# The Evaluation of Innovation Capabilities in Small Software Firms: A Methodological Approach*

*Guido Capaldo*
*Luca Iandoli*
*Mario Raffa*
*Giuseppe Zollo*

ABSTRACT. This paper presents a methodological approach for the evaluation of innovation capabilities in small software firms. The methodology is based on the assumption of a relationship between specific resources managed by small software firms and their innovation capabilities. Within the proposed methodological approach, a model for the quantitative analysis of innovation capabilities is presented. In order to show how the methodology can be applied to concrete situations, three case studies of small firms operating in the software sector and information services are presented and discussed.

## 1. Introduction

This paper is concerned with the issue of evaluating innovation capabilities in *small software firms*.

It is well known that small software firms must continually cope with extremely rapid changes which demand an innovative technological and managerial response. Such a response must redefine the firms' organizational assets in order to achieve a satisfactory degree of adaptation to the external environment (Bellini et al., 1997). As a consequence, innovation is a necessary condition, not only for increasing the small software firms' competitiveness, but primarily to ensure their survival. It is an observable fact that firms which are not able to maintain satisfying levels of innovation capabilities through time show weak performance in terms of competitiveness and economic results (Raffa and Zollo, 1998). Thus, the problem of evaluating innovation capabilities is of fundamental importance both for researchers and practitioners.

This paper tries to offer a contribution to this issue by proposing a methodology that permits the evaluation of innovation capabilities in small software firms.

The methodology is based on the assumption of a relationship between resources managed by firms and their innovation capabilities.

It is well known that one of the most important assumptions of the resource-based competition approach is that a firm's competitive advantage is strictly connected to the kind and the amount of specific resources that firms are able to acquire, develop, and manage in the course of their life (Amit and Shoemaker, 1993; Barney, 1991; Lado and Wilson, 1994; Conner, 1991; Grant, 1991; Rumelt, 1987).

Thus, according to the resource based view, small firms' competitiveness is linked to their capability in acquiring and developing strategic resources. Given that for small software firms competitiveness equates to capability for innovation, our proposal is that it is possible to evaluate innovation capabilities on the basis of the kind and the amount of specific resources managed by small software firms during their life.

In this perspective two main methodological issues arise:

- How can one identify the kinds of resources on the basis of which it is possible to measure innovation capabilities?
- How can one measure innovation capabilities through time?

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*University of Naples Federico II*
*Dept. of Business and Managerial Engineering*
*Piazzale Tecchio 80*
*80125 Napoli, Italy*
*E-mail: gcapaldo@unina.it, iandoli@unina.it, raffa@unina.it, giuzollo@unina.it*

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In order to determine resources linked to innovation capabilities, we identify a set of resources by means of the analysis of the literature on small software firms, as will be shown in Section 2.

Regarding the issue of evaluating innovation capabilities through time, we refer to the *life-cycle stage theory* (Churcill and Lewis, 1983; Greiner, 1972; Miller, 1984; Wiklund, 1996). According to this theoretical viewpoint, a firm's life can be represented as a succession of stable phases separated by critical events, after which firms are forced to modify their own resources in order to adapt and react better to environmental changes. In this perspective, within each stable phase the process of creation and destruction of resources can be represented as a black-box whose inputs, represented as resources, are known.

Once that firm's life has been described in terms of stable phases and critical events, it is possible to identify, for each phase, the resources on the basis of which one may measure a firm's innovation capabilities, as will be shown in the next section.

In particular, in the first part of the paper we describe the proposed methodology (Sections 2, 3, 4) and in the last part it is applied to three case studies of small software firms.

## 2. Evaluating small software firms' innovation capabilities: a resource-based perspective

As stated in the previous section, in this paper we propose to use the resource-based theory to propose a methodology to evaluate a firm's innovation capabilities. To this end, we introduce the following definitions:

- the *degree of market innovation capability* (*DMIC*) as the measure of the firm's capability to enhance and innovate its market in a given instant of time;
- the *market innovation trend* (*LMI*) as the variation of the DMIC through time;
- the *degree of technological innovation capability* (*DTIC*) as the measure of the firm's capability to increase its level of technological know-how and expertise, in a given instant of time;
- the *technological innovation trend* (*LTI*) as the variation of the DTIC through time.

We propose to evaluate the *degree of market innovation capability* and the *degree of technological innovation capability* on the basis of the following subset of resources:

(a) entrepreneurial resources;
(b) human resources;
(c) resources linked to external networks;
(d) economic resources.

Each subset is a cluster of specific resources. Table I contains the list of all resources classified in the four clusters above.

