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Technical skills and small innovative firms in Northern and Southern Italy

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This paper illustrates the outcomes of research carried out on a sample of Italian small software firms. The role of the entrepreneur and the relationships between the firm and professionals are crucial to sustain the firm's innovative capabilities: professional skills, job satisfaction, autonomy and personal knowledge are the most important sources of the software firm's performance. On the basis of the field data, dynamic behaviour is presented to illustrate how the small firms located in Northern and Southern Italy sustain innovative capabilities and development activities. The complex organisational interaction among the entrepreneur, the project team, the professional network and the technological assets of small companies is strictly related to environmental differences between Northern and Southern Italy, and explains the dynamic behaviour of the firms located in the two areas. Our conclusion is that the small companies in the South, to survive and grow in a less developed area, must be more organised and be provided with stronger internal technological competencies than the Northern firms. On the other hand, as it is more difficult to build internal technical skills in the South, a vicious circle is started which makes Southern firms marginal and opens the Southern market to competitors from outside.

1. Small firms' innovative capabilities

The economic literature on innovative firms has underlined that some firms are better positioned than others as to the implementation and use of innovations, even though they operate within the same sector and face the same competitive conditions (Acs and Audretsch, 1990; Rothwell, 1988; Pavitt, 1988; Storey and Johnson, 1987). To explain the different firms' innovative behaviours, a set of factors was identified and analysed (Gibb and Scott, 1985; Kelly and Brooks, 1991): (i) structural incentives to innovate; (ii) internal technological resources; and (iii) resources of the network within which the firm is included (Fig. 1). The literature shows a picture of a small firm that, to support successfully its innovative capability, must have a minimum size and hold internal skills in order to use effectively all opportunities resulting from a network of stable linkages with external economic agents.

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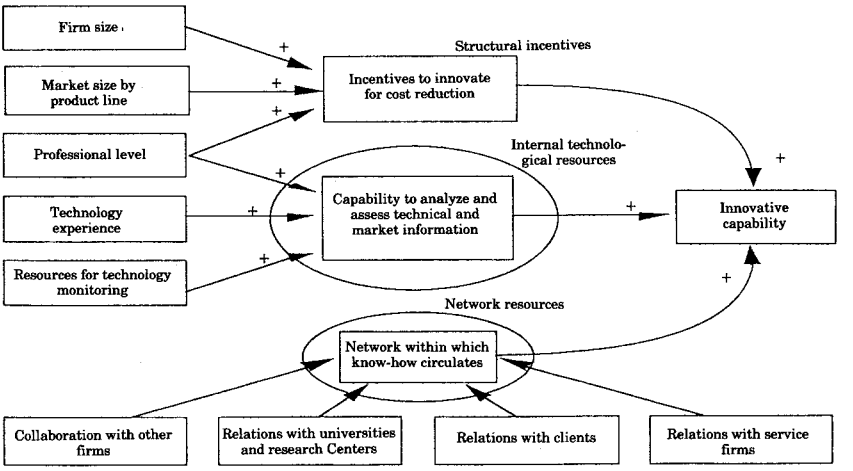

Fig. 1 *The sources of the innovative capability of small firms.*

The in-firm/out-firm relations are crucial to support a small firms' innovative capabilities. This is a result of: (i) the small firms' difficulty to finance long-term internal technological developments (Greiner, 1972; Huppert, 1981; La Belle *et al.*, 1980); and (ii) the difficulty of sustaining their technological capabilities when losing the inventor-founder-manager's support which becomes increasingly concerned with firm management (Marc, 1982; Meyer and Roberts, 1986).[1]

A major role is played by the boundary-spanning activities, namely the set of activities enabling the small firm to get in touch with the external environment (Brown and Swab, 1984; Felman, 1989; Quinn, 1979) and to import and utilise technical skills and information.

The ways in which technical information is imported into the innovative project team is similar to those described by Allen's two-step communication model (1977): a key person, linked both to the project team and to institutions and external subjects, is the source of technical know-how. The firm's acquisition process for technical information takes place in two stages: the transfer of information from the external environment into the firm through the key person (defined 'technological gate-keeper') and information transfer into the project team.

Small innovative firms are forced to manage the paradox of using external technological sources without decreasing their control of the innovation process. This means that the firms, whose technology is mainly person-embodied, are forced to find organisational solutions in order to combine the need to use relatively

[1]Sappho's project, developed in England in the early 1970s, showed that successful innovators make use of external technologies and scientific consultancies (Rothwell *et al.*, 1974). Friar and Horwitch (1986) underlined the need for the firm to have access to external technologies. Pavitt, Robson and Townsend (1987) maintain that high tech small firms depend on external technological resources. Kelley and Brooks (1991) emphasise that a highly developed external network overcomes the learning problems experienced by the small firm when using only internal resources. To the small firm the intra-industry and inter-industries 'horizontal' circulation of technology is particularly crucial (Del Monte, 1980; Antonelli, 1984).

autonomous technical personnel with the requirement of controlling and maintaining their innovative capability. What is the technician/firm relation? How to combine the need to control the technical staff's activities with the need to foster an exchange between the external environment and the firm's technicians?

The following sections (2–4) analyse the importance of these factors in explaining the different innovative performance of software firms located in the Northern and Southern parts of Italy. To this end, innovative capability is defined according to the different skills present in a software firm and the capacity for sustaining the development of new products. The authors conclude that the internal characteristics of the firms do not emphasise meaningful differences between North and South. Instead, differences in innovative capabilities are ascribed to the complex relationships between the firm and the environment.

2. The sample

The outcomes illustrated in this paper are grounded on 50 case studies of small software firms investigated from 1990 to 1992. Thirty-one of these firms are located in Central-Northern Italy and 19 in Southern Italy[1] The study is not a statistic one, as it aims to identify the set of factors underlying the innovative and operational capability of firms operating in two different areas.

As to the major differences between Northern and Southern Italy, it is sufficient to underline that in the former 88% of the firms supply such services. The main macro-economic measures show the overall weakness of the southern economic system: in the South industrial employment is about 23% of the total employment compared to 36% of the North, the unemployment rate is about 21% compared to 7% in the North.

The information service sector in Italy in 1992 accounts for 13,420 billion liras, with about 4000 firms and 68,000 employees. The software development sub-sector accounts for 5279 billion liras with about 1500 firms and 25,000 employees. Among these, 18,000 are technicians: 12,000 full-time internal employees and 4000 experts, consultants, and part-timers linked to the firms' project teams by various labour relationships.

