

The Provision of Finance to Innovation: A Survey Conducted among Italian Technology-based Small Firms¹

Giancarlo Giudici
Stefano Paleari

ABSTRACT. Financial constraints to the development of innovation are often considered one of the main impediments to high-technology firms seeking to expand and grow. In particular this is the case of small and medium size *high-tech* firms. In the U.S. and the U.K. a variety of sources of finance are available to the start-ups of innovative firms; in the other European countries, and particularly in Italy, these means are still uncommon so that the development of technology is often prevented. This paper, based on an empirical analysis on a survey of 46 small high-tech Italian firms, aims at exploring the problems experienced by small businesses in gaining access to debt and equity finance. The results highlight that traditional financial sources are inadequate to finance innovative projects. The questioned firms rely mainly on personal finance, and secondly on short term bank debt; they are truly involved in maintaining control over the firm activities and are willing to issue outside equity only if the new investors also provide non financial competencies. Among the 46 interviewed firms, only 10 are willing to be listed in the future on small firms' stock markets.

1. Introduction

A recent study about the historical evolution of high-technology sectors in Italy emphasizes that in this country, despite a well-timed entry in innovative sectors, there has been no capability to steady the initial competitive position in new research-based industries.² Nevertheless, with the exception of the nuclear sector and, partially, chemistry and electronics, in Italy economic conditions and knowledge seem not to be lacking in order to compete successfully in information and multimedia technology patterns, microelectronics, biotechnology, industrial automation and advanced materials. In particular, this is the case of small innovative niches, in which small size firms tend to have some competitive advantages compared with large firms. Besides, it is well known that an important factor influencing the viability of small firms is capital requirements: there are compelling reasons why lack of finance will serve as an impediment to small firms and there is evidence (Acs and Audretsch, 1990) that SMEs, in particular operating in high-tech sectors, are more likely to be subject to liquidity constraints than the larger firms.

Are Italian small firms really prevented from innovating in high-tech sectors because of capital shortage? The aim of this paper is to answer to this question and consequently to determine which kind of financial contracts are likely to be implemented by Italian rising TBSFs (technology-based small firms) and what reasons induce entrepreneurs to choose a particular mix of financial sources facing the development of innovation; in particular an explorative study is conducted about the capability of the banking institutions, equity investors, corporate venture capitalists and

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Giancarlo Giudici
Università degli Studi di Bergamo
Sezione di Ingegneria Gestionale – Via Marconi, 5
24044 Dalmine (BG)
Italy
E-mail: giancarlo.giudici@polimi.it
Internet: <http://www.unibg.it/sige>

and

Stefano Paleari
Politecnico di Milano
Dipartimento di Economia e Produzione
P.zza L. Da Vinci, 32
20133 Milano
Italy
E-mail: stefano.paleari@polimi.it
Internet: <http://welcome.to/finanza.aziendale>



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business angels to support TBSFs at start-up, in early growth and maturity. The database is derived from 249 Italian SMEs operating in high-technology sectors. A questionnaire has been developed and submitted to the firms in 1997; 46 of them agreed to cooperate and answer.

The paper is divided in four sections. Section 2 proposes a short theoretical outline which links the economic, technological and financing issues of innovation in TBSFs: in particular the different stages in the growth of small high-tech firms, the parallel development of their financial needs and the relationship between the entrepreneur and outside investors are considered. On these basis, the problems in accessing alternative external sources of finance are examined; equity finance, in particular venture capital investing, and the existence of specific stock markets are therefore to be regarded as means to improve the efficiency of TBSFs financing. Section 3 shows the results of the empirical analysis. In particular, section 3.1 describes the methodological features of the research and the approach used to find and classify the high-tech companies; section 3.2 reports some basic characteristics of the survey; sections 3.3 and 3.4 specifically deal with the financial theme and show the relative importance of different sources of external finance and the existence of financial constraints in developing innovation for the questioned firms. An econometric analysis (section 3.5) is presented with the objective to determine the causes of the existence of restricted accesses to capital. Last, in section 4, the main results of the research and some observations are summarized.

2. The theoretical background

2.1. *Small firms and innovation*

The Schumpeterian theory states that because of high barriers to entry, innovative activities require considerable market power and hence take place in large firms. This view has been challenged from many angles. The innovative activity of small firms makes an important contribution distinct from that of large firms (Acs and Audretsch, 1990) and thus may respond to a different set of incentives and resources.

There are several factors which may determine a relative advantage for small firms in order to innovate. The role of industrial structure and local environment, as well as marketing and R&D managing, has been widely pointed out by several studies. Empirical research shows that SMEs are actually not deterred from entering capital-intensive industries and considered overall, SMEs are found to contribute about as many innovations as large firms also in manufacturing and traditional sectors.³ Moreover, barriers to entry can be reduced by network collaboration (Karlsson and Olsson, 1998).

Indeed, the source of innovation activity is established to be different for SMEs in comparison with larger counterparts (Audretsch and Vivarelli, 1996): while private R&D expenditures contribute more to the innovative activity of large firms, the spillovers from university research as well as informal external sources of information are more important for SMEs.

Small enterprises may stake on product specialization and on the specificity of market segments, which represent niches where the large companies are inefficient, because of the difficulties in embezzling processes of learning by doing and learning by using, or simply because the market size is too small for large companies. Their advantages may be a dynamic and entrepreneurial management and efficient network cooperation (Rothwell, 1989). This is particularly true in fast-growing high-tech sectors, where entrepreneurs are supposed to react quickly to changing environment and technology patterns.

In this sense, the success of TBSFs (technology-based small firms) arises from the joining of elements such as entrepreneurial know-how and experience, technological competence resources and networking strategies (Butchart, 1987; Storey and Tether, 1998). Therefore their evolution and development are conditioned by the existence of institutional actors and organization that support small firms in the earlier stages, through a direct relationship, for example providing financial resources from banks or investors, or indirectly through the cooperation with local districts, research centers and universities. Hence on one hand small firms seem to take advantage from their dynamism and flexibility, but on the other hand, contrary to large corporations, they experi-

ence problems in gaining access to finance capital (Acs and Audretsch, 1990).