The list of resources of Table I was obtained through an analysis of the literature on innovative small firms (Reid and Jacobsen, 1988; Kelley and Brooks, 1991; Quinn, 1979; Garden, 1992; De Chiara, 1996) and on software firms (Barocci et al., 1983, Raffa and Zollo, 1988, 1992, 1996). In the following we provide a brief description of each cluster:

(a) *Entrepreneurial resources*: this cluster contains a set of indicators concerning individual know-how and experience of the entrepreneurs. They also concern the involvement of entrepreneurs in the technical and managerial aspects of the firm.
(b) *Human resources*: this cluster includes variables concerning the amount and the kind of human resources available to the firms. The impact of human resources related to the DTIC is measured through the total number of people working for the firm, the number of software developers, their level of qualification and competencies, the intensity of technical training, and the presence of an intense job-rotation policy which calls for highly qualified resources, and allows employees to continually upgrade their technical know-how. The impact of human resources related to the DMIC is measured by the presence of internal employees or external collaborators taking care of marketing and by the intensity of marketing and management training activity.
(c) *Resources linked to external networks*: this cluster contains variables related to the firm's ability to set up and develop contacts and collaboration with other firms and R&D centers. Resources belonging to this cluster are used to evaluate both the DTIC and the DMIC.

TABLE I
Resources employed to evaluate the degree of market innovation capability and the degree of technological innovation capability

| Resources linked to the DMIC | Resources linked to the DTIC |
|---|---|
| C1: **Entrepreneurial resources** | C1: **Entrepreneurial resources** |
| C1.1: Number of persons forming the entrepreneurial group | C1.1: Number of persons forming the entrepreneurial group |
| C1.2: Entrepreneurs' know-how | C1.2: Entrepreneurs' know-how |
| C1.2.2: Percentage of entrepreneurs with market knowledge | C1.2.1: Percentage of entrepreneurs with technical knowledge |
| C1.2.3: Percentage of entrepreneurs with business and management experience | C1.3: Involvement of entrepreneurs in software design and development |
| C1.3: Involvement of entrepreneurs in software design and development | |
| C1.4: Involvement of entrepreneurs in marketing activities | |
| C2: **Resources linked to human resources** | C2: **Resources linked to human resources** |
| C2.1: Total number of employees | C2.1: Total number of employees |
| C2.2: Percentage of software developers | C2.2: Percentage of software developers |
| C2.5: Training | C2.3: Percentage of internal software developers having a graduate degree |
| C2.5.1: Marketing and management training | C2.4: Job rotation |
| C2.6: Marketing aspects | C2.5: Training |
| C2.6.1: Percentage of internal persons involved in marketing activities | C2.5.2: Technical training |
| C2.6.2: Percentage of external persons involved in marketing activities | |
| C3: **Resources linked to external network** | C3: **Resources linked to external network** |
| C3.3: Intensity of commercial collaboration with other firms | C3.1: Use of non proprietary tool or external methodology of software development |
| | C3.2: Intensity of technical collaboration with other firms |
| | C3.4: Intensity of group relationships with R&D centers, other software firms |
| C4: **Economical indicators** | C4: **economical indicators** |
| C4.1: Total profit deriving from firm's software | C4.2: Total profit due to non proprietary hardware and software |
| C4.3: Total profit coming from extra-regional market | |

Frequent relationships with other firms and R&D centers focused on technical collaboration and an intense use of external soft-ware development methodology can imply a meaningful increase in technological know-how. Significant relationships with other firms deriving from commercial collaboration are an obvious indicator of a certain attention to the market.

(d) *Economic resources*: information concerning profit composition can be also useful. High profits in extra-regional markets, as well as a large profit deriving from commercialization of proprietary software are the result of a strong focus on the market. An intense commercialization of non-proprietary hardware and software is typical of small software firms strongly engaged in the development of new products and at the same time temporarily unable to offer a competitive product.

As one can observe, in Table I some resources are employed to measure both the DTIC and the DMIC at the same time; others may affect the evaluation of the DTIC and the DMIC in opposite ways. For example a deep involvement of entrepreneurs with software development can be considered as a signal of less close attention to the market.

Furthermore, it should be observed that there is

only a partial symmetry between the structures of DTIC and DMIC. For example, while some resources used to evaluate the DTIC have their counterpart in the DMIC structure, such as *the percentage of entrepreneurs with technical knowledge* and *the percentage of entrepreneurs with market knowledge*, in other cases the *market* counterpart of a *technical* variable does not exist, as is the case for the *degree of involvement of entrepreneurs in software development*. The reason for this imperfect symmetry lies in the fact that the development of small software firms is usually mainly *technology-push* rather than *demand-pull*. For example, since entrepreneurs usually have a strong technical background, their intense involvement in software development activity may imply a lack of attention to the market. On the other hand, an entrepreneur's strong involvement in marketing activities usually does not mean a lack of interest in technology, but rather a separation between the management and production activities which are almost entirely delegated to specialized personnel.