Sixty-eight percent of the software firms are located in Northern Italy (29% in the area of Milan), 20% in the Centre (mainly in Rome), and only 12% in Southern Italy (mainly in the area of Naples and Bari).

Southern Italy's software demand depends mostly on the public sector and on traditional services. Both from the market and technological point of view, the small software firms operate in a poorly developed area. They meet great difficulties in facing competition based on a high rate of product innovation.

The research aims to answer two questions: how are southern small firms organised to face competition? What are the development possibilities of southern innovative small firms?

[1]Hereafter Central-Northern Italy will be shortened. The term Northern Italy will be used.

Table 1. *Firms' distribution by age and specialisation degree in software development*

	Degree of specialisation in software development (software sales revenue %)							
	A Specialised (>65%)		B Systemic (35–65%)		C Marginal (<35%)		Total	
Firms age	North	South	North	South	North	South	North	South
1 Young (0–3 years)	4	2	4	0	0	3	8	5
2 Well established (4–7 years)	11	4	1	3	0	2	12	9
3 Mature (>7 years)	4	4	3	1	4	0	11	5
Total	19	10	8	4	4	5	31	19

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

Small software firms were chosen for two reasons.[1]

(i) In the software industry manufacturing technology is basically made up of technician-embodied professional skills. In spite of the remarkable development of software engineering in the last 10 years, and notwithstanding the early availability of advanced development environments such as the CASE, professional skills will still be crucial in the near future. For this reason software firms are an excellent laboratory to analyse the organisational implications of person-embodied technologies;

(ii) In the software industry small firms are prevalent. The first seven European firms control only 7% of the market. The 4000 Italian firms manufacturing software or supplying information technology services employ 11 people on average, and 97% of the firms are small firms (up to 50 employees and 8 billion liras) and cover 60% of the market (Torrisi, 1991; OECD, 1989; Assinform, 1991). In the last decade small firms prevailed in the industry's development. However, the competitive situation is changing owing to the increasing focus of traditional information technology leaders (hardware producers) on software manufacturing. This, together with the strong technological dynamics and the new demand characteristics, is rapidly changing the small firms' room to manoeuvre.

The sample is categorised according to two variables: the age of the firms and their specialisation level in software manufacturing (Table 1). The firms are subdivided into three age clusters: young firms (aged from 1 to 3 years), well-established firms (from 3 to 7), and mature firms (more than 7 years old). According to their age, firms have to face different choices and activities: (i) young firms are

[1]In the years 1983–87 the authors investigated about 200 software firms located in different areas of Italy. The outcomes of this research are included in the book '*Software, tecnologia e mercato*' (Raffa and Zollo, 1988). In 1990 new research was started in order to analyse the software firms' development trajectories and the organisation and technology changes experienced by them during the 1980s. A new field survey was simultaneously started aimed at investigating the firms already analysed in the previous research and to widen the sample of firms. Firms were investigated as case studies in order to collect not only the most accessible quantitative information but also to understand, by means of interviews with business managers, the complex organisation problems faced by a small firm introducing innovations. The outcomes illustrated in this paper refer to 50 firms investigated in the period 1990–92.

looking for their own business idea and are engaged in organising the internal and external resources required to sustain their activity. In this early stage the entrepreneur's professional and managerial skills play a crucial role in shaping the firm's strategy; (ii) well-established firms have already tested their business idea with varying rates of success. Their crucial problem is how to shift from a technology and market position, acquired thanks to the initial spur of the founding group, to a development strategy involving new professional and organisational resources; (iii) mature firms have already tested their production organisation. Their problem is to incorporate into the organisation new organisational procedures in order to support not only their production capacity but also innovation.

The second classification refers to one of the basic issues in formulating the software firms' business ideas: the degree of specialisation in software development. This issue is linked both to strategic and operational choices as well as to organisational arrangements. Three sets of firms were identified: specialised firms with a software sales revenue equal to more than 65%; systemic firms, with a software sales revenue ranging between 35 and 65%; marginal firms (from the software stand point) with a software sales revenue of less than 35%.

These three sets of firms must be analysed and assessed differently: (i) in the firms specialising in software development what is crucial is the choice of the product portfolio and of the market segment the firm is positioned in: a major role is played by technology innovation problems as to the product and process; (ii) systemic firms view software development as a component of a larger business, usually involving also hardware commercialisation and supply of information technology and professional services. Their strategic choices are related to the product and service mix as well as to their commitment for software development; (iii) in the marginal firms software is an activity supporting the firm's core business. In these firms software activities are usually driven by specific market requirements and usually involve customisation of non-proprietary products.

3. Firms' innovation characteristics

3.1. Issues analysed

The small firm's performance is the result of its various skills. In order to analyse a firm it is necessary to identify the skills underlying its operation and innovative capability and the way in which these skills interact and change over time.The firm's skills were ranked by four categories:

(i) Capability to exploit rent positions: The rent of the small software firm is determined by the amount of installed packages. Another rent factor might be the entrepreneur's origin (for instance, a technical entrepreneur exploiting this advantage is one who keeps contacts with the university he comes from or with other firms worked for). All rent positions are exhausted over time; for this reason the firm cannot rely only on current advantages for its survival and growth but must build up new advantages by introducing other skills.

(ii) Operational capability: This includes the ability to implement an efficient development system through development methodologies, the criteria for training and management of the project teams, the definition of internal standards, the

definition and management of the firm's procedures. These skills are quite crucial to software firms operating in an environment with few technical constraints in which the individual contribution is always the crucial variable, where each project has strong peculiar characteristics, and where it is difficult to establish stable routines.

(iii) Capability of adjustment to the specific framework: This includes the possibility to introduce constant changes into current products and processes and the ability to adjust to market requirements and to technological strains without undermining the production system or generating organisational tensions. Examples include market enlargements through the inclusion of similar markets, development of new programme releases, and ability to customise products.

(iv) Research capability: This includes monitoring of the environment to introduce basic changes into the current processes by experimenting new solutions, anticipating trends, and getting familiar with new technologies and new market requirements. This often means that the firm is able to accept an order requiring different capabilities from its established ones, to acquire a new technology, and to take risks in partially known fields. For this purpose the firm must allocate specific resources to explore the environment it operates in. This can be done by attending courses and workshops, or through research projects and through joint-ventures.

The four capabilities described above are necessary to the innovative firm and, during the firm's life, they have a different weight giving rise to different strengths, different organisation routines, and different ways to sustain competition. To highlight the interconnections between the various capabilities, an analysis of the firm is required that goes beyond the quantity data statistically gathered. It is necessary to investigate each firm as a case. This paper is a first elaboration aimed at defining—according to a more traditional approach—some of the most meaningful variables characterising the firm's capabilities. This paper then focuses on some factors explaining in broad terms the operational and innovative capabilities of the firms, whereas little room is given to the analysis of how these factors turn over time into the firms' specific capabilities.