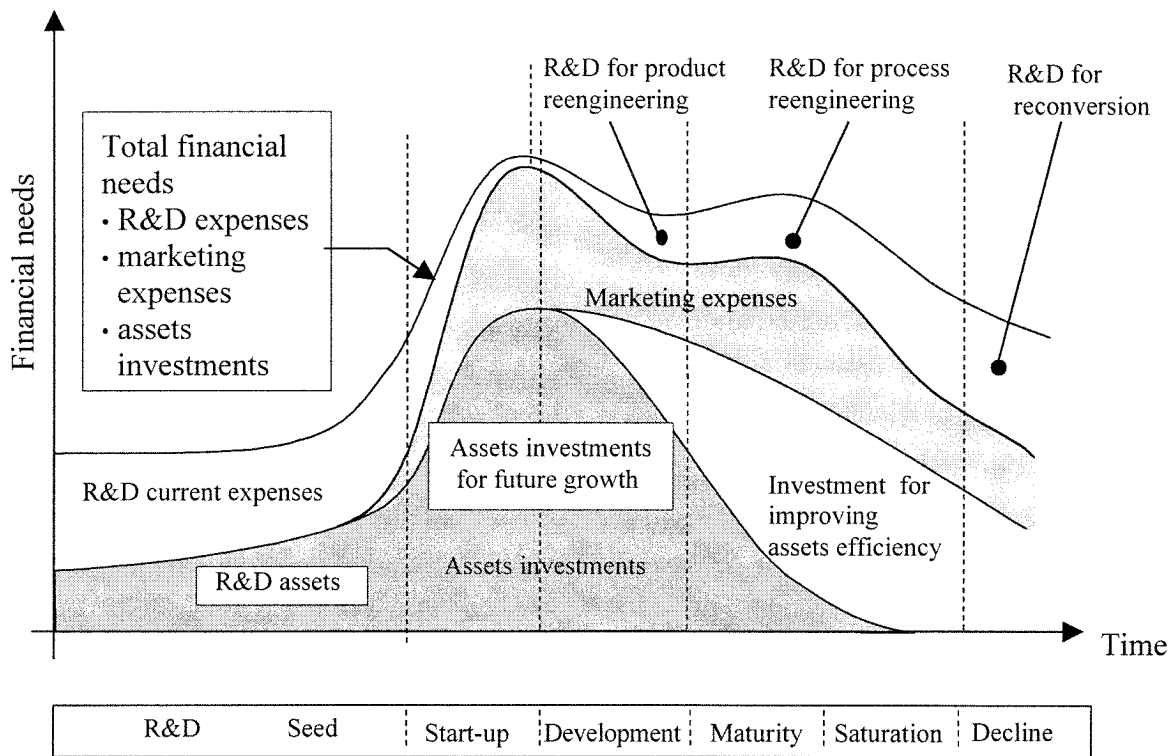
This constraint should be particularly accentuated for TBSFs; in fact, firms belonging to traditional sectors may remain small, but fast-growing innovative firms have to enlarge in order to follow the development of the market, to expand and diversify production in new niches, to develop new technological and managerial skills. In the early-development phase the lack of financial resources may be the most relevant problem faced by these firms (Westhead and Storey, 1997).

2.2. The provision of finance to TBSFs

Technology-based small firms experience different financial problems during the business lifecycle, due to the need of R&D and marketing expenses and peculiar typologies of investments (see Figure 1).

Several empirical studies show that access to and costs of finance are some of the most important factors which affect the ability of a technology-based firm to grow. This is particularly true during the phase of the introduction of a new product in the market because finance is needed in order to develop intangible and specific resources.⁴ Different reasons seem to explain this phenomenon, as highlighted, among others, by Prakke (1988), Budworth (1996), Oakey (1995) and Zara (1995 and 1996) and in a survey edited by the European Commission (1994).

The risk of failure in developing new technologies is higher than in traditional firms: thus, new products may be technically unfeasible or not tradable, or a dominant design pattern may be not yet spread out. In these sectors the technological paradigm is fluid, there is no standardized design and several engineering paths may be followed; firms compete in order to impose their new technical standards on the market giving rise to



Source: European Commission (1994).

Figure 1. Financial needs in the different stages of the lifecycle of an innovative product.

the risk of projects becoming obsolete. Moreover, once a dominant design pattern has been imposed, there is no certainty about the customer appeal of the new product, since markets could be underdeveloped or even not existent.

So, firms entering in high-tech sectors incur in high “exogenous” sunk costs (Sutton, 1996) determined by R&D activity, but also in “endogenous” costs like advertising and information expenses in order to enhance the knowledge and demand for products.

Then, small firms often develop a single research with the risk of experiencing periodical difficulties in accessing finance, for example every time the increase of R&D costs is contextual to a decrease of products sales. In this sense, large firms may diversify their innovative projects and obtain more stable cash flows.

Last, TBSFs are in general established by entrepreneurs gifted with high technical and scientific skills, but with little capability and experience in complex business administration: often the entrepreneurs speak with difficulty to existing and potential stakeholders, risking to present the firm as a non-appealing business.

All these factors (in particular the innovation content of products, the high technological and commercial risk, the peculiarities of intangible assets and investments) combine to present constraints and difficulties in securing finance, and consequently to slow down innovation in technology-based small firms.

The phase of the introduction of new products on the market is the most critical in the lifecycle of a firm. In this situation uncertainty is very high and the finance required is at its maximum level, in comparison with the existing assets (see Figure 1), so that resorting to outside financing is usually necessary and often essential if compared to the capital provided by the entrepreneurs.⁵ Several theoretical contributions (the agency costs theory (Jensen and Meckling, 1976), the pecking order theory (Myers, 1984), the signaling hypothesis (Myers and Majluf, 1984)) explain why small innovative firms often experience troubles in obtaining external finance.

According to the agency costs theory, financing problems arise primarily as a consequence of information asymmetries between external investors and entrepreneurs. Such problems are

strongly emphasized in TBSFs due to the high risk of the business. The most relevant implications of these asymmetries deal with adverse selection and moral hazard problems arousing agency costs, which can be mitigated through a continuous flow of information to potential investors, but may endanger the competitive advantages of the firm. According to Binks et al. (1992) and Della Bella (1993), external equity financing is therefore costly and difficult to be managed, in particular through traditional stock markets, not only due to the binding requirements decided by authorities. In this case an equity gap may be overcome through a private placement of shares to other firms or individuals (corporate venture capitalists and business angels) or to institutional investors, who are able to mitigate information asymmetries since they have a strong knowledge of the sector and can be actively involved in the business management.