## 3. The proposed methodology

Within the theoretical assumptions described in the previous sections, our methodology focuses on two main aspects: the description of a firm's life (case study analysis) as succession of stable phases separated by critical events, and the evaluation of resources managed by firms during each stable phase by means of a formal model presented in Section 4. The steps of the methodology can be summarized as follows:

(a) *Case study analysis*;
(b) *Evaluation of resources*;
(c) *Quantitative analysis of firms' innovation capabilities*.

In the following a brief description of each step is provided.

*Case study analysis*: in this step data and information concerning the firm's history has to be collected through interviews with entrepreneurs. In particular, interviews should focus on how the innovation capabilities of a firm have changed, and which kinds of resources have allowed the company to sustain innovation through time. Through a case study approach, critical events in the firm's life that caused notable modifications of resources, and stable phases, in which there are no significant changes, have to be identified. Examples of critical events are failure/initiation of collaborations with other firms (joint ventures, supply relationships), failure/initiation of relationships with important customers, loss/acquisition of critical professional resources because of turn-over, or very rapid growth.

*Resource evaluation*: in this step the amount of resources contained in Table I and available to the firm in a given stable phase must be evaluated. Two critical points arise in this step: (i) entrepreneurs are very often not able to remember the exact values exhibited by some resources in the past, so they usually express only approximate and vague judgements; and (ii) some resources are intrinsically qualitative or hard to measure through precise indicators. In order to cope with uncertainty and vagueness deriving from ignorance or intrinsically qualitative assessments, the proposed methodology allows entrepreneurs to express their judgements through verbal scales and to model, in the next step, such qualitative assessments through fuzzy set theory (Zadeh, 1973).

*Quantitative analysis of the firm's innovation capabilities*: In this step, data and information characterizing critical resources are elaborated through a mathematical model described in the next section. The objective of this step is to determine, in each stable phase, a quantitative evaluation of the innovation level achieved by a firm, starting from imprecise and qualitative judgements expressed by entrepreneurs and employees in the previous step. By repeating the assessment for each phase, it is possible to trace the market and technological innovation trends of a firm. Before applying the proposed methodology to a set of case studies as shown in §5, in the next section we provide a description of the mathematical model for the evaluation of innovation capabilities.

## 4. An evaluation model for the determination of small firms' innovation capabilities

In this section a mathematical model for evaluating the degree of technological innovation

and the degree of market innovation is presented. By using the proposed model, it is possible to evaluate the Degree of Technological Innovation Capability (DTIC) and the Degree of Market Innovation Capability (DMIC) of a firm in each stable phase, on the basis of the amount of the resources described in Section 2 and summarized in Table I.

The model can be described with respect to the following salient aspects:

(a) assessment of resources;
(b) data elaboration.

### 4.1. *Assessment of resources*

A main issue in the construction of the model is to define a reliable procedure for assessing the values of the resources summarized in Table I. It is evident that among them there are both quantitative and qualitative variables.

While, for example, it is easy to determine values such as the number of software developers or the amount of profit from extra-regional markets, it is difficult to assess the *intensity of the collaboration with other firms or the degree of involvement of the entrepreneurs in software development*. Moreover, because of a lack of information, a certain amount of imprecision could affect also crisp data. Chen and Hwang (1992), for example, identify four situations that may produce qualitative uncertainty: unquantifiable information, incomplete information, non-obtainable information, and partial ignorance.

In order to cope with qualitative or imprecise information, the elicited variables are represented as linguistic or fuzzy variables, that is variables assuming as their values linguistic terms such as *low, very low, more or less high* represented through fuzzy sets (Zadeh, 1973).

Fuzzy representation helps to keep account of the ambiguity and vagueness embodied in qualitative assessments. For example, if we consider the variable *intensity of technical collaboration with other firms* one could say that it is *low or average* or *more or less high*.

Because of their ambiguity, linguistic judgements can be represented in a more meaningful way through fuzzy sets rather than through numerical scales. Also the imprecision contained in statements such as *about five or six software developers* or *a high amount of my time was devoted to software design* can be taken into account by a fuzzy representation.

The rationale behind the fuzzy approach is that the transition between *low involvement* and *average involvement* is not sharply defined but is, rather, a matter of degree. This approach is much more valid than a binary point of view in many real-life situations, where it is often impossible to determine what is the exact value marking the boundary between two categories by fixing an arbitrary threshold.