3.2. The firm's size

The size of the firm is viewed as an important incentive to introduce process innovations aimed at reducing costs through the introduction of technologies, methodologies and procedures making the new product development process more predictable and reliable.

In the sample of firms, the size in terms of sales revenue ranges from a minimum of 100 million up to 13.5 billion liras. The number of employees varies from two to more than 50. Table 2 illustrates the average sales revenue and the number of employees, showing the existence of large variations among firms. This is due to: (i) the artisanal nature of a large part of the manufacturing process; (ii) a 'novice' expert demand generating continuously changing market niches; (iii) low financial entry barriers; and (iv) various technologies and languages, some of which have been used for more than two decades (Raffa and Zollo, 1991B).

Firms can be easily established if the founding group is able to catch some specific order or to identify a market opportunity, even though it is a small opportunity restricted to a specific territorial area. As a result, most of the firms are small-sized

Table 2. *Firms' size characteristics (average values)*

	Degree of specialisation in software development (software sales revenue%)							
	A Specialised (>65%)		B Systemic (35–65%)		C Marginal (<35%)		Total	
Firms age	North	South	North	South	North	South	North	South
Sales revenue (billions of lira)								
1 Young (0–3 years)	0.70	0.28	1.35	0.00	0.00	1.77	1.02	1.17
2 Well established (4–7 years)	1.87	0.98	0.25	1.00	0.00	5.25	1.73	1.93
3 Mature (>7 years)	5.90	3.55	4.00	5.00	12.13	0.00	7.65	3.84
Total	2.47	1.87	2.20	2.00	12.13	3.16	3.65	2.23
Total employees (# of employees)								
1 Young (0–3 years)	9.00	5.50	8.00	0.00	0.00	9.00	8.50	7.60
2 Well established (4–7 years)	14.55	13.50	3.00	11.33	0.00	34.50	13.58	17.44
3 Mature (>7 years)	51.25	28.25	87.67	27.00	51.00	0.00	61.09	28.00
Total	21.11	17.80	37.25	15.25	51.00	19.20	29.13	17.63

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

with an average sales revenue that amounts to about 3 billion and with the number of employees ranging from 20 to 25.

To verify whether size has driven the firms to seek process innovations, the larger firms were investigated to analyse the consistency of their technological endowment. The building up of a technological endowment required three elements: (i) identification of development technologies for product manufacturing and maintenance; (ii) planned staff training to introduce technological competencies into the firm; and (iii) standardised project management.

An Innovation Investments index (*II*) has been built based on the investment in human resources [calculated by the ratio between graduate software employees (*GSE*) and software employees (*SE*)] and the presence of investments in development technologies (*D*), training (*T*), and standards (*S*). Because it has been difficult to evaluate the investments, we defined only the full presence (value=1), the absence (value=0) and a partial presence (value=0.5) of the investment. The *II* index has been built using the following formula:

$$II=\frac{GSE}{SE}\times\frac{D+T+S}{3}.$$

This index ranges from 0 (absence of innovation investments) to 1 (maximum effort in innovation).

There is no significant correlation between the size index (calculated as the normalised value of the employees) and the innovation investments index. In any case, the correlation is not meaningful because the firms in the sample are not homogenous. The systemic (group B) and the marginal firms (group C) display different innovative behaviour firms because of their different strategic orientation, while the young firms (group 1) are not comparable with the other groups because of the uncertainties in their strategic orientation owing to their youth. Consequently, we developed a deeper qualitative analysis of groups A3 and A2, which are the most homogenous.

The analysis of the mature and well-established specialised firms (groups A2 and A3) in Northern and Southern Italy (Tables 3.1 and 3.2) indicates exhibits that all firms faced the problem of organisational change to support a size increase. With reference to the three variables identified above, there are no meaningful differences between North and South for group A3, while differences emerge for group A2.

In general the firms introduced development technologies, such as tools for document recording, prototype generators, and database advanced platforms (Oracle and Informix were amongst the most widely used environments). Even though all firms carry out training activities, northern firms undertake both in-firm and out-firm training, whereas southern firms undertake mainly out-firm training. As a matter of fact, their standards are simply the well-established procedures experienced internally without comparison to the models and procedures usually used domestically and internationally for software quality certification. Therefore the firms approach the process innovation from the local perspective of adjustments in organisation and production problems, rather than from a higher strategic and competitive perspective.

Table 3.1. *Development technologies, training and standards of group A3 firms*

Firms' no.	Employees [*E*]	Sw employees [*SE*]	Graduate Sw employees [*GSE*]	Development technologies [*D*]	Training [*T*]	Standards [*S*]	Innovation investment index [*II*]
North							
18	30	21	9	Yes	Yes	Yes	0.43
21	45	30	17	No	Yes	Partially	0.28
26	30	18	8	Partially	Partially	Partially	0.22
32	100	45	45	Yes	Yes	Yes	1.00
South							
1	23	18	14	No	Yes	Partially	0.39
5	15	15	13	Yes	Yes	Partially	0.72
42	70	50	10	Yes	Partially	No	0.10
44	5	5	4	Yes	Yes	Partially	0.67

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

Table 3.2. *Development technologies training and standards of group A2 firms*

Firms' no.	Employees [*E*]	Sw employees [*SE*]	Graduate Sw employees [*GSE*]	Development technologies [*D*]	Training [*T*]	Standards [*S*]	Innovation investment index [*II*]
North							
17	14	8	7	Yes	Partially	Yes	0.73
24	9	5	2	Yes	Partially	Yes	0.33
25	6	4	2	No	Partially	No	0.08
28	5	4	4	No	No	No	0.00
34	5	5	2	Yes	No	Yes	0.27
35	15	13	10	Partially	No	Partially	0.26
38	17	13	1	No	No	No	0.00
39	42	31	27	Yes	Yes	Yes	0.87
47	23	17	8	Partially	Partially	No	0.16
48	9	7	4	No	Partially	No	0.10
50	15	12	4	Yes	No	Yes	0.22
South							
3	20	15	13	Yes	Partially	Partially	0.58
36	14	10	2	No	No	No	0.00
37	10	9	0	No	No	No	0.00
45	10	6	2	Partially	No	No	0.06