Dealing with the access to debt finance, Pencarelli (1995) underlines that the existence of contingent market failures should not be neglected due to the *ex-ante* information asymmetries and the institutional quality of potential investors, that is the poor ability to evaluate the business, which creates the potential for credit rationing by banks, allowing high-risk borrowers to drop out.

Alternatively, a mechanism for addressing the problems of adverse selection is the use of contractual provisions as bonding and signaling devices, such as collateral (capital gearing approach)⁶ securing loans against appropriate assets. Thus in a debt contract the bank grants the shareholders a call option on the value of the assets, with strike price and time equal to the value and the duration of the debt itself. Since high-tech companies engage in risky investments, the value of the call is very high. On the other hand, due to the existence of an upper bound on interest rates, the bank cannot recover the whole value of the option, and the willingness to pledge collateral becomes the way to reduce its cost. Thus the problem for TBSFs is the availability of appropriate valuable assets, since their resources are essentially intangible. Binks et al. (1992) and Caprio and Spisni (1994) show that these firms are overwhelmingly endowed with intangible assets and their tangible assets (if existing) have a limited “carcass” value, because they consist of specific

assets whose value is hard to be determined and to be recovered out of the firm specific activity.

The provision of personal collateral in the form of a guarantee is only partially an efficient solution, because it is often limited in supply. Moreover, in these cases such requirements effectively erode the limited liability status, so that the additional risk borne by the entrepreneur may discourage the investment project, pointing out inefficiencies in the capital allocation in the financial markets.

In sum, the agency costs theory suggests that TBSFs face several problems in external debt and equity finance collecting. In the latter case the literature also points out that, in addition to the fact that the providers of finance do not offer enough capital to business, there are firms who consider external equity as a way of loosing voting and control power.⁷

In this view the pecking order hypothesis by Donaldson (1961) emphasizes that firms first choose self-financing; then, if necessary, firms resort to borrowing and consider equity partners only as their last resort. This occurs because external financing is costly, but also because firms often do not choose the optimal financing policy, but attempt to maintain the maximum level of autonomy versus banks and financial markets, adopting suboptimal choices (Myers, 1984).

Starting from a different point of view, the theory of signals reaches the same results as the pecking order approach, pointing out that the provision of inside equity (capital raised from the entrepreneurial team) is positively acknowledged by the market, as existing shareholders seem to rely on the firms' future innovative projects. An increase in the equity capital through the issue of new shares subscribed by new investors would be considered as a negative signal; in this case borrowing could be a better solution, as it would confirm the firm's earning capacity and the willingness of the entrepreneur not to share with other investors the expected good profitability generated by the investment (Myers and Majluf, 1984).

The aim of the empirical analysis will be to analyze the financing decisions of a sample of Italian TBSFs with reference to the above hypotheses to verify whether a finance constraint on the growth of small firms does exist and to test the validity of the pecking order hypothesis.

2.3. *The role of venture capitalists and financial markets*

The observations made in the previous sections suggest that TBSFs, in order to maximize the value of their investments, should resort to external financing by seeking investors willing to evaluate their investment based on the future opportunities of value creation rather than the present (or "carcass") value of assets. Sandri (1994) and Caprio and Spisni (1994) define venture capital as a "patient capital", expected to follow the project lifecycle: thus, by the fact that high-tech investments are risky and have a long maturity, equity capital should be used more intensively by innovative firms than by traditional ones in order to finance the grow-up phase.

Similar considerations are pointed out by corporate finance theories: in TBSFs costs related to financial distress are higher than in traditional firms, because bankruptcy fixed costs have a heavier impact due to the limited size of the firms, and because the value and the organization of the firm are more sensible to difficulties in managing the business. According to Brealey and Myers (1993), TBSFs, whose assets are essentially technology, growth opportunities and human competencies are more likely to forgo profitable investments and, if default occurs, their assets may erode rapidly. Hence, these firms should borrow significantly less than other firms.

Similarly, the theory of transaction costs (Williamson, 1988), with reference to the financing process, states that the more specific are investments to be financed, the less are the possibilities of a reinvestment, the higher are risks of losses for finance providers in case of default, since these assets cannot be easily transferred and traded on other markets. Hence, highly specific investments should be financed through equity rather than debt.

Therefore, considering the obstacles to direct access to financial markets, during the first stages of high-tech firms development, the role of venture capitalists, merchant banks and closed-end funds (who in the medium/long run have the aim of obtaining capital gains from selling stakes of fast-growing small and medium size companies) is extremely relevant.

A number of models in the literature⁸ show that

venture capitalists (VCs) are well-informed financial intermediaries, able to face problems related to risky investments in high-technology projects, to engage in active monitoring and therefore to add value to the entrepreneurial team. VCs place valuable managerial competencies at growing small firms' disposal; their stakes in the equity capital have a relevant image effect, which arouses intangible benefits in objective markets. A network of relationships with other enterprises can be exploited by VCs in order to solve technical, legal, management and human resources problems which might be experienced by TBSFs in the first stages of their life, thus stimulating the firm's growth. In this sense Florida and Kenney (1994) interpret the role of VCs as an interface among the various "network resources" needed to promote the innovative activity in SMEs (large companies, investors, research labs, districts, universities).

In Italy, a legislative background potentially suitable to promote the equity market development has been at work for a few years;⁹ however, an integration with other EU small markets joining the Euro-NM, in order to establish a specific stock market for fast-growing SMEs ("*Nuovo Mercato*"), has just been launched and the establishment of liquidity segments in the existing official Stock Market is forthcoming. Recent analyses about the experiences of international small caps' markets¹⁰ show that the most relevant problem is the "thinness" of SMEs (and in particular TBSFs) equity trading. This is due both to the limited equity of listed firms and to the investors' holding period, which is necessarily long in order to obtain a significant capital gain from the long term growth opportunity of small innovative firms. Moreover, the lack of liquidity generates inefficiencies in the pricing mechanism and affects the cost of the IPO, since stock markets investors demand a "liquidity premium". For these reasons the role of market makers (or specialists) and of sponsors seems to be important; in fact they provide investors with a warranty about the quality of the investment, reducing the costs of uncertainty and information problems in market trading.