### 4.2. *Data elaboration*

In this model, the issue of determining values for the DTIC and the DMIC is resolved through a fuzzy multi-attribute decision-making approach. Generally speaking, this representation of the problem can be synthesized as follows: given an alternative A to be evaluated with reference to a set of $n$ attributes or criteria $\{C_1, C_2, \ldots, C_n\}$, the overall evaluation $g$ of $A$ with respect to the $C_i$'s can be determined in the following way:

$$g(A) = f[c_1(A), c_2(A), \ldots, c_n(A)] \qquad (1)$$

where $c_i(A)$ is the score obtained by $A$ with respect to the criterion $C_i$ and $f$ is a monotonically non-decreasing aggregation function satisfying some intuitive criteria, usually represented in a formal way by means of a set of axioms.

In our representation $A$ is the firm to be evaluated with respect to the DTIC or the DMIC, $C_i(A)$ is the amount of one of the resources contained in Table I and managed by the firm at a certain instant of time, $c_i(A)$ are fuzzy scores expressing the values assumed by each resource obtained from a fuzzy representation of the verbal terms used during the interviews.

Consequently, in order to calculate $g(A)$ according to the (1), it is necessary to choose a suitable fuzzy multi-criteria aggregation operator.

Several operators have been proposed in literature (Chen and Hwang, 1992). In our study we have used a family of aggregation operators called OWA, Ordered Weighted Average operators (Yager, 1988).

This choice can be justified on the basis of the specific context of application. It is possible to demonstrate that an OWA operator can be associ-

ated to a fuzzy quantifier, i.e. a fuzzy set representing a vague linguistic quantifier such as, for example, *many, most, almost all*. In the DTIC and DMIC calculations we have used the quantifier *most*. By aggregating single scores through the quantifier *most*, the evaluation of the DTIC or the DMIC is high if a firm is able to manage a high amount of *most* of the considered resources. In this way we are able to bear in mind our ignorance of the way in which resources are employed and exploited by firms. In other words, the aggregation mechanism is such that if a firm has *most* of the resources, it does not matter which in particular, the firm's innovation capabilities are high.

## 5. Case studies

In order to illustrate the application of the proposed methodology, and to show how it can be used in the evaluation of the degree of market innovation capability and of the degree of technological innovation capability, in this section the results obtained from the analysis of three case studies of small software firms are presented. This description is articulated in two steps:

(a) *Analysis of firm's history* (*case description*): the material concerning the case studies was collected though the examination of company documentation and through several interviews with entrepreneurs and managers. The interviews were aimed at identifying the firm's history through a narrative perspective, by emphasizing the main changes and turning points of the firm's life. The entrepreneur found it easy to describe her/his firm's history through the concepts of stable phases and critical events, as well as to identify resources that were critical in each phase. The synthesis obtained by both interviews and company documentation was shared with the entrepreneurs who were asked to validate the results through a careful analysis of the transcriptions.
(b) *Evaluation of innovation capabilities*: through the model presented in the previous section, the values of the degree of market innovation capabilities and of the degree of technological innovation capabilities are calculated for each stable phase. Each phase is characterized in terms of the amount and the kind of the resources summarized in Table I and managed by the firm.

### 5.1. *Case 1*

#### 5.1.1. *Case description*

The firm was founded in 1980 by three entrepreneurs with a good knowledge of the market and strong management experience. The firm's main activity was the development of software for warehouse and stock management. Its customers were large supermarkets. At the beginning, the firm seemed to place itself in an intermediate position between market and technology, and the entrepreneurial group demonstrated a certain emphasis on market expansion. The firm did not have any kind of external relationships with other technical centers; its workforce consisted of experienced but not highly qualified software developers.

In the early stage of the firms' life the entrepreneurs were essentially focusing on increasing technical innovation. The number of internal software developers increased considerably and the firm also enjoyed the external technical support of a software consultant. In the absence of innovative "home-grown" products, the firm was able to survive through an increase in profits from itscommercialization of software and hardware. Innovative effort was directed to the upgrading of existing products for the same market, rather than the development of new products or the introduction of the existing product to new markets. The entrepreneurs seemed to be aware that they had a highly innovative product and their primary objective was to enlarge the firm's presence on its current market. As a result of these efforts the firm was able to achieve a certain growth in profit due to software development (about 30% of total profit).

The first *critical event* the firm had to face was the *saturation* of its market. This circumstance induced the entrepreneurs to shift their attention to market expansion. In order to accomplish this goal, the company modified the amount and nature of its resources in order to develop its marketing competencies: a marketing expert was employed and, at the same time, there was a remarkable shift in the firm's emphasis away from technological innovation (reduction of the number of software developers; the entrepreneurs stopped collaborating with the software project team).

This reconfiguration of the resource mix marked the beginning of a stable phase from 1983 to 1990. In this period ('83–'90) the firm experienced remarkable growth (profits were 400% higher than 1983).

