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Embodied Technological Change in Supplier Dominated Firms*

The Case of Italian Traditional Industries

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Abstract. This paper identifies the role of new capital goods as the main external source of innovation for supplier dominated firms belonging to traditional consumer good industries. After a brief survey on the role of inter-industry technology flows, the results of a field study are presented concerning the amount of technological change embodied in the new machinery acquired during the 1980s by a sample of Italian manufacturing firms producing traditional consumer goods. We show that industries and firms differ in the quality of technological change embodied in (or allowed by) new capital goods, and that such differences depend on industry-specific and firm-specific factors. The former primarily refer to product characteristics, the latter mainly to the age and the affiliation of the firm with an industrial group. The final section contains some policy suggestions for fostering the diffusion of new machinery (embodying technological change) among small firms and traditional industries.

Key words: Traditional industries, adoption of new machinery, embodied technological change.

JEL code: O30

I. Introduction

Traditional consumer good industries (such as food, textiles, clothing, and footwear) are characterized by a very low level of autonomous innovative capability. To benefit from the advancements of science and technology they rely essentially upon external sources of innovation: in this connection Pavitt (1984) introduced the concept of 'supplier dominated' firms (henceforth SDFs). This paper focuses on the role of embodied technological change as the main external source of innovation for SDFs belonging to traditional industries.

The second section is devoted to a brief survey of the main studies concerned with inter-industry technology flows; it is shown that there are different channels of technology transfer across industries but in any case – no matter the channel considered – traditional industries are highly dependent on external sources of technological change. Moreover, in the case of Italian traditional industries the most effective (external) source of innovation is the adoption of new machinery.

The third section analyzes the results of a field study concerned with the extent and the innovative content of new machinery acquired during the 1980s by a sample of Italian firms belonging to the clothing, furniture and footwear industries. Although during the last decade the amount of resources devoted to the acquisition of machinery and equipment has increased for all the firms included in the sample, we show that there have been significant differences among industries and firms in the quality of innovation embodied in (or allowed by) new capital goods. These differences depend on both industry-specific and firm-specific factors. The former refer mainly to the product characteristics which affect the potential for introducing process innovations in the design and production phases. The latter are mainly identified by the age and the affiliation of the firm with an industrial group.

With particular reference to the Italian experience, the fourth section deals with some policy interventions that foster the diffusion of new machinery among small firms belonging to traditional industries.

II. External Sources of Innovation and the Role of New Capital Goods

The indicators usually employed in the measurement of innovative activity (R&D spending and patenting) represent a good proxy for the autonomous innovative capability of firms and industries which internally produce most of the technology they use. In this case, either at the industry or firm level, these technology variables are in general positively and significantly correlated with indicators of economic performance (such as productivity growth, market power, export shares, and profits).

Conversely, if one focuses upon SDFs as defined by Pavitt (1984), R&D expenditures and the number of patents are far from being satisfactory in evaluating their innovative capability. In effect, according to Pavitt (1984, p. 354), SDFs mainly belong to traditional consumer good industries and 'make very little contribution themselves either to their product or their process technology. [. . .] Most innovations come from suppliers of equipment and materials [. . .] In-house R&D and engineering capabilities are weak'. These considerations, however, do not mean that innovative activities are irrelevant in determining, for instance, the productivity or the market shares of SDFs. On the contrary, once the external sources of technological change are taken into account, the relationship between technological capability and economic performance remains strong even in the case of the traditional industries in which SDFs prevail. This is the most important conclusion arising from a large body of empirical studies concerned with the evaluation and the effects of inter-industry technology flows (see, for a survey, Marengo and Sterlacchini, 1990).

Scherer (1982a, 1984) mapped out a matrix of inter-industry technology flows in the US by linking R&D expenditures to patented inventions originating in certain industries and used by other industries. He found (Scherer, 1982b) that inter-industry differences in terms of productivity growth were better explained

TABLE I. Industry ratios of external R&D to internal R&D

	R&D via patents – United States[a]	R&D via capital goods – Italy[b]	R&D via innovations – United Kingdom[c]
Chemicals	0.55	0.13	0.24
Metal products	1.37	0.51	0.80
Mechanical machinery	0.24	0.36	0.74
Instruments	0.14	0.02	0.81
Electrical & Electronics	–	0.02	–
Electrical	0.32	–	0.39
Electronics	0.26	–	0.47
Motor vehicles	0.21	0.07	1.12
Textile, Clothing & Footwear	1.38	13.00	4.14
Food, Beverages & Tobacco	1.18	2.22	0.67
Paper & Printing	1.31	3.80	4.25
Rubber & Plastics	1.12	0.25	1.17