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

Table 4. *Firms' market orientation*

Firms age	Degree of specialisation in software development (software sales revenue%) A Specialised (>65%) North	A Specialised (>65%) South	B Systemic (35–65%) North	B Systemic (35–65%) South	C Marginal (<35%) North	C Marginal (<35%) South	Total North	Total South
Vertical markets								
1 Young (0–3 years)	3	2	3	0	0	0	6	2
2 Well established (4–7 years)	8	4	1	1	0	1	9	6
3 Mature (>7 years)	3	4	1	1	1	0	5	5
Total	14	10	5	2	1	1	20	13
Horizontal markets								
1 Young (0–3 years)	1	0	1	0	0	3	2	3
2 Well established (4–7 years)	3	0	0	2	0	1	3	3
3 Mature (>7 years)	1	0	2	0	3	0	6	0
Total	5	0	3	2	3	4	11	6

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

3.3. The market size

The second condition affecting process innovation is market size. Most of the firms (33 out of 50) are vertical or niche market oriented. The markets may be very specialised—such as the building industry, notaries, or commercial lawyers—thus enabling the firm to exploit its direct knowledge of the market or of the technical procedures used by the customers (Table 4). The crucial element to assess their importance for process innovation is the number of installed packages. In the vertical market the number of installations varies widely, ranging from six to 3000 units. Excluding the young and marginal firms, undertaking a small number of installations, in the four other groups the number of installations depends on the kind of software project (large orders or small projects) and on the firm's ability to compete in the market. In general there is no relationship between market size and process innovation. Also the firms with a large number of installations do not perform customer management or maintenance and updating through the use of the most advanced management and manufacturing technologies. In some cases, the firm does not even know its customers since the relationship with them is delegated to distributors.

The firms operating in horizontal markets (17 out of 50) develop packages for general management utilisation (accounting, personnel, etc) and, carry out different numbers of installations (from 50 to 3000). These firms focus more than others on development problems of releasing new products and consequently they try to implement a higher degree of standardisation to the production process.

In total, there is nearly the same proportion of firms in Southern and Northern Italy in the two segments of the software market. Nevertheless, in analysing the behaviour of the different groups of firms differences in the orientation between the two regions emerges.

Products for the horizontal market in software, i.e. tools and packages for general purposes, are difficult to design, develop and update. Furthermore, marketing and maintenance require continuous effort. Consequently, some young firms serving horizontal markets can be found in Southern Italy. However, in general they are not able to grow by pursuing a horizontal strategy. Indeed from Table 4 we note that in Southern Italy the firms selling software for horizontal markets are concentrated in the first two stages of their life-cycle. In contrast, in Northern Italy, six horizontal market firms are in the maturity stage. Furthermore, in Southern Italy the horizontal market firms belong only to the B and C groups, that is to the less important groups from the innovative point of view.

The major differences among the firms are due to the external conditions that supported their growth during recent years. A more advanced demand in the North favoured the establishment and development of firms operating also in horizontal markets, whereas southern firms operate almost exclusively in vertical markets.

3.4. The network size

The network resources of the firms are quite different. There are firms having relations only with hardware suppliers and firms that are part of a complex game of exchanges involving other software firms, universities and the most innovative customers. We evaluated the most important social links bringing new information and knowledge into the firm's research group. For the purpose of the analysis the degree of formality of the channel is not relevant.

One might expect that the network relations of the northern firms with other firms and research institutions is larger than the networks of the southern firms and that this factor can affect in a remarkable manner the firms' innovative capabilities. This expectation is only partially confirmed by the outcomes of the field research. Both in the South and in the North a wide range of situations exist. Firms range from those having relations only with hardware suppliers to firms whose contacts include software firms, universities and the most innovative customers.

To analyse both the amount of the external relations network and its impact on the firm's activities we must investigate how firms build and manage network resources. Tables 5.1 and 5.2 synthetically illustrate the outcomes of an investigation of eight firms of the group A3 (specialised, mature) and on 15 firms of the group A2 (specialised, well-established).

In general we can see that:

(i) Mature firms have a wider network than the well-established firms. Therefore a higher degree of openness to external collaborations seems to be a condition for increased growth and competitiveness. This observation is supported by another factor. All firms in the groups A2 and A3 kept increasing their exchanges and level of collaboration with the external environment in order to find and manage new opportunities and to complete and up-date the initial know-how introduced by the entrepreneurial group.

Table 5.1. *Network resources of group A3 firms*

Firms' no.	Other firms	Collaboration with University, research centres	Innovative clients	Service firms
North				
18	Yes	Yes	Yes	Yes
21	Yes	Yes	Yes	No
26	Yes	No	Yes	No
32	Yes	No	Yes	Yes
South				
1	Yes	No	Yes	No
5	Yes	No	Yes	No
42	No	Yes	Yes	No
44	Yes	No	Yes	No

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

Table 5.2. *Network resources of group A2 firms*

Firms' no.	Other firms	Collaboration with University, research centres	Innovative clients	Service firms
North				
17	No	Yes	No	Yes
24	No	No	No	No
25	Yes	No	No	No
28	No	Yes	Yes	No
34	Yes	No	Yes	No
35	Yes	No	No	No
38	—	—	—	—
39	Yes	No	No	No
47	Yes	No	Yes	Yes
48	No	Yes	Yes	—
50	No	No	Yes	No
South				
3	Yes	No	Yes	No
36	No	—	—	—
37	Yes	Yes	—	—
45	Yes	No	Yes	No

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

(ii) At the beginning of its activities the firm's network, is as a rule extremely poor and based on the entrepreneur's-founder's personal relations. The enlargement of the personal relations network of the entrepreneurial group is affected by the entrepreneur's origin. For instance firms having relations with universities are

usually founded by professors and university researchers or by graduate technicians still connected to their universities. This is true both in Southern and Northern Italy. What seems to be missing, however, is a strategy aimed at enlarging the network in specific directions.

(iii) The question of know-how and its relationship with the customer is mentioned frequently. Von Hippel's research (1988) emphasised how the customer is one of the small firm's most effective resources for developing an innovative capability. This resource is often neglected and mismanaged. All the firms in group A3 (mature specialised firms) maintained that they received suggestions on how to improve their products from their own customers. In some cases customers even provided suggestions on new products, whereas this happens very rarely with firms in group A2 (well-established specialised firms). The customer is surely perceived as a crucial resource but is mentioned frequently. In this case there is no strategic or organisational response by the firm. The firm allocates very limited resources to customers; their involvement is usually restricted to the product test stage and very rarely do they contribute to the design stage. Above all, no attention is paid to identifying and managing especially innovative customers that might anticipate market trends and requirements. In many cases the relationship with the customer is indirect and is managed by commercial intermediaries providing temporary and short-term responses to the customers' demands.