The *critical event* marking the beginning of the third phase ('90–'93) is the loss *of two experienced software developers*. The strong orientation to the market was also confirmed in this phase, and was accompanied by a growing indifference to technical aspects (low involvement of entrepreneurs in software development, low intensity of technical collaboration with other firms).

As a consequence of an excessive focus on the market aspects, the firm began to pay for its indifference to technological innovation: at the end of 1993 the firm's profit diminished by 50% compared to 1990 because of the increasing obsolescence of the firm's software products.

5.1.2. *Evaluation of innovation capabilities*

Figure 1 shows the innovation performance of the firm described in the previous paragraph through time. These figures have been obtained by calculating the degree of technological and market innovation (respectively DTIC and DMIC) through several years, by means of the evaluation model presented in Section 4.

Case 1 represents an example of what we term *market-oriented behavior*. The firm described in this case shows an very rapid initial growth of the technological innovation trend (LTI) due to the high innovative content of its early products, followed by a period of decline. In this case, the attention of the entrepreneurs to market aspects allowed the firm to survive for a long period of time ('83–'93) with good economic results, even in the absence of substantial technological innovation efforts. Nevertheless, the strong market orientation, despite the lack of a real technological innovation policy, was able to slow down but not to prevent firm's LTI decline.

In order to provide some details concerning the application of the methodology to the described case study we offer the following example in which we show how to calculate the DMIC in a fixed instant of time.

*Example*

In order to calculate the value of DMIC and DTIC for a given firm, we need to assess the amount of resources listed in Table I available to the firms in a given instant of time. For example, with reference to case study 1, we have the following data as regards the DMIC in 1990 (see Table II).

According to the proposed methodology, verbal judgements are represented by means of fuzzy sets corresponding to a set of seven verbal terms {*very low, low, more or less low, average, more or less high, high, very high*}; verbal terms are represented for each variable contained in Table I through triangular membership functions defined on a specific universe $U$ (e.g. the number of entrepreneurs is defined on the interval [0, 10]). Values are collected both from interviews and from the analysis of company data. Judgements are then converted in crisp numbers (third column of Table II) through the *dual truth model* (Zollo et al., 1999), which permits us to take account of the uncertainty of the judgement in determining the

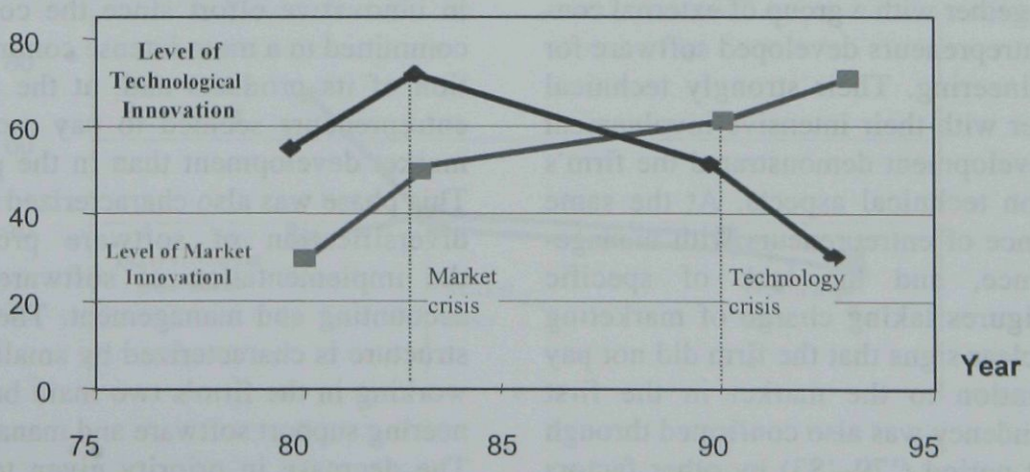


Figure 1. Case-study 1 results.

TABLE II
Application of the proposed methodology: An example

| Resources linked to the Degree of Market Innovation (1990) | Evaluation | Fuzzy value |
|---|---|---|
| C1: **Entrepreneurials resources** | | |
| C1.1: Number of persons forming the entrepreneurial group | High | 0.725 |
| C1.2.2: Percentage of entrepreneurs with market knowledge | More or less high | 0.615 |
| C1.2.3: Percentage of entrepreneurs with business and management experience | High | 0.725 |
| C1.3: Involvement of entrepreneurs in software design and development | Very Low | 0.165 |
| C1.4: Involvement of entrepreneurs in marketing activities | Very high | 0.835 |
| C2: **Resources linked to human resources** | | |
| C2.1: Total number of employees | Average | 0.5 |
| C2.2: Percentage of software developers | Low | 0.275 |
| C 2.5.1: Marketing and management training | Average | 0.5 |
| C 2.6.1: Involvement of internal persons in marketing activities | High | 0.725 |
| C 2.6.2: Involvement of external persons in marketing activities | Low | 0.275 |
| C3: **Resources linked to external network** | | |
| C 3.3: Intensity of commercial collaboration with other firms | High | 0.725 |
| C4: **Economical indicators** | | |
| C 4.1: Total profit deriving from firm's software | Average | 0.5 |
| C 4.3: Total profit coming from extra-regional market | High | 0.725 |

crisp value, and aggregated through a fuzzy quantifier *most* according to the relation (1) in Section 4.