[a]Source: Scherer (1982a); [b]Source: Sterlacchini (1989b); [c]Source: Sterlacchini (1989a)

by the intensity of 'used' R&D rather than the intensity of 'performed' R&D. Moreover, as reported in the first column of Table I, the ratio of external R&D to internal R&D was higher in traditional industries characterized by a low intensity of internal R&D.

A second procedure to measure technological transfer among industries was first introduced by Terleckyj (1974) who assumed that external or 'used' R&D is mainly embodied in intermediate and capital goods. As a consequence, R&D activities undertaken by different industries diffuse to the rest of the productive system according to the direct purchases of capital and intermediate inputs. Even with this procedure the extent of external or 'embodied' R&D contributed effectively to explain the rates of productivity growth of US manufacturing industries. With the same rationale, Momigliano and Siniscalco (1984) measured inter-industry technology flows in Italy by taking into account both the direct and indirect purchases of intermediate goods: in this way they found that even the final products of Italian traditional industries embody a relevant share of R&D activities and that the export performance of Italian products is significanty associated with the intensity of external R&D. Sterlacchini (1989b) computed the level of 'embodied' R&D among Italian industries by using an inter-industry matrix of capital good purchases: with this procedure the ratio of external to internal R&D is particularly high in the case of traditional consumer good industries (especially footwear, clothing and textiles) characterized by a prevalence of SDFs (cf. the second column of Table I).

A third attempt to evaluate inter-industry technology flows has been based upon the data collected in UK by the Science Policy Research Unit (SPRU) of Sussex University (cf. Townsend *et al.*, 1981). More than 4,000 technological innovations

TABLE II. Relative importance and relative cost of capital goods and R&D activities in innovation

	Relative importance	Relative cost
Clothing & Footwear	3.15	11.80
Wood & Furniture	2.73	9.80
Total manufacturing	1.90	2.87

Source: ISTAT (1988).

commercialized in UK from 1945 to 1983 were classified according to the principal activities of the innovating firm and the first using firm: as a consequence industries can be classified in terms of produced and used innovations.[1] Moreover, a production/use matrix of technological innovations can be mapped out and employed, as a linear operator, to allocate R&D expenditures performed by innovating industries among user industries (cf. Sterlacchini, 1989a): this procedure is similar to the previous ones, but, in this case, innovations rather than patents or capital goods are the carriers of R&D expenditures.

The ratio of external R&D (acquired via innovations) to internal R&D can be computed and the results, presented in the third column of Table I, are consistent with those arising from the alternative procedures discussed above: in effect, even in this case the ratio is particularly high for paper & printing and the miscellaneous group of traditional industries including textiles, clothing and footwear.

In general, the studies previously discussed have shown that if the concept of technological capability also includes external sources of innovation, traditional industries are not as far behind as they would appear when only internal or autonomous innovative activities are taken into account. It must be added that this finding is not influenced by the type of external source of innovation considered or the country examined. Moreover, at least in the Italian case, technological change embodied in capital goods seems the most important external source of innovation for SDFs belonging to traditional consumer good industries.

This last finding is also supported by the survey carried out in Italy by the Central Statistical Office on the extent and the sources of innovations introduced by manufacturing firms during the period 1981–85 (cf. ISTAT, 1988). 8,220 innovating firms returned the questionnaire in which, among other information requested, they were asked to evaluate the importance of different factors in the introduction of their innovations (R&D, design, acquisition of patented inventions, intermediate goods, machinery and equipment, etc.) and to break down the total cost of innovations into R&D, design & engineering, marketing, and investment in capital goods. Table II shows that, in general, Italian manufacturing firms assign a higher priority to the purchase of capital goods as opposed to R&D activities and, in order to introduce innovations, the cost for capital goods is almost three times the cost of doing R&D. However, in traditional industries such as clothing & footwear and wood & furniture the importance of purchasing capital goods is two or three

TABLE III. Number of firms by industry and size class (employees)[a]