(iv) Relationships with other firms, above all with consortia, are viewed by the firms as necessary but basically marginal relations, not having a crucial impact on the firm's operational and innovative capability. Therefore these relations may be characterised as opportunistic or lacking trust. There are few or no consultancy relations with service firms.

In general, the existing network was built up randomly. On the other hand, when the network is well established we find firms carrying out complex projects through it, having a high product innovation capability and using advanced development technologies. This discrepancy—namely the firm's lack of commitment to network building and, lack of understanding of its importance for supporting its innovative capability—seems to reflect a culture of entrepreneurship typified by a focus on the firm's internal resources, viewed as more reliable and controllable.

From a quantitative perspective there are almost no differences between the networks used by firms in Southern and Northern Italy. But some cases suggest that there are some qualitative differences. Tables 5.1 and 5.2 show that none of the Southern firms have relationships with service firms. Furthermore, the Southern entrepreneur often does not know who his most direct competitors are, and the other firms he co-operates with are mainly hardware suppliers. Consequently, the Southern software firms usually develop networks only along the vertical linkage of supplier–firm–customer, leaving the surrounding environment unknown.

4. Role of professional skills

Professional skills are the small software firms' most important resources for acquiring the expertise and information needed to support their innovative

capability. The identification of the technological market opportunities and updating of the firm's expertise is achieved through the introduction of new operational skills into the firm.

The small software firm can very rarely develop procedures, methodologies and internal standards that are independent of the characteristics of the available professional skills. The firm's technological endowment is basically made up of two types of resources that are strictly inter-related: technical staff (software technicians, engineers, researchers, experts, consultants, etc) and methodologies (analysis and development methods, test procedures, development environment, communication and recording systems, etc) (Floyd, 1979; OECD, 1986; Reifer, 1981). Technical skills are undoubtedly the most important component of the technological endowment. Together with satisfaction, autonomy and individual know-how, they crucially affect project quality and effectiveness in meeting product requirements (Barocci *et al.*, 1983; Couger and Zawacki, 1980; Weinberg, 1982).

Other elements play a major role such as the nature of the programmer/analyst relation, the research team members, the project leader and the users (Goldstein, 1982). In particular, a major role is played by the technical-managerial aspect of the entrepreneurial group and by the kind of responsibilities assigned by the entrepreneurial group to the project leader and to the programmer/analyst as regards a specific part of the software project (Gallino, 1983; Gibb and Scott, 1985). The 50 software firms being investigated have 24.8 employees on an average. Northern firms are slightly larger than those located in the South (29.1 employees in the North compared to 17.6 employees in the South). Table 6 illustrates the percentage of software employees in total employment for the different types of firm.[1] The number of employees concentrating on software development is very high, ranging from 62% to 69% of the total, in Southern and Northern Italy, respectively.

The numerous professional roles identified through the field survey reflect differences in the firms' definition of personnel tasks. In fact, there are employees performing very complex roles (experts, project leaders, system engineers, project engineers, product managers); multi-functional technicians (software technician, analyst-programmer, analyst-trainer); a more standard classification (making the distinction between analyst and programmer), and support roles (documentationalist and installer).

The various professional skills within the firms result from different organisational arrangements. Some firms have a complex and formal organisation, typified by a high number of professional skills compared to the average. Other firms are typified by only one or two professional roles. This low number of professional skills is offset by the complexity of the tasks performed by the entrepreneur-founder who simultaneously performs managerial and technical functions. Moreover this low

[1]A comparison of 30 firms investigated both in 1984 and in 1990–91 exhibits that the percentage weight of software employees declined remarkably. It shifted from 72% to 51% of the total employees, regardless of firm size. A further investigation shows that both in the firms that increased their total employees and in those that performed a personnel reduction, the percentage of software employees declined because small software firms have major difficulties in specialising in software development. Consequently they try to sustain their growth through diversification such as hardware commercialisation, systems selling and/or the supply of a range of professional services (Raffa and Zollo, 1991B).

Table 6. *Software employees: % of total employees (average values)*

	Degree of specialisation in software development (software sales revenue %)							
	A Specialised (>65%)		B Systemic (35–65%)		C Marginal (<35%)		Total	
Firms age	North	South	North	South	North	South	North	South
1 Young (0–3 years)	87.50	100.00	46.25	0.00	0.00	25.00	66.88	55.00
2 well established (4–7 years)	93.00	91.25	50.00	43.33	0.00	20.00	89.42	59.44
3 Mature (>7 years)	80.00	83.75	48.33	35.00	17.75	0.00	48.73	74.00
Total	89.11	90.00	47.50	41.25	17.75	23.00	69.16	62.11

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

number of professional skills is usually combined with a work team organisation which does not envisage the use of formal methods.

While an increasing specialisation of professional skills seems to be unavoidable, there are some forces hindering this process, such as external environmental problems (market growth, availability of proper skills in the labour market) and internal organisational problems (resource co-ordination and need to allow for already existing in-firm skills and for uncertain turn-over).

Many distinctions among professional skills are purely nominal being related to a hierarchy based on wage and labour agreements. However, there is a linkage between real professional skills and the firm's organisation which is mainly due to the following elements:

(a) the smaller the firm's size, the higher the overlapping of professional skills;

(b) the number and the kind of professional skills cannot be immediately linked to the software product being developed (dimension, quality, etc) as the firms must balance the need to meet production requirements and the need to manage and co-ordinate the individuals' activities;

(c) integrated individual employees able to unify the different project stages meet the need to control the whole manufacturing process in a horizontal manner.

In order to compare the professional skills of the different firms, we subdivided them into six classes based on their work content: (a) the technical entrepreneur, who in addition to firm management performs also some functions for software development; (b) the project manager, who has the responsibility for defining project performance. Sometimes he also performs a part or all of the development activities; (c) the system engineer, who is involved both in software development and in hardware and system-related issues (system configuration, installation, maintenance); (d) the software engineer, performing integrated technical activities during software development and various other functions according to the kind of project; (e) the analyst-programmer performing the task of analyst in a strict sense and programming activities; (f) the programmer, including both the technicians

Table 7. *Professionals involved in software development*

Professionals	North		South		Total	
	No.	%	No.	%	No.	%
Entrepreneurs	23	5.62	25	12.56	48	7.89
Project managers	29	7.09	7	3.52	36	5.92
System engineers	19	4.65	3	1.51	22	3.62
Software engineers	151	36.92	75	37.69	226	37.17
Analyst programmers	64	15.65	31	15.58	95	15.63
Programmers	123	30.07	58	29.15	181	29.77
Total	409	100.00	199	100.00	608	100.00
University degree	224	54.77	76	38.19	300	49.34
High school degree	185	45.23	123	61.81	308	50.66

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

responsible for drawing up the codes and those performing file recording and testing.