In the example we obtain an aggregated value equal to 0.61; this result should be interpreted as the degree of truth of the proposition "*Most of the resources linked to the DMIC are available to the firm in the instant* $t_0$".

## 5.2. *Case 2*

### 5.2.1. *Case description*

This firm was founded in 1979 by three entrepreneurs with a high level of technological knowledge. Together with a group of external consultants, the entrepreneurs developed software for structural engineering. Their strongly technical culture together with their intensive involvement in software development demonstrated the firm's strong focus on technical aspects. At the same time, the absence of entrepreneurs with management experience, and the lack of specific professional figures taking charge of marketing activities, are clear signs that the firm did not pay sufficient attention to the market in the first phases. This tendency was also confirmed through the whole first period ('79–'83) by other factors such as the firm's relationships with other technical centers, and the involvement in software development of ten external collaborators offering technological consultation. In practice, everyone working for the firm (employees, consultants, and entrepreneurs) was involved in software design and development. This phase was characterized by a rapid growth in profit: in 1983 the firm doubled its profit compared to the previous period.

The *critical event* marking the beginning of the second phase from 1983 to 1990 was the *recruitment of several new software developers* and a consequent significant increase of the company's number of employees. Notwithstanding this event, in this phase, there was an evident decrease in innovative effort since the company seemed committed to a more intense commercial exploitation of its products and, at the same time, the entrepreneurs seemed to pay more attention to market development than in the previous phase. This phase was also characterized by a significant diversification of software products through the implementation of software packages for accounting and management. The organizational structure is characterized by small project groups working in the firm's two main businesses: engineering support software and managerial software. The decrease in priority given to technological innovation was not accompanied by an effective

policy of market expansion, though there was a certain increase in this direction. In other words, the company management perceived the difficulty of enlarging the market but tried to solve this problem through a re-engineering of internal organization and procedures, instead of initiating an effective policy of market expansion.

A *change in the entrepreneurial group* because of the departure of one of the founders was the *critical event* marking the beginning of the third phase ('90–'93) in which the same tendency of the previous phase seemed to be confirmed. The main customers were banks (40%) and engineering societies (40%); a certain amount of profit derived from software development for small firms (20%). In this phase, again, the company management tried to modify the organizational structure by the introduction of a divisional structure made up of two business units: bank services and technical services. Notwithstanding the introduction of innovative methodologies in software development and in project management, the overall innovative performance remained quite low. In fact, in about ten years the firm only introduced two new products, followed by their upgraded releases onto the market. Consequently, in this period the firm's profit remained unaltered. The redefinition and rationalization of the organizational structure as well as the introduction of innovative methodologies in software development and project management were not able to ensure an increase in the innovative performance as they were not accompanied by real and effective product innovation and market expansion.

5.2.2. *Evaluation of innovation capabilities*

The evaluation of DMIC and DTIC for this firm is depicted in Figure 2.

This case represents an example of what we term *technology oriented behavior*; the firm shows a strong initial orientation toward technology followed by a rapid decline of its innovative capabilities. The substantial difference with the previous case study lies in the fact that this firm was not able to compensate the low level of technological innovation by developing an effective policy for enlarging its market. A small firm following this pattern may perish or may survive in a very limited market niche (local or linked to a very specialized product), as happened in this case (extra-regional profit showed a drastic decrease). This case also shows that innovation in organizational structures and in design methodologies not followed by an adequate innovation transfer to new products is not sufficient to produce an increase of the firm's innovation capabilities.

5.3. *Case 3*

5.3.1. *Case description*

This firm was founded in 1978 by four entrepreneurs. In this case too, the entrepreneurial group was characterized by a strong technical culture. In the first phase ('78–'82) the firm seemed to attach great importance to technological innovation. The entrepreneurs were totally involved in the activity of software design and implementation. The whole organization was composed of the entrepreneurial group and one external software collaborator. The firm's market was limited to a local dimension.