In this condition financial markets may also represent a direct source of equity collection (as confirmed by the fact that recently some Italian TBSFs have been listed on international markets)¹¹

at least for mature high-tech firms. In the next section we will verify for our survey if equity capital investors and financial markets do play an adequate role in providing capital to TBSFs.

3. The empirical analysis

3.1. The data collection and selection method

After identifying the high-tech sectors based on the ENEA (1992) classification¹² we have singled out a group of 249 high-tech firms;¹³ these firms have been screened individually: some of them, though belonging to high-tech sectors, did not exhibit characteristics of really innovative firms and were rejected. Due to the lack of public information, the firms have been identified first considering only those belonging to high-tech sectors and exhibiting at least one of the following characteristics:

- introduction on the market of technologically innovative products;
- high intensity of internal R&D expenses (more than 10% of gross sales);
- high proportion of qualified employees¹⁴ (more than 30% of total);
- location in technological parks or incubators specific for small size innovative firms;
- research co-operation with important scientific and academic institutions;
- technological leadership in their sector.¹⁵

The limit size of the firms has been derived from the EU directives (issued by the European Commission in July 1996), according to which SMEs should employ less than 250 workers, report sales of less than € 40 million or alternatively report an accounting asset value of less than € 27 million. Obviously the firms of the survey had to comply with an independence criterion, namely no more than 25% of their equity capital must be owned by one or more large companies (this limit can be exceeded when the stake is held by public financial companies, VCs, funds or other institutional investors out of control).

As said, the potential sample is made up by 249 companies. In 1997 a questionnaire was submitted to these firms; on the basis of the 49 answers received, 3 firms were deleted from the sample since they were found to be off target.

Consequently, the actual sample is composed of 46 TBSFs.

In the following we analyze the answers with four aims. First, some descriptive data will be presented to indicate age, size, sector of activity and growth rate. Second, consideration will be given to the extent to which the firms experience an advantage in innovation activity and rely on several (internal or external) sources of innovation and R&D managing. This will allow us to point out differentiated requirements and experienced problems, among which the lack of finance. Third, the data presented on the firms' finance will show how the firms raise capital to grow up and how they trade-off costs and benefits of alternative sources of liquidity. Last, we want to point out if in the entrepreneurs' opinion banks and investors are efficient partners in providing capital.

By the existing literature, we expect some forms of financial constraints in the development of innovation, depending on different technological patterns, typology of R&D investments, sources of innovation, but also on the entrepreneur's attitude. We will verify the pecking order hypothesis and the existence of changes in financing policy according to the life-cycle approach.

3.2. The survey: some descriptive data and facts about innovation activity

Tables I and II describe the basic characteristics of the firms. The distribution of responses between different classes is generally good; the exception is the smallest size group, for which the response rate was higher. Chi-tests and F-tests were conducted to find significant differences in the answers by size group or by sector.

Age, size and growth rate of the firms by macrosector¹⁶ are summarized in Table I; it may be noted that "Electronics" and "Information Technology (IT)" firms are, on average, smaller and younger than the others. In Table II the sample firms are divided by size groups;¹⁷ it is shown that the group of "very small" firms is the largest (43.5% of the survey).

Consistently with the selection criteria, about 75% of the firms in the sample (the majority in every macrosector) use up the largest part of the R&D resources (on average 20% of gross sales) to develop technology internally¹⁸ (on average this activity takes up 54.3% of the total expenditure in the mechanical sector, 74% in the electronics sector and 56.8% in IT sector, data not reported in Tables). Note that 100% of the firms in the

TABLE I
Average (median) characteristics of the sample by macrosector

Sector	Mechanics	Electronics	Information Technology	Total
Age (years)	26 (17)	11.6 (10)	7.4 (6)	15 (11.5)
1996 gross sales (€ million)	5.16 (2.32)	1.03 (1.37)	3.05 (0.67)	3.56 (1.6)
Employees (#)	47 (30)	13 (13)	20 (8)	27 (14)
Growth rate of sales (last 3 years average)	23.6% (21%)	27.2% (18%)	47.9% (17%)	33.4% (19%)
Total	15	12	17	46

TABLE II
Characteristics of the sample by size

Size	Criteria		Firms of the sample		1996 gross sales (€ million)		1996 employees (#)	
	Gross sales (€ million)	Employees (#)	No.	(%)	Average	(Median)	Average	(Median)
Very small size	< 1.03	< 15	20	43.5%	0.62	(0.52)	5	(5)
Small size	1.03–6.97	15–50	16	34.8%	2.94	(2.53)	25	(25)
Medium size	6.97–40	50–250	10	21.7%	10.07	(8.88)	75	(72)
Total			46	100%	3.56	(1.6)	27	(14)

electronics sector have a strong preference for home-made R&D (against 63% and 64% of the firms in the other two sectors). This statistically significant difference could be related to the fact that the mechanical sectors (as previously defined) are characterized by a more intensive employment of innovations (Archibugi, 1988); as a result, the technology is not only developed inside the firm's boundary, but also acquired from external sources. The same consideration applies to the IT firms, whose products are often carried out using tools acquired on the market.

As expected, in the selected firms the percentage of graduated fellows on total employees is extremely high and equal to 29.1% (data not reported in Tables);¹⁹ considering also other technically gifted fellows the percentage of skilled workers is equal to 43% (data not reported in Tables); therefore, on average, 72% of the employees of the sample firms may be classified as "highly qualified staff". The difference among sectors we observed may be due to the lack, in the case of the IT firms and software houses, of a production chain typical of the manufacturing industries, in which unqualified workers may be more easily employed.

As regards the source of competencies and know-how, Table III shows that in a considerably high number of firms, in addition to the home-made research, a close relationship with customers and supplying firms plays an important role, besides the one attributed to the reverse engi-

neering process, specialized magazines and journals reading and the recruitment of employees with former experiences in the same sector (these last sources are classified as "other external sources"). This is consistent with Audretsch and Vivarelli (1996) and with the results of a survey conducted in the U.K. (Oakey, 1995), which shows that TBSFs are characterized by a frequent exploitation of a wide source of information and competencies, sometimes informal and occasional.

The available data show also that a different use of the various sources of information is made depending on the firm's sector (see again Table III) and size. In particular, medium size firms are more likely to resort to external consultants, while very small firms, probably because of the financial constraint, rely on reverse engineering and other informal sources (data not reported in Tables). Regarding the activity sector, mechanical firms distinguish themselves by an intensive relationship with customers and supplying firms, while electronics companies prefer other kinds of external sources.