	Footwear		Clothing		Furniture		Total	
9–19	2	(06.1)	1	(03.8)	5	(17.2)	8	(09.1)
20–49	9	(27.3)	4	(15.4)	14	(48.3)	27	(30.7)
50–99	11	(33.3)	6	(23.1)	8	(27.6)	25	(28.4)
100–299	11	(33.3)	11	(42.3)	2	(06.9)	24	(27.2)
300–499	0	(00.0)	4	(15.4)	0	(00.0)	4	(04.6)
Total	33	(100.0)	26	(100.0)	29	(100.0)	88	(100.0)

[a] Column percentages in brackets

times higher than the importance of doing R&D while the cost of capital goods is, on the average, more than ten times higher than the R&D cost. In other words, technological innovation in Italian traditional industries relies essentially upon technological change embodied in new machinery and equipment; in the case of Italian SDFs this seems to be the most effective external source of innovation.

III. Embodied Technological Change in Supplier Dominated Firms: Evaluation and Determinants

In this section we focus on the differences among SDFs in their capacity to take advantage of technological change embodied in new capital goods. For this purpose we introduce a procedure which, on the basis of the technological content of the new machinery and capital equipment acquired during the 1980s by a sample of Italian SDFs, allows us to measure their innovative capability. Our approach considers the impact of embodied technological change on the products, the office/factory communication systems, and the overall production process of the firm. In other words, by looking at the innovations which are made possible by investing in new capital goods we evaluate the impact of embodied tecnological change at firm level. This procedure is essentially inductive but has the advantage of taking into account the fact that in the process of innovation diffusion users do not behave symmetrically: there are not only early or late adopters but even the technological content of new capital goods can be different across firms and industries.

To single out the extent and the determinants of embodied technological change in SDFs, we studied a sample of Italian firms located in the Marche Region (where traditional consumer good industries are well-developed) that during the 1980s have been characterized by increasing investments devoted mainly to the acquisition of capital goods (cf. Santarelli, Sterlacchini and Quaglia, 1991). As Table III shows, our study refers to 88 firms which belong to the clothing industry, the footwear industry (with a prevalence of suppliers of components and intermediate products), and the furniture industry (with particular regard to producers of pre-fabricated panels).

These 88 firms were selected because, during the 1980s, they obtained long term loans from Mediocredito Regionale delle Marche in order to cover a substantial part of their investments. Mediocredito is an important financial institution which operates in Italy at the regional level and provides long term loans to industrial firms by employing either its own liabilities or intermediating funds on behalf of the central government.[2] Mediocredito allowed us to use its files, which contained detailed descriptions of each kind of machinery, group of machinery, or capital equipment acquired by the firms considered in our study. In addition, these files usually contained comprehensive information about the impact of new machinery and equipment in terms of process automation, product quality and other characteristics. When such information was lacking we interviewed suppliers of the relevant machinery and insiders of the adopting firms. At the end, to each item of machinery or equipment acquired by the SDFs included in the sample we were able to associate one or more of the following characteristics which identify different types of product or process innovation:

1. *product innovation*; this item includes products that are entirely new for the industry or, at least, for the country and that have been introduced thanks to the adoption of new machinery or capital equipment;
2. *process innovation determined by machinery developed through a process of producer-user interaction*; emphasizes the importance of the interaction between SDFs and 'specialized suppliers' (cf. Pavitt, 1984) since customized machines are likely to be employed more efficiently by the adopting firms and yield higher productivity gains and quality improvements;
3. *innovations and improvements related to the introduction of CAD, CAM, CAE, CIM, JIT, and TQC systems and/or LAN*; this item includes some specific information technologies of increasing importance for manufacturing firms, such as Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Computer Aided Engineering (CAE), Computer Integrated Manufacturing (CIM), Just In Time (JIT), Total Quality Control (TQC), and Local Area Network (LAN). These are mainly computerized systems which allow the efficient integration of numerically controlled, flexible and automated machinery. In addition computer networks are likely to enhance the efficiency of the office/factory communication;
4. *high automation*; denotes all those numerically controlled machines (NC) and controlling entities which allow the achievement of higher productivity level;
5. *product improvements*; denotes quality improvements of existing products;
6. *product differentiation and/or diversification*; include products that are new for the firm;
7. *vertical integration*; denotes the production of intermediate or finished goods which were previously provided by other firms;
8. *low computerization*; includes personal computers and workstations;
9. *low automation*; denotes station-type (ST) and automatic assembly machines (AA).