Table 7 shows the percentage composition of the professional skills involved in software activities in the firms of the sample. Two professional skills prevail: software engineers (37.17% of the software employees) and programmers (29.77%) amounting to a total of 67.94%. The degree of involvement of the entrepreneurial group in software development is one of the key factors in the software firm's organisation. Project managers amount to 13.81% of the software employees, of which 7.89% are entrepreneurs.

Compared to the national average there is a clear-cut difference between Northern and Southern Italy: in the former entrepreneurs are 5.62% of the employees working for software development, whereas in the South they amount to 12.56%.

Table 8 summarises the characteristics of the project team and the degree of the entrepreneur's involvement. In this table the professionals involved in software development are analysed. To correctly interpret Table 8 we must keep in mind that the implementation of the software project usually requires four types of decisions at four different responsibility levels: firm, function, project, development.

Firm level. The decision concerns the amount of the firm's resources to be allocated for an innovative project. An assessment is made of the risk entailed in the use of new technologies given the state of the market. Potential markets, financial requirements, and the adequacy of the firm's technological and professional endowment are assessed.

Function level. Required competencies and technologies are identified (choice of project leader and technical personnel). The kind of relation with the project members is decided. The need to acquire new technologies or to hire new personnel is evaluated together with the opportunity of training the firm's personnel. The project team is established.

Project level. At this level we usually find the project leader. The product design is made and the methods for the project management are defined. Functional priorities of the programme and manufacturing methodologies are settled.

Table 8. *Project teams for software development*

Firm Classes	Entrepreneur		Entrepreneur+ Sw Employees		Entrepreneur+ Project Leader+ Sw Employees		Project Leader+ Sw Employees		Total	
	North	South	North	South	North	South	North	South	North	South
A Specialised (>65%):										
1 Young (0–3 years)	0	1	4	1	0	0	0	0	4	2
2 Well established (4–7 years)	0	0	7	2	2	2	2	0	11	4
3 Mature (>7 years)	0	0	0	0	2	1	2	2	4	4
B Systemic (35–65%):										
1 Young (0–3 years)	0	0	2	0	1	0	1	0	4	0
2 Well established (4–7 years)	1	0	0	3	0	0	0	0	1	3
3 Mature (>7 years)	0	0	0	1	0	0	3	0	3	1
C Marginal (>35%):										
1 Young (0–3 years)	0	1	0	1	0	0	0	1	1	3
2 Well established (4–7 years)	0	0	0	2	0	0	0	0	0	2
3 Mature (>7 years)	0	0	0	0	0	0	4	0	4	0
Total	1	2	13	11	5	3	12	3	31	19

Source: ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

Each member of the project group is assigned a task and the various project activities are managed. At this level the product's compliance with the initial requirements are verified and relations with customers are managed for the prototype field test.

Development level. At this level we have technical personnel, analysts and programmers. Operational choices for project implementation are made through the evaluation of the various technical options as to the modules or parts of the project. Technical priorities are identified. Quality test evaluation and module reliability are assessed.

Table 8 refers to the professional skills used in design and development. When the project team is made up of the entrepreneur and software developers—as in 48% of the cases—we can infer that the entrepreneur makes decisions as to the firm, project and function levels whereas the technical personnel are responsible for the development level. In general the entrepreneurs' involvement is very high: in 70% of the firms the entrepreneurial group is engaged in software development as well as with co-ordination activities.

Table 8 shows the composition of the project teams in software development. In 54% of the firms entrepreneurs are heavily involved both in design and development activities. In 16% of the firms the entrepreneur is supported by one or more project leaders committed in the same or other projects. Sometimes the project leader performs also as a function manager for a set of projects. Thirty percent of the firms are more functionally specialised, with a clear distinction between management and development functions. While in systemic and marginal firms—simply because of the marginal role of software development—the entrepreneur is usually less involved in technical activities; in 79% of the specialised firms the entrepreneur plays a major role.

This leads us to conclude that in most of the firms the entrepreneur is the major source of technical capability. Around this core element the network of technical professional skills is built.

The data do not show significant differences between the North and the South. The analysis of the activities performed by the entrepreneur seems to indicate that the technical entrepreneur remains involved for a long time in development activities, devoting most of his time to them. On the contrary project responsibility in some northern firms is more easily delegated to a manager who is not a member of the entrepreneurial group.

How shall we interpret the fact that the comparison between the characteristics of the firms located in Southern Italy and the ones located in the rest of Italy does not reveal significant differences? Structural incentives, networks and professional skills are basically the same. Shall we conclude that these firms are equal? The only factor that seems to explain the difficulties of the southern firms is the less developed environment in which they are forced to operate. Is it possible that external differences do not have any impact on the firm? Is it possible that firms, even operating in different environments, are equal from standpoint of their internal characteristics?

It must be kept in mind that software firms have to be viewed as a collection of diversified skills and interacting activities. To appreciate this it is necessary to

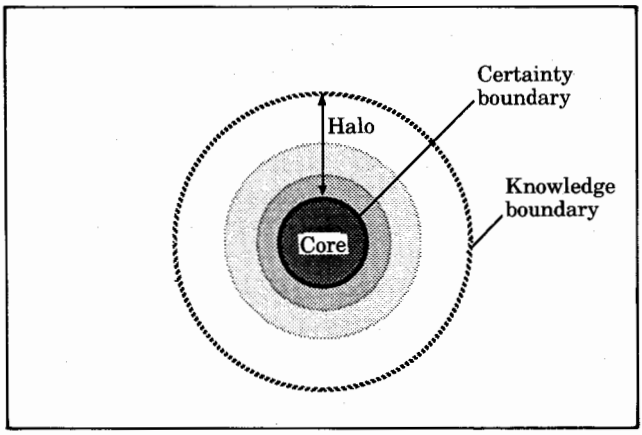

Fig. 2. *Fuzzy innovative firm model. Source:* ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

probe into the firms' organisational characteristics and especially into the professional skills/organisation relation.

5. The small software firm as a network of professionals

The software firm as a network of professional skills around a centre of internal competencies is a general model which fits well the organisation of small software firms. For the application of this organisational model the firm must learn how to balance the two requirements of an innovative organisation: (a) 'the closing requirement'—that is planning, predictability of production processes and insulation from environmental turbulence, through the scanning of external opportunities (Fig. 2).