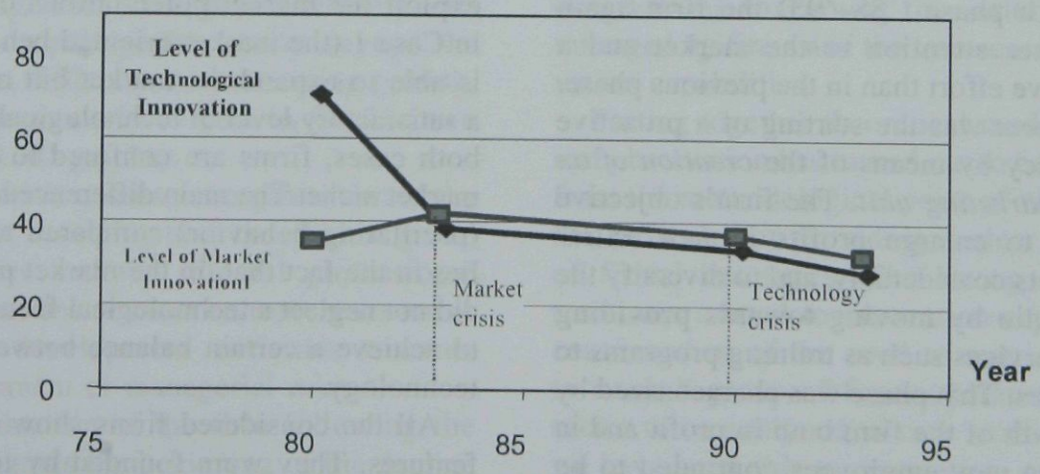


Figure 2. Case-study 2 results.

About 35% of the firm's profit came from other activities that were not linked to software production.

The passage to the second phase ('82–'83) was marked by the perception by the company's management of an evident *market saturation* immediately followed by a certain increase in the firm's attention toward marketing aspects. There was a substantial growth of the number of employees from 4 to 8. Employees were exclusively devoted to software development, while entrepreneurs partially took charge of marketing aspects. The entrepreneurs still maintained the direction of the project team. The growth of the firm's profit was rather consistent in this phase.

The third phase ('83–'88) was characterized by the *acquisition of an important technical partner* (a large software firm) and some new important customers among the largest public and private Italian companies. Those *events* provoked a renewed interest in technological innovation, thanks to the acquisition of important know-how from the new partner, and a remarkable general growth of the firm. The number of employees doubled compared to the past and, as in previous phases, most of them were highly qualified software developers. At the same time, the entrepreneurs were no longer involved in software development and their role became essentially managerial, though still anchored in a technical grounding. An intermediate organization level was formed and the coordination of the project team was delegated to a project manager who did not belong to the entrepreneurial group. A certain degree of flexibility was achieved by an intensive job rotation policy.

In the fourth phase ('88–'93) the firm again showed a closer attention to the market and a lower innovative effort than in the previous phase. The *critical event* was the starting of a proactive marketing policy by means of the *creation of an autonomous marketing unit*. The firm's objective was twofold: to enlarge profits in new extra-regional markets considerably, and to diversify the product portfolio by moving towards providing professional services such as training programs to other companies. This phase was characterized by a striking growth of the firm both in profit and in workforce. The new employees continued to be software developers, though less qualified than the older ones. From the organizational point of view there were substantial innovations. The firm presented an articulated organizational structure designed to enhance and develop technological transfer through a high degree of flexibility and an intensification of the relationship between marketing and R&D. In order to accomplish this result, the organizational structure was characterized by a matrix model, which related the firm's business units to competency-based professional areas. Also, in this phase, intensive research into innovative software development and analysis methodologies was carried out by the firm, which was involved in a national research program into software engineering. It is worth noting that in all phases, intense internal training activity was taking place.

#### 5.3.2. *Innovation capabilities evaluation*

The results concerning the evaluation of the DMIC and the DTIC for this firm are shown in Figure 3.

This case is an example of what we term *oscillating behavior*: the firm is able to alternate phases in which there is a strong attention to technological innovation with phases in which market aspects are given greater prominence.

## 6. Discussion of results

In this section we present a comparison among the three case studies in order to better highlight some results emerging from the field study, concerning the analysis of innovation capabilities.

In Case 2 (technology-oriented case), the initial growth ends because of the firm's inability to exploit the market potentialities of its products; in Case 1 (the market-oriented behavior) the firm is able to expand the market but not to maintain a satisfactory level of technological innovation. In both cases, firms are confined to a very limited market niche. The main difference in the third case (oscillating behavior) compared to the first two lies in the fact that, in the market phases, the firm did not neglect a technological focus, and was able to achieve a certain balance between market and technology.