TABLE IV. Number and type of innovations induced by the acquisition of machinery and capital equipment

	Footwear	Clothing	Furniture	Total
Product innovation	1	–	1	2
Producer/user interaction	1	–	2	3
CAD, CAM, CAE, CIM, JIT, TQC and LAN	2	16	–	18
High automation	9	13	35	57
Product improvement	7	6	–	13
Product differentiation or diversification	4	–	18	22
Vertical integration	3	2	6	11
Low computerization	6	–	–	6
Low automation	50	22	99	171
Total innovations	83	59	161	303
Number of induced innovations per firm	2.51	2.27	5.55	3.44

The above list must be read in a decreasing order of importance, moving from the highest impact of embodied technological change (items 1, 2, 3) to the lowest innovative content of new capital goods (items 8 and 9). Besides, it must be pointed out that each machine, group of machines or capital equipment can be associated with more than one of the above characteristics.

The number and type of innovations allowed or induced by the acquisition of different machinery are presented in Table IV. If innovations are not distinguished on the basis of their technological content, the furniture industry, in terms of the number of innovations per firm, appears to be the most innovative one while there are not significant differences between clothing and footwear.

However, the picture is quite different if a score denoting the importance of induced innovations is associated to each of the nine types of innovation previously identified. In particular, following the relevant literature and the suggestions of experts and firm insiders, we have developed the following scoring system:

- innovations included in items 1, 2, and 3 obtain the highest score equal to 5 points;
- innovations listed in items 4 and 5 are evaluated with 3 points;
- 2 points are associated with innovations included in items 6 and 7;
- innovations corresponding to items 8 and 9 obtain the lowest score of 1 point.

On the basis of these scores, each machine, group of machines, or capital equipment can be evaluated in terms of its technological content, i.e. the importance of induced innovations.[3] The same evaluation criteria allow one to associate a 'technological' score to each firm according to the score obtained by the acquired machinery. At the firm level we compute two indicators:

TABLE V. Average impact (VALINV) and total impact (VALTOT) of embodied Technological change – means and standard deviations (in brackets) by industry.

	VALINV	VALTOT
Footwear	1.22	4.30
	(0.83)	(5.02)
Clothing	2.62	6.27
	(1.80)	(5.25)
Furniture	1.60	9.17
	(1.05)	(9.79)
Total	1.76	6.49
	(1.37)	(7.23)

– the first one is VALINV ('value of innovation') and denotes the average impact (total score of the firm divided by the number of innovative machines) of embodied technological change;
– the second is VALTOT ('total value of innovation') and simply identifies the cumulated technological impact for all the new capital goods acquired by the relevant firm.

The second index is obviously influenced by the number of innovative machines introduced by each firm while VALINV emphasizes the innovativeness of SDFs which have adopted machinery with the highest technological content.

Table V shows, for all the firms included in the sample, the average values and the relevant standard deviations of VALINV and VALTOT broken down by industry. These figures suggest that the innovative capability of Italian SDFs is influenced by industry specific factors. In particular it emerges that SDFs belonging to the clothing industry underwent the deeper process of technological innovation: their average VALINV is more than two times greater than that for firms belonging to the footwear industry, while the VALINV for furniture firms gets an intermediate value. The furniture industry obtains instead the highest VALTOT, suggesting that these SDFs firms have been characterized, during the 1980s, by a more intensive investment activity towards the acquisition of new machinery.

These results confirm the findings of specific case studies. In particular, it has been argued (Balloni *et al.*, 1990) that technological innovation is still in its infancy in the Italian footwear industry due mainly to the particular characteristics of the materials and the final products which still involve the presence of important manual operations (and skilled workers) that cannot be effectively substituted by NC machines or flexible manufacturing systems.[4] Technological opportunities associated with embodied technological change are more effective in the furniture[5] and, above all, in the clothing industry. According to Humbert (1988), clothing

TABLE VI. Average impact (VALINV) and total impact (VALTOT) of embodied technological change – means and standard deviations (in brackets) by size class.