The closing requirement defines a certainty boundary (core). It refers to what the firm can actually do, its organisational memory, its rules and its routines. The opening requirement defines a knowledge boundary (halo), i.e. the wider field of information, technologies, market opportunities scanned by the firm through various relationships with external sources of information and competencies (mainly professionals and technicians). The extent of the certainty boundary is an index of the ongoing performance of the firm, while the knowledge boundary is an index of the firm's innovative capabilities.

In an earlier paper (Raffa and Zollo, 1991B) we showed through an empirical analysis that the most innovative firms are those with an intermediate opening degree. The most innovative firms use both internal expertise (entrepreneur and employees) and external consultants and experts. The typical trajectory of these firms is strictly related to the way they organise and manage their competencies. On the other hand, the software firms' behaviour is consistent with the insights in the recent literature on the firms' competencies and their strategic growth (Teece, 1978; Dosi, *et al.*, 1992).

During their life, these small companies display an oscillating behaviour: in the first phase their technical capabilities are mainly based on the internal expertise of

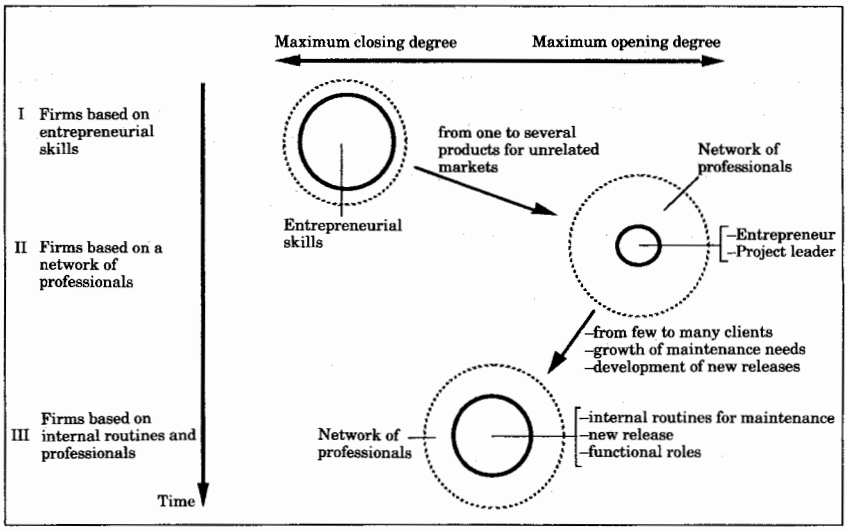

Fig. 3. *The oscillating behaviour of small software firms. Source:* ODISSEO-DIS, Faculty of Engineering, Naples, Italy.

the founder-entrepreneur. Thus the knowledge boundary is almost equivalent to internal expertise. In the following phase the small firm opens up to professionals by means of a wide range of employee–employer relationships in order to sustain its growth, develop more products and manage new technologies. Finally, in the third phase the company tries to define internal routines to efficiently manage the maintenance of existing products and the releases of new ones, and its relationships with a large number of customers. In so doing the small firm shifts from a maximum closing degree (the use of entrepreneur-embodied internal skills) to a maximum opening degree (where the support of external expertise prevails). The firm shifts to a third phase, in which a new equilibrium is built between a core of internal routines (maintenance and new release) and external competencies.

This analysis of the firm's organisational characteristics allows us to track the non-linear path along which the small software firms can implement and define the boundaries of internal expertise (core) and the extent of external expertise (halo) (Fig. 3).

6. The building up of a fuzzy organisation through the network of professional skills

6.1. Firms based on entrepreneurial skills

Most of the small software firms are established by technical entrepreneurs who are simultaneously responsible for management and development. Many firms (about 43% of the firms of the A2 and A2 groups) maintain this organisational arrangement for a very long time. In these firms the entrepreneurial group, or even the single entrepreneur, performs all the firm's activities without any clear-cut distinction amongst the various responsibilities and functions: entrepreneurs are also directly involved in project development. This organisation is typical of the early stages of

life of firms founded by technical entrepreneurs. There are many two-headed firms, where one of the entrepreneurs-founders performs marketing and commercialisation functions, while the other one is concerned with technical issues and project development. These firms usually focus on one or few products and face some difficulties in sustaining their innovative capability over the time. In fact these firms experience the highest technological performance at the beginning of their life, but then gradually settle down to a lower level of innovation (new releases, programme up-dating) and end up managing only the current market.

6.2. Firms based on a network of professionals

The critical event to be overcome by this organisation is the distinction between management and development functions and the identification of a new firm's functions such as marketing and commercialisation. As the number of products increase, markets diversify and technologies change, firms have two options:

(a) to delegate to technicians the development of the product, with the entrepreneurial group holding the responsibility for the business and the other strategic functions;

(b) to delegate both development responsibilities and the other business functions such as marketing. In this latter solution the entrepreneurial group holds only general responsibilities such as co-ordination and strategy definition.

Southern firms undertake only partially the first kind of delegation: most of the firms investigated did not overcome the critical event; the remainder usually delegate the low development stages to technicians and the remainder of the firm's functions are performed almost exclusively by the entrepreneurs.

Many northern firms successfully overcame the first critical event; in these firms technology and market-oriented professionals can be found that are not members of the entrepreneurial group.

The statistical evidence does not allow us to generalise the differences. However, based on the cases investigated, it is possible to list some factors affecting the firm's choices. A first factor affecting the delegation process is the customer's typology. In the South there are medium-sized firms producing almost exclusively for the public market (local government, hospitals, public administration, schools, etc), where the personal, formal and informal relations between customer and supplier are very crucial; the entrepreneurial group has a direct relationship with the customer. Firms operating in the private market can with difficulty survive and develop in the specific market segment to which they supply specific products. The small firms that passed the early life stage must simultaneously explore various market segments with very different characteristics. This activity requires not only marketing but also entrepreneurial capabilities. In other words, the possibility of committing resources to explore a new kind of market must be assessed for each project.

A second factor—linked to the product and affecting in a remarkable way the firm's organisational and professional skills—is the kind of software manufactured. Southern firms produce customised software rather than standardised packages. The order acquisition is usually made by the entrepreneur.

A third factor, linked to the market, is the type of customer demand. The customer usually demands a set of services that are not confined to software

manufacturing and include, personnel training, hardware consultancy and, sometimes, data entry. To meet this demand the software firm usually uses integrated professional skills rather than specialised ones. For the southern firms it is more useful to have a multi-functional performing technician than an expert in an advanced technical field.

