons between shares of innovations and shares of employment represent a reliable proxy of the relation between market structure and innovation in each industry, the best measure of innovative activity when comparing firms belonging to different size classes is the innovation rate (cf. Acs - Audretsch, 1993). Given the particular structure of Italian industry, we can define the large-firm innovation rate as the number of innovations made by firms with at least 200 employees, divided by the number of employees (hundreds) in such firms. Analogously, the small-firm innovation rate is the number of innovations developed by firms with fewer than 200 employees divided by the number of employees (hundreds) in small firms.

[18] In fact, firms with between 50 and 499 employees account for more than 53 per cent of total innovations identified for this industry.

TABLE 14 - *Innovation rates for large and small firms by industry, 1989*

INDUSTRIES:	TOTAL INNOVATIONS	SMALL-FIRM INNOVATIONS	LARGE-FIRM INNOVATIONS
Food & beverages	0.19	0.70	0.16
Clothing & textiles	0.12	4.11	0.09
Wood & furniture	1.29	1.29	- - -
Paper, printing & publishing	0.26	100.00	0.13
Chemicals	0.36	0.86	0.23
a) primary chemical products	*0.99*	*0.99*	- - -
b) pharmaceutical products	*0.36*	*0.69*	*0.34*
c) soap, polishes & sanitation goods	*0.16*	*0.56*	*0.12*
Rubber & plastics	0.09	1.49	0.06
Leather & footwear	1.24	1.24	- - -
Extractive	1.25	1.25	- - -
Metal products	1.35	2.42	0.45
Machinery	0.71	2.20	0.21
a) food & beverages mach.	*0.89*	*2.36*	*0.23*
b) clothing & textiles mach.	*0.20*	*1.10*	*0.12*
c) woodworking mach.	*1.92*	*1.99*	*1.85*
d) printing mach.	*1.67*	*10.00*	*0.28*
e) leatherworking mach.	*3.03*	*3.03*	- - -
f) footwear mach.	*2.66*	*3.41*	*0.47*
g) rubber & plastics mach.	*1.04*	*1.83*	*0.29*
h) other mach.	*0.99*	*1.78*	*0.32*
Office & professional equipment	0.20	1.88	0.13
a) electronic-computing, etc.	*0.14*	*1.43*	*0.11*
b) computer programm. & software ind.	*0.52*	*2.36*	*0.24*
Electrotechnical & electronics industry	0.23	3.25	0.09
Motor vehicles, parts & accessory	0.02	- - -	0.02
Instruments	1.22	1.72	0.40
Total	0.18	1.97	0.07

The first column in table 14 shows that the total innovation rates are higher for those industries - such as, in particular, metal products, wood & furniture, leather & footwear - shown by previous studies to be characterized by a very small average employment size (cf. Santarelli - Sterlacchini, 1994a). Comparison of the large-firm and small-firm innovation rates for each of the industries analyzed in PRODIN89 reveals that small firms always have an innovation rate higher than that of large firms, with the sole exception of motor vehicles, where none of the innovations registered in our data base were introduced by small firms[19]. This finding confirms the strength of Italian small firms in innovation[20], although it casts some doubt on the reliability of this indicator in capturing the innovative contribution of large firms. Nonetheless, in spite of this possible bias towards small firms, one cannot help but note that the results obtained with PRODIN89 are consistent with those yielded by analysis of the US Small Business Administration Innovation Data Base (cf. Acs - Audretsch, 1993). In effect, Acs and Audretsch found that in the US fourteen out of eighteen industries display a small-firm innovation rate which exceeds that computed for large firms. It therefore seems that, when a direct measure of innovative output is used, small firms have in general a relati-

[19] Large firms have not introduced innovations in five industries: wood & furniture, primary chemical products, leather & footwear, extractive, and leather machinery.

[20] As shown by earlier field studies of certain Italian regions (cf., among others, Brusco, 1982; Santarelli - Sterlacchini, 1994b)

ve innovative advantage, and that this finding applies to countries (like Italy and US) characterized by a sigificantly different industrial structure.

Analysis of the distribution of innovations by size class and degree of complexity (table 15) shows that 13 out of 15 (86.67%) innovations with a high degree of complexity were introduced by firms with more than 1,000 employees, while the same firms were responsible for 99.64 per cent of total employment in firms comprised in PRODIN89. Moreover, these firms developed only 18.80 per cent of the innovations displaying a low degree of complexity. However, as already pointed out in sections 3 and 4, the degree of complexity is a simple measure of the breadth of the knowledge base upon which an innovation relies. This finding therefore does not imply that the innovative capability and the technological level always increase with firm size.