	VALINV	VALTOT
9–19	1.15	2.38
	(1.02)	(3.62)
20–49	1.28	4.48
	(2.20)	(6.60)
50–99	1.74	6.44
	(1.32)	(6.34)
100–299	2.05	9.52
	(0.93)	(8.45)
300–499	4.06	10.20
	(2.27)	(8.07)
Total	1.76	6.49
	(1.37)	(7.23)

is likely to become a 'knowledge-intensive industry', characterized by increasing rates of adoption of information technology both at the factory and the office level. This technological trend is confirmed by the intensive diffusion of CAD and, partly, CAM and LAN among the clothing firms included in our sample (cf. Table III).[6]

The final part of this section tries to identify some firm-specific characteristics that affect the different capabilities of SDFs to take advantage of embodied technological change. First of all the relationship between embodied technological change and firm size can be examined and, at first sight, Table VI shows that both VALINV and VALTOT rise with the size class of the firms included in the sample. By applying the Z-test, the differences in means of VALINV among the size classes are significant at the 99% level of confidence: the only exception refers to the two groups of smaller firms (with fewer than 50 employees). Conversely, in terms of VALTOT, the differences among size classes are never statistically significant.

In search of a more complete framework in which, together with firm size, one can identify the impact of other firm-specific and industry-specific factors on VALINV and VALTOT, a regression analysis has been carried out. For the firms included in our sample we were able to employ the following explanatory variables:

a) the age of the firm;
b) the affiliation of the firm with an industrial or business group;
c) the nature of the firm as subcontractor.

Along with firm size, it is likely that variables a) and b) exert a positive influence on VALINV and VALTOT. The age of the firm should be positively associated with its capacity to learn how to effectively exploit external sources of technological change while the affiliation with a business group provides the firm with those tangible and intangible assets which foster its investment in new capital goods (cf. Cainarca, Colombo and Mariotti, 1990): in particular, firms affiliated with an industrial group have access to (internal and external) financial resources that are larger than those available to independent firms. Conversely it is difficult to identify *a priori* the impact of variable c). However, if subcontractors are specialized in certain phases of the production process characterized by very low capital/labour ratios the impact of variable c) on VALINV and VALTOT should be negative: this seems to be the prevalent case of subcontractors included in our sample and belonging, above all, to the clothing and footwear industries.[7]

To explain the differences among our SDFs in the extent of embodied technological change we estimated, by means of OLS, the following equation:

$$\begin{aligned}\text{VALINV}_i &= a_0 + a_1\,\text{SIZE}_i + a_2\,\text{AGE}_i + a_3\,\text{DGROUP}_i \\ &\quad + a_4\,\text{DSUBC}_i + a_5\,\text{DCLOTH}_i + a_6\,\text{DFURN}_i + \varepsilon_i \qquad (1)\end{aligned}$$

and a similar equation in which the dependent variable is VALTOT_i. The subscript i identifies the ith firm (i = 1, 2, ..., 88), SIZE denotes the average number of employees registered by the ith firm during the 1980s and AGE stands for the age of the ith firm in 1990; DGROUP (equal to one if the firm is affiliated with an industrial group and zero otherwise) and DSUBC (equal to one if the firm is a subcontractor and zero otherwise) are firm dummies. Equation (1) contains two other dummies for clothing (DCLOTH) and furniture (DFURN) firms in order to capture the impact of industry-specific factors on VALINV (or VALTOT).

When the complete set of explanatory variables is considered, the regression results – presented in Table VII – show that the impact of firm size on the extent of embodied tecnological change is not significant.[8] Conversely, firm age is positively associated with embodied technological change and its coefficient is particularly significant when the dependent variable is VALTOT: since VALTOT is a cumulative index of the technological content of all the capital goods acquired by each firm this latter result is not surprising. More interesting is the positive impact of AGE on VALINV since it suggests that learning processes improve the capacity of SDFs to take advantage of external sources of technological change. Moreover, firms that are affiliated with a business group are characterized by a higher average impact of embodied technological change while the subcontracting nature of the firm exerts a negative influence on VALINV: when the dependent variable is VALTOT the same explanatory variables (DGROUP and DSUBC) are no longer significant. Finally, along with the above firm-specific factors, industry-specific characteristics captured by DCLOTH and DFURN show, respectively, a positive and significant impact on VALINV and VALTOT.