This whole set of factors gives rise to a development process in which small southern firms progressively lose their capability to keep pace with technological developments. Further, when professionals leave the firm and the entrepreneur is no longer concerned with technical issue but also takes care of the market and/or of management issues, the organisation is deprived of the skills required to explore the supply of technologies within the market.

The few southern firms able to avoid the loss of technical expertise, which might shut them out of technological competition, are those whose entrepreneurial group is made up of two or more people. When the critical event occurs, they differentiate their responsibilities. Consequently, some of them take care of marketing and management while the others are concerned with technological and strategy issues.

In Northern Italy, where environmental factors (market, customer, etc) are more favourable, firms decide more frequently to differentiate entrepreneurial responsibilities, to delegate marketing activities and to use specific professional skills. This technology and market specialisation allows the firm to have various relations with the external environment (universities, research centres, laboratories, large firms, innovative customers, etc) thus strengthening its competitive capabilities.

The entrepreneurial group in some cases fully delegates technical tasks, and sometimes the project development is fully delegated to external consultants. In most cases a member of the entrepreneurial group also takes on the role of project leader, whereas analysts and programmers may be either full-time employees or external consultants. The entrepreneurial group is mainly concerned with professional skills management and project team co-ordination. In the majority of the software firms two problems arise: the need for a constant relation with the consultants as they are managing the firm's technological capabilities; and the need for updating the existing professional skills, in order to have access to new technologies. These organisational solutions show several strengths and weaknesses: if the professional skills are strongly linked to the firm (for instance technicians are full-time employees), the firm is able to control and stabilise its own know-how but faces serious problems as to its updating and replacement. On the other hand, if technicians are external, the firm can have an easier access to updated knowledge but it does not have its own technical endowment to rely on. By means of such operational flexibility these firms can easily introduce high level innovations that are not linked to an explicit innovation strategy but rather are targeted to catch market opportunities consistent with available professional resources.

6.3. Firms based on internal routines and professionals

Firms based on a network of specific professional skills have one weakness: their technological expertise is person-embodied. When an expert technician leaves the firm it irreversibly loses part of its competency and knowledge, thus giving rise to many difficulties, especially the maintenance and development of new programmes.

To solve this problem the firm can develop its own technological endowment in a way that allows it to be partially independent of the employees' skills. To do this the firm must transform both its organisational structure and its employees' professional skills. Two new functions become strategically crucial: technology monitoring and in-firm training.

For these functions to be introduced a quality leap is required that very few northern firms were able to implement. The few firms of the sample that tried to implement this introduction were established more than 5 years ago and their level of employment was greater than 20. The basic difference with other firms is that they acquired or developed internally a set of methodologies, techniques and development tools. The project leader and the project team are not autonomous in software development, but they must operate in conformance with standards and methods imposed by the firm. The relations between the entrepreneurial group, the project team and the firm's methodologies are crucial to innovation success.

The entrepreneurial group not only chooses the required professional skills, but develops two new activities: planned training for the research team in order to transfer the know-how needed to use development methodologies; and technological monitoring to update or replace technologies. In this way a new activity of the entrepreneurial group is identified: the management of the technological endowment that allows these firms to implement innovations in a whole range of technologies. Because of their need to exploit scope economies owing to their technological endowment, these firms can only with difficulty develop fully new innovations. It can be maintained that this shift is the real challenge of the 1990s for the whole Italian software industry.

7. Conclusion

A first general outcome is that the survival of most of the firms is based on products developed in their early stages of life. Only some firms can manage their installations-derived rent position through programme maintenance and steady up-dating. And this hold true both in the South and in the North. Two measures corroborate what was just stated: 80% of software resources are allocated for maintenance of current programmes and less than 10% of the firms developed fully developed new products in recent years. These percentages are similar for the two territorial areas.

The differences between the two areas comes out with reference to the way in which maintenance and development (the first two capabilities) combine with adjustment and innovation (the other two capabilities). In the North there are firms that are able to specialise in a specific market segment—through continuous product releases that keep the product competitive—and to manufacture standardised products that can be placed in horizontal markets. In the South, on the contrary, firms specialising in software production operate only in vertical markets; often they are not strong enough to remain competitive in a unique market segment and are forced to operate in various parallel markets. Therefore, in the North firms can accumulate technology and market experience along a technological trajectory which leads them to grow from the size and market share standpoint. In the South,

on the contrary, firms are forced to implement a mobility strategy for pursuing market opportunities and for this reason they do not accumulate long-term advantageous position.

Our assumption is that the high capabilities that do exist in the southern firms are used to continuously restore the uncertain equilibrium in which firms are forced to operate. In other words, the firm's most important resources, mainly the entrepreneur's skills and time, are not used to shift the firm to new competitive areas and to build a self-sustained development mechanism. Entrepreneurial and professional resources are mainly used to preserve what already has been acquired.

The characteristics of the environment surely affect the situation experienced by southern firms. Because of their less developed demand, the lack of innovative customers, the difficulty to get in touch with the market, and the opacity of the technological sources, many Southern entrepreneurs think that it is more convenient to have limited targets, to avoid risky choices, costly investments or too innovative projects. When a firm decides to avoid risk as much as possible, it is progressively marginalised from the core of the software market based on a high product innovation and on a timely use of new technologies. Only a few southern firms were able to escape this marginalisation; they realized that to be able to compete and survive in a weak region, a strong organisation had to be built. Only companies that, thanks to their investments in the firm's organisation, were able to communicate directly with the sources of know-how and with the market have the possibility of facing the competitive challenges of the coming years.

At the beginning of the 1990s, the competitive position of the firms in the sample is the following:

(a) Many firms have lost their innovative capability even though they still hold their position in the market niches they were established in. These niches are increasingly undermined by the firms' difficulty in meeting the new quality requirements demanded by the users.

(b) The firms' organisation is in many respects inadequate to meet the requirements of the market and of technological innovation due to the poor differentiation of responsibilities and functions.

(c) The establishment of a skills network is often an alternative to the building up of the firm's technology endowment but this might translate into a long-term weakness.

In the meanwhile two new events are taking place in the 1990s that might totally change the competitive environment and undermine the few strengths of the southern firms: the increasing interest shown by large hardware firms in software manufacturing and the availability of new manufacturing tools, new methodologies and development environments. Large firms and new development tools might lead to a new type software manufacturing, making obsolete and excluding from the market artisanal firms producing for restricted market niches.

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