The existence of an internal and formalized R&D function is more frequently noticed in larger firms. Other firms' activities indirectly involved in the innovative process are the technical offices (69% of the survey, data not reported in Tables), marketing (52%) and production (36%); moreover, the presence itself of a formal R&D activity seems to stimulate innovation through the relationship with the other functions of the firm.

TABLE III
The source of know-how by macrosector^a

Macrosector Source	Mechanics	Electronics	Information technology	Chi test	Total	
	%	%	%		No.	%
Home-made R&D	92%	80%	82%	0.659	35	83%
Partnership with customers and suppliers	92%	50%	35%	0.006*** ^b	24	57%
External consulting	15%	30%	53%	0.094* ^c	14	33%
Joint research	15%	30%	29%	0.621	11	26%
Other external sources ^d	31%	90%	65%	0.014*** ^c	25	60%

^a The percentages represent the number of firms who attributed the maximum rank in a three point scale, with higher score indicating a higher perceived importance of the corresponding source.

^b The difference is statistically significant at the 99% level.

^c The difference is statistically significant at the 90% level.

^d This category groups magazines and reviews reading, meeting and congress participations, reverse engineering, information from public offices and hiring employees with former experience.

^e The difference is statistically significant at the 95% level.

The number of registered patents is often considered as a proxy of the efficiency of the technological activity: even though the panel is made up by TBSFs, only 33% of them registered a patent in Italy (data not reported in Tables) and the percentage is even lower if we consider only patents registered in other countries (12.2% at the European Patent Office and 4.9% at the U.S. Patent Office). In fact output proxies for innovations are more suited to compare the technological level of several countries in a same sector, rather than firms belonging to different sectors (Griliches, 1990). The data are likely to suggest that the patent is not believed as a mean to protect innovations. Indeed, only 18% of the sample firms rely on patents (the small size of the firms may be a weakness in this case), whereas shortening the lead time is considered the best mean to protect innovation (particularly by IT firms).²⁰ This is consistent with empirical findings reported by Griliches (1990).

3.3. Finance of the firms in the sample

Although in the literature the existence of the financial constraints has been acknowledged as a relevant problem in the start-up phase of TBSFs, little effort has been spent to systematically analyze the lack of finance as one of the obstacles that high-tech firms experience in their innovation activity. Therefore it is interesting to analyze the perceived financial constraint together with other major problems faced by the firms; this will provide some indicator of actual quantitative restrictions on the availability of finance but also will have a significant attitudinal component such that even if finance is available, respondents may continue to perceive some form of credit constraint due to a conservative attitude.

Therefore, we asked the entrepreneurs to point out the major problems they experienced in the business.

Table IV shows that the lack of marketing capabilities is the problem more frequently experienced in the start-up phase (high-tech companies tend to be technology oriented rather than market oriented, thus products may be technically advanced but with little potential customer appeal). The provision of financial funds and competencies ranks immediately following in the

TABLE IV
Major problems experienced by the firms of the survey at the start-up^a

	No.	%
Lack of competencies in area:		
Technology	3	7%
Marketing	23	53%
Management and organization	13	30%
Finance	16	37%
Major financial problems		
Scarcity of self-generated profits in the first years	22	51%
Difficulties in accessing external sources of finance	20	49%

^a Number of firms of the survey declaring problems in the reported areas.

firms' opinion; indeed half of the sample companies experienced difficulties in funding innovative projects and their development has been sensibly slackened by the scarcity of self-generated profits. This is particularly relevant since TBSFs face peculiar problems in raising external finance, also because their entrepreneurs are often reluctant to sell shares of their company to external investors. Therefore, self-financing should be their preferred, but in most of the cases unavailable, source of capital particularly in the start-up phase.

To verify this hypothesis, the provision of several internal and external financial sources by the questioned firms has been analyzed according to the lifecycle model, in the course of the different inter-temporal phases (in particular in the earlier development and in the following years).

It is well known that the availability of alternative sources of finance (apart from the entrepreneurs' personal savings) is strongly differentiated among the major industrialized countries depending on to the peculiarities of their financial markets.²¹ In our survey a very scarce role has been recognized to external sources of finance; therefore, 73% of the start-ups (data not reported in Tables) have been financed exclusively with the entrepreneurs' personal wealth; in only one case an alternative source has been accessed, namely a partnership with an industrial firm. Not surprisingly, 76% of the sample TBSFs think that it is dangerous to issue debt in the start-up phase,

because this may interfere with the future growth of the firm. Notice that none of the firms experienced a venture capital relationship: this is probably due also to the fact that VC in Italy is essentially at work in fast-growing firms more than in start-ups.

In the first development phase the largest part of finance capital is employed for R&D activity. On one hand, if self-financing were not adequate, access to external finance would be essential; on the other hand, empirical research shows that in the years following the start-up, in order to finance the process of product marketing, TBSFs rely on more accessible sources, combining self-financing with bank debt (Moore, 1994; Manigart and Struyf, 1997).

As Table V shows, the sources of finance which are more frequently employed by the sample firms in the development phase are self-financing (through retained profits and inside equity) and short-term debt (bank overdrafts and commercial credit). Long-term debt is less frequently used; external equity (by individuals, industrial firms or institutional investors) is almost never issued. No significant systematic differences have been detected among the different sectors: nevertheless, individual shareholders are likely to be more determinant in the mechanical sector.

It is interesting to investigate the change of these preferences over the following years in

which TBSFs should be less risky and have more tangible assets; moreover their growth opportunities should be evident. Therefore, we expect that during the years following the development phase these firms choose a mix of finance among more diversified sources. This hypothesis is confirmed by the increase of relevance attributed by the sample companies to their sources in the lifecycle phases following the first development (see Table VI). Notice that the firms' preferences do not change over time; they can simply rely on a larger set of sources. Notice also the significant increase of long-term debt issuing (49% vs. 29% in Table V): this phenomenon is consistent with the hypothesis that the older is the firm, the more tangible assets are available to secure long-term financing.

From Tables V and VI the difference between the IT firms and the other TBSFs is remarkable. IT firms are considered "soft companies", as their need for financial resources is limited, whereas the other firms are characterized by expensive hardening processes in order to develop innovative activity (European Commission, 1994).