All the considered firms show some common features. They were founded by technical entrepreneurs and were born around a product idea

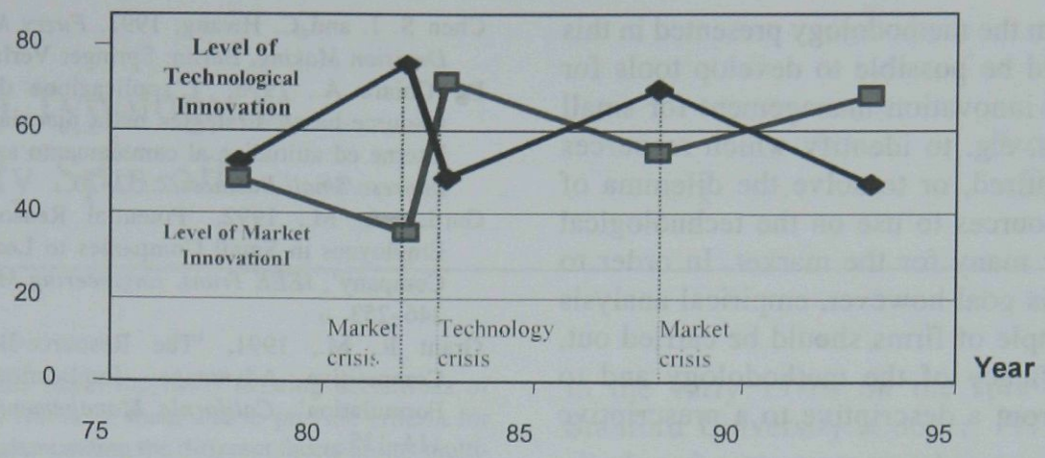


Figure 3. Case-study 3 results.

developed for a specific market, often limited to a regional market. The acquisition and the updating of initial know-how took place in several ways: through relationships with large firms or by means of close relationships with technical groups or research centers, which allowed the firm to experiment with high levels of technological innovation and specialize in a well-defined market segment. The field analysis showed that all the firms, because of the high degree of technical expertise of the founders and their network of relationships with other technical centers, reached a good level of technological innovation (LTI) in the first years of their life. This tendency is shown in all the presented cases in which LTI is always more or less high in the first phase or at the firms' birth.

Nevertheless, the strong focus of a group on the technological side usually implies neglecting market vision and development (customer fidelity, marketing and commercialization, services and assistance, connections with other firms). For this reason all the considered firms experience a more or less dramatic market crisis, here essentially seen as an inability to enlarge the market beyond the local area and a difficulty in maintaining growth. This crisis is particularly evident in the first two cases (see the LMI graphs).

The market crisis causes a reorganization of the firms' activities, involving both the original group of entrepreneurs and the internal professional skills. In general, one or more entrepreneurs move from product development activities towards market development or managerial roles.

The reorganization of the firm following the market crisis signals the beginning of the decline in a firm's innovative ability. Firms reduce their engagement in product development and progressively concentrate on the supply of IT services or limit themselves to updating the initial product, as in Cases 1 and 2, in which it is possible to observe a remarkable fall of the LTI while LMI increases or remains stable. In Case 3, the firm managed to interrupt the decline with a reorganization of activities to take advantage of opportunities arising from a new relationship with the market. This firm shows continuous progress in innovative activities (the LTI increases again after the initial fall).

## 7. Conclusion

In this paper we have presented a methodology to evaluate the innovation capabilities of small software firms. The main hypothesis on which our approach is based, i.e. the presence of a relationship between innovation capabilities and certain kinds of resources managed by firms, has a double source: the resource-based theory and the literature on small software firms, based on empirical observations concerning the variety of resources managed by firms and the transience of their innovation capabilities.

Putting together theoretical models and empirical observation has turned out to be a critical task from the methodological point of view because of the difficulty of providing a clear identification of firms' resources. The strong specificity of resources related to innovation capabilities have convinced us of the need to restrict the analysis to a small group of firms operating in the same sector to be analyzed as case studies. In this way we have been able to concentrate our attention on the methodological aspects.

Starting from the methodology presented in this paper, it should be possible to develop tools for the support of innovation management for small software firms, e.g. to identify which resources should be acquired, or to solve the dilemma of how many resources to use on the technological front and how many for the market. In order to accomplish this goal however, empirical analysis on a large sample of firms should be carried out, to test the efficacy of the methodology and to transform it from a descriptive to a prescriptive methodology.

As regards the possibility of generalizing the results of the field analysis, the three kinds of behaviors (technology-oriented, market-oriented and oscillating) have also been detected in other case studies that are not presented here. Notwithstanding this, in order to understand if these three behaviors correspond to general trends, large sample and cross-sector studies should be performed.

## Note

* Although the paper is the fruit of the collaboration of all the authors, in this version, Section 1 is by M. Raffa, Section 2 is by G. Zollo, Section 3, 5.1.1, 5.2.1, 5.3.1 are by G. Capaldo and Section 4, 5.1.2, 5.2.2, 5.3.2 are by L. Iandoli and remaining parts are the fruit of collaborative work.

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