These findings suggest that the different propensity of SDFs to rely on embodied technological change cannot simply be explained by their relative size: there are other important organizational factors, learning capabilities and industry characteristics which foster the adoption of the most innovative machinery. Considering the

TABLE VII. Regression results[a]

	Dependent variables VALINV	VALTOT
Constant	0.725	−1.068
	(2.80)	(0.69)
Size	0.001	0.015
	(0.10)	(1.59)
Age	0.063	0.434
	(3.63)	(4.17)
DGROUP	1.126	0.519
	(3.28)	(0.25)
DSUBC	−0.776	−1.583
	(3.04)	(1.04)
DCLOTH	0.996	0.328
	(3.34)	(0.18)
DFURN	0.531	5.047
	(1.74)	(2.79)
Adjusted R^2	0.447	0.331
F	12.72	8.17

[a] Number of observations = 88;
T-statistics in parentheses.

characteristics of our sample, it must be said that two of the above factors – namely, the age of the firm and its affiliation with a business group – could positively affect the credit-worthiness of the firm, i.e. the probability of having received, during the 1980s, larger financial loans by Mediocredito Regionale delle Marche in order to buy more expensive capital goods with higher technological content. Nonetheless, even these financial considerations cannot be excluded from the analysis since they play an important role in the process of innovation diffusion.

IV. Policies Affecting the Diffusion of New Machinery in Traditional Industries

Within the European Community (EC) policies which foster the adoption of technologically advanced machinery might be helpful in bridging the gap between countries with a prevalence of 'scale-intensive' firms (such as Germany, UK, and The Netherlands) and countries where SDFs are widely diffused (like Italy, Greece, Spain, Portugal, and partly France). These considerations notwithstanding, in Europe – at both the national Government and EC level – the diffusion of new technologies has usually been considered as a problem of strengthening the industrial potential for R&D in order to meet the 'American Challenge' (Servan-Schreiber, 1965) during the 1960s and the 1970s and the Japanese Challenge in the 1980s. Until the early 1980s these goals had been pursued by the various national Governments through the promotion, mainly via mergers and subsidies, of large

TABLE VIII. Ratio of investment in new machinery financed through the Sabatini Law to gross fixed investment

	1984	1985	1986	1987	1988
Chemicals	1.69	2.06	3.14	5.47	5.15
Metal products, mechanical & electrical machinery	–	–	–	6.82	4.98
Motor vehicles	–	–	–	1.32	0.82
Food, beverages & tobacco	2.58	2.24	3.23	4.51	3.85
Textile, clothing & footwear	1.52	2.54	3.72	9.18	7.25
Paper & printing	2.95	2.74	2.20	5.44	5.58
Other manufacturing	1.59	1.66	0.95	2.31	2.05
Total manufacturing	1.86	2.02	2.77	5.18	4.34

Source: Balloni, Santarelli and Sterlacchini (1992).

firms in technologically strategic industries. A shift in the focus of technology policies from national Governments to the Community occurred in the 1980s with the joint development of interventionist programs aimed at nurturing new high-tech industries[9] and diffusion oriented schemes. The latter are particularly devoted to improve manufacturing technologies (BRITE) and promote technology transfer (SPRINT), technology initiatives at the regional level (STRIDE), and training and human mobility (cf. Sharp and Pavitt, 1993). However, the large majority of these policies focus upon the need of creating the potential for generating innovations and, in this respect, they are severely biased against industries and firms which do not internally perform innovative activities.

In particular, within this technology policy framework the diffusion of advanced production technologies in SDFs has played a secondary role, remaining excluded from the crucial goals of the Community. The case is somewhat different when seen at the national level, since some countries in the EC (especially France and Italy) have introduced programs providing financial incentives and/or tax benefits to SDFs which invest in new machinery and equipment.

In France, Adepa – an agency promoted by the Ministry of Industry – launched two programs in 1980 specifically devoted to supporting innovation in small and medium sized firms via embodied technological change (cf. Odifreddi, 1991): the first program – called Meca – provides financial incentives for the introduction of new machinery; the second one – called Logic – is specifically designed to fund the adoption of CAD/CAM systems. These programs have been largely utilized by firms with fewer than 50 employees and in particular by those belonging to the mechanical, electrical, electronic, textile and other consumer good industries.