The absence of external equity investments is still evident, depending probably on the reluctance to open to new investors, but also on the risk-aversion of the investors themselves or on the high monitoring costs that they would have to bear by investing in such small firms.

TABLE V
Importance of different sources of finance in the earlier-development stage by macrosector^a

Macrosector	Mechanics	Electronics	Information technology	Chi test (p)	Total	
	%	%	%		No.	%
Self-generated profits	77%	73%	82%	0.45	33	79%
Entrepreneurs' personal savings	23%	18%	24%	0.98	9	21%
Equity capital from existing shareholders	54%	27%	59%	0.38	20	48%
New individual shareholders	23%	18%	6%	0.05** ^b	6	14%
New corporate shareholders	0%	9%	6%	0.57	2	5%
VCs or merchant banks	0%	9%	0%	0.25	1	2%
Short term credit	77%	45%	53%	0.10* ^c	24	57%
Commercial credit	54%	45%	41%	0.79	19	45%
Long term credit	31%	27%	29%	0.86	12	29%
Long term facilitated credit	38%	45%	6%	0.13	11	26%

^a The percentages represent the number of firms who attributed the first two ranks in a three point scale, with higher scores indicating a higher perceived importance of the corresponding source.

^b The difference is significant at the 95% level.

^c The difference is significant at the 90% level.

TABLE VI
Importance of different sources of finance in the stages following the earlier-development by macrosector^a

Macrosector	Mechanics	Electronics	Information Technology	Chi test	Total	
	%	%	%	(p)	No.	%
Self-generated profits	86%	67%	93%	0.03** ^b	35	85%
Entrepreneurs' personal savings	21%	22%	13%	0.30	8	20%
Equity capital from existing shareholders	50%	78%	47%	0.48	23	56%
New individual shareholders	7%	33%	7%	0.24	6	15%
New corporate shareholders	7%	22%	7%	0.47	5	12%
VCs or merchant banks	7%	11%	7%	0.56	3	7%
Short term credit	79%	78%	40%	0.09** ^c	25	61%
Commercial credit	64%	56%	40%	0.71	20	49%
Long term credit	57%	44%	47%	0.17	20	49%
Long term facilitated credit	43%	22%	13%	0.19	11	27%

^a The percentages represent the number of firms who attributed the first two ranks in a three point scale, with higher score indicating a higher perceived importance of the corresponding source.

^b The difference is significant at the 95% level.

^c The difference is significant at the 90% level.

3.4. The relationship with the banking system, equity investors and financial markets

TBSFs typically complain with banks of their limited competency in analyzing and exploiting the business potential and about the excessive amount of warranties required by investors. Consequently, we may argue that the smaller is the firm, the more the entrepreneur will complain with banks.

In order to confirm this assumption, the entrepreneurs were asked to express a judgement about their relationship with the banking institutions. The answers show that 96% of the firms criticize the banks' limited knowledge of high-tech sectors; 93% think that bank loans are too costly and 91% claim that banks are not able to evaluate correctly their growth opportunities.²² Indeed the answers, grouped by firm age and size, highlight that a correlation between complaint degree and scale exists. Thus this is not a peculiarity of TBSFs but in general of SMEs.

An interesting finding shows that almost half of the companies ask investors not only capital but also strategic and managerial advice; this implies that TBSFs do not look only for finance, but also for complementary competencies in their business sector. Qualified information is needed in order to consider correctly the business opportunities and weakness; likewise a more intensive involve-

ment of the bank in the operative management could reduce the information asymmetry which causes high cost of debt and capital rationing, as seen in section 2.

Despite the scarce availability and the high cost of bank loans, an aversion to resort to equity issues has been noticed. TBSFs' entrepreneurs and managers consider this chance as the last, and (according to the pecking order theory) they rely on alternative sources. As a matter of fact, the entrepreneurs are often the only owners; only 20% of the sample firms (in particular the largest ones) have actively involved outside investors (individuals or companies) in the ownership structure. The unwillingness to open the firm to other people is confirmed by a series of judgements (data not reported in Tables); 53% of the entrepreneurs claim that self-financing is the best source of equity finance with not statistically significant difference by size stratum. If external finance is needed, individuals are in most cases preferred to companies and entrepreneurs are worried about losing or weakening independence and control over their firm's activities. This is particularly true in very small firms (55.5% versus 18.7% in small size firms and 11.1% in medium size firms), even if this attitude hampers the company growth.

The preference granted to individuals (business angels) or corporate investors (see Table VII) is probably related to the fact that these categories

TABLE VII
Preference of alternative source of finance by size^a

Preferred investors	Very small size	Small size	Medium size	Chi test (<i>p</i>)	Total (%)
Merchant banks and VCs	23.1%	7.7%	33.3%	0.07* ^b	7 (20%)
Corporate investors and other firms	21.4%	33.3%	44.4%	0.54	13 (31.6%)
Business angels	50%	37.5%	50%	0.81	20 (45.2%)

^a The percentages represent the number of firms who attributed the first rank in a three point scale, with higher score indicating a higher perceived agreement with the statement.

^b The difference is significant at the 90% level.

of investors are able to bring complementary technological or managing expertise in the company. In other words, outside equity finance is considered only in exchange for new competencies. This is related to the secondary role acknowledged to institutional investors (as Table VII shows, only 20% of the sample companies believe that this source of finance is a good mean to support the firm's growth); it is evident that the entrepreneurs think financial institutions are not able to bring the requested competencies in the business.

It is interesting to investigate this attitude: in the past, Italian investors turned out not to be willing to establish a long-term venture capital relationship with SMEs (Sandri, 1994); this phenomenon is due not only to the investors' lack of technological competencies, but also to the scarce level of entrepreneurs' financial culture, since they are very cautious in selling equity of their company. Therefore, it is not possible to lay the blame only on banks and investors; on the contrary we can argue that there exist market impediments both in the supply and in the demand of equity capital.

Among the firms considered, a not negligible number of companies (10 out of 46) declared to be interested to be listed on a stock market in the next years.²³ The data related to these firms (not reported in Tables) show that they are larger than the others in terms of gross sales and employees but that they are similar in age (on average, they are 14.6 years old versus 15 years of the whole sample), so it is likely that they experienced a faster growth. Furthermore, the firms which are planning to go public have an international interest (since, for example, they export a large part of the production, or compete on several foreign markets) and claim to have a world-class technological excellence. The listing on stock markets probably represents a mean to reduce leverage and raise funds for growing, and in some cases, a way to cultivate their image or acquire a reputation in particular in foreign countries.