TABLE 15 - *Per cent distribution of innovations and employment by degree of complexity of the innovations and size class of the innovating firm*

	HIGH		MEDIUM		LOW		TOTAL			
SIZE CLASS	INN	EMP	INN	EMP	INN	EMP	INN		EMP*	
	%	%	%	%	%	%	a.v.	%	a.v.	%
1 - 19			22.38	0.50	7.52	0.21	42	14.43	364	0.22
20 - 49	6.67	0.03	20.98	1.51	23.31	2.32	62	21.31	1,711	1.05
50 - 199			23.08	5.47	34.59	10.41	79	27.15	7,317	4.48
200 - 499	6.67	0.33	16.78	10.32	12.03	8.76	41	14.09	9,082	5.56
500 - 999			7.69	7.05	3.76	7.62	16	5.50	6,141	3.76
1000 & more	86.67	99.64	9.09	75.14	18.80	70.68	51	17.53	138,646	84.92
Total	100.00	100.00	100.00	100.00	100.00	100.00		100.00		100.00
absolute value	15	78,113	143	57,188	133	36,618	291		163,261	

* Average values and percentages are calculated on total employment by innovating firms. Firms may be responsible for more than one innovation.

In fact, inspection of the distribution of innovations by size class and type of novelty (table 16) provides a significantly different figure: firms with fewer than 200 employees - accounting for 1 per cent of total employment - introduced 56 per cent of the products "totally new for the industry" and 2 of the 3 process innovations registered in PRODIN89, responsible for 28.30 per cent of employment; whereas those with more than 1,000 employees - representing in their turn 96.92 per cent of total employment - accounted for only 24 per cent of the totally new products and for none of the process innovations.

As expected, "new accessory products" representing intermediate goods were developed mostly by firms belonging to the size classes comprising between 20 and 200 employees[21]: firms in these size classes were in effect responsible for 61.22 per cent of the innovations included in this category.

Although reflecting some unexamined biases[22], analysis of the distribution of the innovations contained in PRODIN89 by size class of the innovating firms gives results consistent with those of previous studies on Italian industry. In particular, small firms specialized in niche productions appear to be even more adept than large firms in developing products which are completely new for their industry. This finding provides stronger support for the hypothesis that in certain traditional industries, with a low commitment to formal R&D, small firms are nonetheless able to carry out

[21] In firms belonging to this size class are employed 14.38% of the employees of firms comprised in PRODIN89.

[22] In particular, firms belonging to traditional consumers goods industries were the most reluctant to answer questions about the number of employees working in their plants.

their innovative activities without resorting to formalized procedures (cf. Santarelli - Sterlacchini, 1990). Italian small firms specialized in selling capital goods (i.e. those that belong to the machinery and the electrotechnical & electronics industries) to supplier dominated firms producing mostly consumer goods confirm instead their well-known competitive advantage in terms of innovative capability (cf., among others, Piore - Sabel, 1984).

TABLE 16 - *Per cent distribution of innovations and employment by type of novelty and size class of the firm*

	(1)		(2)		(3)		(4)		(5)	
SIZE CLASS	INN %	EMP %	INN %	EMP %	INN %	EMP %	INN %	EMP %	INN %	EMP %
1 - 19	8.00	0.03	20.22	0.14	10.20	0.27	13.60	0.13		
20 - 49	20.00	0.21	17.98	0.39	30.61	3.35	20.80	0.56		
50 - 199	28.00	0.76	22.47	1.47	30.61	11.03	28.00	2.93	66.67	28.30
200 - 499	16.00	1.36	12.36	2.32	16.33	16.07	14.40	4.03		
500 - 999	4.00	0.72	6.74	2.18			6.40	3.36	33.33	71.70
1000 & more	24.00	96.92	20.22	93.49	12.24	69.29	16.80	88.99		
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
absolute value	25	84,994	89	125,672	49	11,858	125	122,624	3	947

Notes: (1) product totally new for the industry; (2) modestly improved product; (3) new or improved accessory product; (4) product differentiation; (5) process innovation.

7. Concluding remarks

In this paper the application of a direct, literature-based measure of innovative output has yielded more thorough understanding of the features of technological change in Italian industry.

The conventional wisdom that R&D oriented industries and large firms predominate in innovation does not appear to fit well with the Italian case. These findings coincide with the results of previous studies, which have shown that Italy is characterized by a significant presence of consumer goods industries and small firms in innovation. Moreover, our data indicate links between trade competitiveness and strength in product innovation, showing the comparatively higher capacity for product innovation of some of the industries in which Italy achieves favourable performance in international trade. In this respect, our results are consistent with those of previous studies using different innovation indicators. In addition, the presence of spillovers at the regional level from both private and public R&D expenditures - also identified in other studies relying on patent statistics - proves to be linked with the development of product innovations. Finally, these literature-based data show that small firms with fewer than 50 employees are more innovative than is usually believed to be the case, confirming the results of researches conducted by direct investigation of the innovative activities of small firms.

These results, and those obtained by earlier studies employing a similar procedure for other countries, suggest that literature-based classifications of innovation events enable adequate assessment of innovation trends at both the industry and the geographical area levels. The various National Statistical Offices should therefore consider the possibility of adopting this promising measurement procedure, which would be of benefit to students of technology and indeed would lead to better understanding of the dynamics of innovation.

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