In Italy, policies specifically designed to promote the adoption of new machinery in SDFs have been introduced since the second half of the 1960s. In particular, the Sabatini Law of 1965 (n. 1329)[10] had represented, until the early 1990s, the most important source of financial support for firms investing in new machinery and capital equipment. Even though firms of all sectors were admitted to the benefits of the Sabatini Law, Table VIII shows that, at least during the second half of the 1980s, the incentives introduced by this program represented an important source of financing mainly for firms belonging to traditional industries, particularly those analyzed in the third section of this paper.

During the 1980s, other laws had complemented the Sabatini Law by providing financial support for investment in numerically controlled and operated machines and related software. Among those, Law 696 of 1983 was specifically devoted to fostering the adoption of embodied technological change in small and medium sized firms (with less than 300 employees):[11] in effect, like the Logic program in France, it funded the introduction of 'highly automated machines'.

In 1991 Law 317 was introduced in order to promote innovation in firms having less than 200 employees and to provide either financial incentives or tax benefits (which encourage internal financing) to those firms which adopt new microelectronics-based machinery. Moreover, it is aimed at stimulating the autonomous innovative capability of small firms; to this end, it grants financial assistance to cooperative R&D projects involving industrial firms and private or public research centers.

Law 317 has replaced all previous national policies for embodied technological change and its implementation by the Italian Government is extremely important. In effect, the Italian experience shows that this kind of public intervention is particularly effective in raising the technological level of SDFs belonging to traditional industries since, as stressed in the previous sections, they are mainly small and medium sized firms and rely primarily on embodied technological change. Moreover, looking at the different ability of Italian SDFs to cope with this external source of innovation, we found that the extent of the innovative process depends not only on industry-specific factors but is also associated with the learning capabilities and the organizational structure of the firm. In this connection, it is difficult to design specific policies in order to provide small independent firms with the positive externalities available to firms affiliated with large organizations. Policies affecting the diffusion of innovation among traditional industries should instead be more linked with the provision of fiscal and financial incentives to the SDFs involved in a process of merger, affiliation, integration or, in any event, coordination with other firms.

Notes

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1. By using these data Sterlacchini (1989a) and Geroski (1991) found that, throughout UK industries, the impact of used innovations on total factor productivity growth was stronger than the impact of produced innovations.

2. In the Marche Region, during the 1980s, about a half of the gross fixed investment undertaken by the clothing, footwear and furniture industries were financed through Mediocredito loans.
3. It must be reminded that each machine can give rise to more than one type of innovation. As a consequence, the maximum (theoretical) score attributable to one machine is 30 since the presence of 'high automation' or 'LAN' excludes, respectively, that of 'low automation' or 'low computerization'.
4. A CAD system for footwear was finally introduced in Italy at the end of the 1980s, but it has not been adopted by the firms included in our sample. At the international level, other important technological advancements in the footwear industry during the early 1980s are analyzed by Boon (1984) and Guy (1984).
5. In Italy, during the 1980s, there had been a very intensive adoption of NC machines by the firms producing pre-fabricated panels for a variety of furniture products (cf. in Table III the number of innovations classified under the items 'high automation').
6. The technological level of the clothing firms included in our sample reflects a peculiar feature of the European clothing industry in which more automated equipment is employed than in the U.S. and other OECD countries (cf. Hoffman and Rush, 1988).
7. The case of subcontractors belonging, for instance, to the mechanical or electrical machinery industries is different since their plants' level of automation and the 'standardized' quality of their products are both much higher.
8. This result is attributable only partially to the positive correlation between SIZE and AGE (the coefficient of simple correlation is equal to 0.33): in effect, even when AGE is not inserted in the same regression, the coefficient of SIZE remains statistically insignificant.
9. In particular, the Community has established programs devoted to promote generic research, even at the pre-competitive stage, and collaborative research: ESPRIT and RACE in the information technology field; BRIDGE, FLAIR and ECLAIR in bio-technologies, etc. (for a survey, see Sharp and Pavitt, 1993).
10. The original aim of Sabatini Law was that of strengthening the Italian producers of specialized industrial machinery facing an adverse trade cycle during the early 1960s.
11. Law 399 of 1985 and Law 165 of 1989 were extensions of Law 696. In particular, Law 399 promoted the adoption of CAD/CAM systems (cf. Scanagatta, 1989).

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