None of these firms seem to consider listing at the official Italian Stock Exchange; in fact, a strong interest has been shown towards secondary markets for SMEs, and (in 5 cases) towards foreign markets which are positively considered for image purposes.

TABLE VIII
Benefits brought by VCs and merchant banks as perceived by the firms of the survey by size^a

	Very small size	Small size	Medium size	Total %
Enhancement of the management team	21.4%	9.1%	0%	12.1%
Operations management	0%	0%	0%	0%
Contacts with new customers and suppliers	42.9%	36.4%	37.5%	39.4%
Managerial support	23.1%	0%	25%	15.6%
New finance accessing	57.1%	45.5%	50%	51.5%
Assistance for future IPO	42.9%	54.5%	62.5%	51.5%
Assistance for special financial operations	35.7%	63.6%	37.5%	45.5%

^a The percentages represent the number of firms who attributed the first rank in a three point scale, with higher score indicating a higher perceived importance of the benefit.

3.5. Regression analysis

In this section some econometric methodologies will be applied in order to find the determinants of specific factors in bounding the firms' capacity to finance innovation. The remarks highlighted in the previous analysis suggest that a series of motives (among which the expected profitability, the products' degree of innovation, the market maturity, the typology of tangible and intangible assets and the attitude of entrepreneurs towards finance management) combine to generate capital constraints for TBSFs' growth.

Intuitively, the verification of this hypothesis and, in particular, the definition of the dependent variable is problematic, since it is difficult to obtain an impartial measure of the real finance constraints experienced by a firm. Therefore, we use a discrete dependent variable (DIFF), namely the entrepreneurs' judgement about difficulties met by firms in financing innovation; DIFF is equal to 1 if significant problems were experienced, and 0 otherwise.²⁴ As a consequence, a *probit* model was drawn up for the analysis.

Owing to the limited size of the sample, we saved on the number of independent variables and we considered three significant indexes to verify the correlation between the firms' technological level and the financial constraints. Two of them are firm-specific indexes, namely the percentage of sales deriving from innovative products compared to the whole sales (INNOV) and the amount of intangible investments (typically R&D

expenses) in comparison with the firm's tangible assets (IMMAT);²⁵ the third index is business-specific and is referred to the market maturity: it is a dummy variable (STAGE) which is equal to 0 if, in the entrepreneurs' opinion, the business will grow further and is equal to 1 if the business is considered close to maturity. We expect that firms which are particularly focused on innovative products or have intangible assets or operate in new growing sectors or experience more problems than the others.

Then, we considered other simple variables, namely we control for the size of the firm (SIZE), measured in terms of employees, and the age (AGE), measured from the foundation year. We also considered the variable GROWTH, which represents the sales' average growth rate in the last three years²⁶ to verify if the growth rate has some effects. Last, by considering that entrepreneurs may not desire to issue new capital sacrificing the firm's growth, we added the dummy OPEN, which is equal to 1 if the entrepreneur thinks that opening to third parties could be a danger in terms of control weakening, and 0 otherwise. The willingness of opening the firm to third parties should determine lower probabilities to limit finance.

As expected, the results reported in Table IX highlight that age and size of a firm are negatively correlated with the difficulty of financing innovation, for the older and the larger is the firm, the lower are the risk of the business and the probability of existence of information asymmetries between entrepreneurs and investors. These

TABLE IX
Probit analysis on the survey: causes of perceived problems in accessing finance

Variable	Expected sign	Coefficient	Standard error	T-Ratio (<i>p</i>)
AGE	-	-0.063108	0.029550	-2.1356 (0.039)** ^a
SIZE	-	-0.026279	0.012875	-2.0410 (0.048)** ^a
GROWTH	?	-0.21251	0.39362	-0.53987 (0.592)
IMMAT	+	0.11261	0.31087	0.36222 (0.719)
STAGE	-	0.83106	0.39335	2.1128 (0.041)** ^a
INNOV	+	0.0057195	0.078179	0.73158 (0.469)
OPEN	+	0.29659	0.48141	0.61609 (0.542)
CONSTANT		-1.3829	1.2546	-1.1023 (0.277)
Observations: 46 – Dependent variable is DIFF		DIFF average = 0.45652		Estimated DIFF average = 0.45652
Marginal effects factor = 0.36488		Goodness of fit = 0.78261		Pseudo-R-squared = 0.31596
Log-likelihood function maximized value = -21.6914		Akaike information criterion = -29.6914		

^a 95% significance level for two-tailed tests.

elements appear to be the most important.²⁷ Surprisingly enough, considering the general discontent about the ability of the Italian financial community to support TBSFs' growth, the expected sign of the business' lifecycle variable (STAGE) is significantly positive; this could mean that firms operating in evident fast-growing sectors obtain finance more easily than the others. The variable related to the firm's growth rate (GROWTH) could confirm this hypothesis since firms exhibiting a brilliant past performance are likely to have more chances; unfortunately the significance level is low, and a deeper study is needed to comment further on this point. Similarly, the other variables (IMMAT, INNOV and OPEN) have the expected correlation (yet, the significance is not so relevant as in the previous cases).

4. Conclusion

In this paper we presented the results of a recent survey on Italian TBSFs facing the problem of financing innovative activity and investments. The survey could be extended in the future, by considering a larger number of firms or by further differentiating high-tech sectors. It is clear, from the results, that IT firms have peculiar characteristics, and different needs for finance, relative to electronics and mechanical firms, which have to support hardening processes. This difference was pointed out also by Butchart (1987) who distinguished "high technology manufacturing" from "high technology services".

In our opinion this study allowed us to make a number of interesting points, concerning not only the firms' financial constraint. First, we verified that Italian TBSFs in developing R&D rely on a wide and diversified number of sources of information (both external and internal) but particularly trust the competencies of human resources, although an R&D function is almost never formalized in the firm's organization. Second, Italian TBSFs do not rely on patents to protect innovation but rather on their market dynamism, favored by their small size.

Dealing with the finance of the firms, the data confirm the "pecking order theory", for the firms of the survey seem to follow some preferences in financing: in relation to their lifecycle firms prefer self-financing over debt, and debt over external

equity financing. In this sense the most critical phases are the start-up stages during which self-generated profits and entrepreneurs' personal wealth may be not available. Control and ownership considerations are found to be fundamental in determining the entrepreneurs' demand of equity.

Only if self-financing is not accessible, TBSFs rely on short term debt and commercial credit, which are more easily accessible than other sources. Long term debt seems to be preferred by mature firms, whereas facilitated public credit is believed to be inadequate because of the long procedure to access it relative to the fast obsolescence of high-tech products. Selling equity to external investors is considered only as a last choice, and TBSFs surely prefer investors who may bring complementary competencies to the managers (such as marketing and management expertise) like large firms and business angels versus financial intermediates, like VCs and banks. New customers finding through the investors' network of relationships and image purposes are other important objectives.

The managers' judgements collected in the survey about the ability of the financial community to support high-tech innovations are on the whole pessimistic. The major problems experienced in capital raising are the cost and the shortage of debt capital by banks, and the lack of adequate technical competencies. Often the entrepreneurs and their potential financiers seem to speak different languages: investors are believed to lack the knowledge needed to become partners. Moreover TBSFs are not willing to open to external shareholders if the newcomers are not able to add new value to the firm in exchange for a weakening of the entrepreneur's control. However, there are some mature firms which are aware of the benefits related to the listing on a Stock Market.

The issue of TBSFs financing is important and strategic for modern industrialized economies, but at the same time complex to study. From this survey we can assess an agenda for future reforms in order to improve the relationship between Italian TBSFs (and in general small firms) and capital markets. On one hand, banks and institutional investors should develop a capacity to consider high-tech firms for what they really are

(i.e. future growth opportunities rather than standing asset value), to monitor their performance and to intervene in the business' management. For a long time in Italy banks have been forbidden to hold shares in industrial firms, and only in the '90s they felt the urgency to acquire technical competencies for firms evaluation. Similarly, closed investment funds and venture capital are just now appearing in Italy.

In 1994 ("*legge Tremonti*") and in 1997 ("*riforma Visco*") particular incentives have been introduced by the Government for firms investing retained profits, collecting new equity capital rather than debt and going public on a Stock Market: for a long time the high rates of the Italian tax regime favored debt and discouraged investments on Stock Markets.

The market for private equity is now growing in Italy:²⁸ during the first six months of 1998 investments have been 15% higher than in 1997. Investors shall be ready to provide new finance to TBSFs, but also entrepreneurs have to modify their attitude towards external newcomers.

Last, a more significant and dynamic role should be played by the public authorities, in particular concerning the timeliness of decisions and simplicities of procedures. Bureaucracy should not hinder domestic high-tech firms in global competition.

Notes

¹ Even if this is the output of a research work jointly carried out by the authors, Giancarlo Giudici has written sections 1, 2.2, 3.1, 3.3 and 3.4, Stefano Paleari sections 2.1, 2.3, 3.2, 3.5 and 4. The authors are grateful to Roberto Bianchi and Enrico Pellizzoni for excellent research support, and to all those who provided helpful comments, in particular Antonio Abate (Università degli Studi di Bergamo), Maria Sole Brioschi (IDSE-CNR), Mario Calderini (Politecnico di Torino), Massimo G. Colombo (Università di Pavia), Paola Garrone (Politecnico di Milano) and the two anonymous referees. Research support from CNR (grant no. 96.01515.CT10) is also acknowledged.

² See Malerba, Torrisi and Bussolati (1997).

³ These findings emerged both for the U.S. (Acs and Audretsch, 1990) and for Europe (Van Dijk et al., 1997; Rothwell, 1989, and for Italy Santarelli and Sterlacchini, 1990).

⁴ Empirical evidence about the financial problems faced by Italian SMES can be found in Pencarelli and Dini (1995) and Scanagatta (1997). The key role played by finance constraints in inhibiting the development of TBSFs in other EU countries is highlighted also by Kulicke (1987), Landström (1987),

Hunsdiek and Albach (1988), Urban and Arnold (1993) and Westhead and Storey (1997). Moore (1994), in a survey of 89 English TBSFs, shows that the most mentioned problems faced by start-up companies are obtaining and managing finance, market intelligence and product development, management and organization, respectively.

⁵ Anyhow the R&D investments, typically intangible, are high during all the product lifecycle and must be added to the investments to develop a productive activity following a process of hardening, as defined by Bullock (1983). Thus, there are grounds for believing that finance problems (although generally easing as the small firm matures) are more likely to be faced by TBSFs compared to "traditional" firms.

⁶ See Stiglitz and Weiss (1981), Bester (1987), Binks and Ennew (1996) and Zara (1996). The latter two papers show that in fast growing high-tech companies, whose value strongly depends on development opportunities, incentives to opportunistic behavior are higher, and inefficient risky investments may be implemented. In this situation the provision of collateral may mitigate moral hazard problems (ex-post information asymmetries) and determine a lower bound to losses for investors.

⁷ On the Italian case, see Carlesi (1990) and Pencarelli and Dini (1995).

⁸ See, among others, Barry (1994), Gompers (1995), Fried and Hisrich (1995), a survey by the OECD (1996) and Reid (1996).

⁹ We refer, in particular, to the new discipline of investment funds (for example, pension funds), to the recent tax reform, which encourages the firms to recapitalization (*Dual Income Tax*), and to the reform of corporate governance rules (*Riforma Draghi*) aimed at increasing efficiency and transparency in financial markets.

¹⁰ See Dessy and Vender (1996), AIFI (1997), Petrella (1997), Pivato (1997).

¹¹ For example, Gruppo Formula and Algol have been listed on the EASDAQ market since December 1997. Other Italian TBSFs have gone public on the NASDAQ market in 1996.

¹² According to "*La mesure de la haute technologie*" (OCSE, 1988), "high technology sectors should strongly depend on a scientific or technological base, and be characterized by high R&D efforts, intense innovative activity, high percentage of graduated and technical employees, strong tendency to internationalization of production, R&D activity and trade". The classification we adopted has been proposed in a joint research involving the Alternative Energy Centre of Research (ENEA) and national universities.

¹³ The firms were selected through newspapers and specialized magazines (Il Sole 24 Ore, Business, Mondo economico, Espansione, Il Mondo, etc.), the World Wide Web, sectorial lists (KOMPASS guide), industrial associations (ASSOBIOTEC, ANASIN, ASSOBIOMEDICA, FEDERCHIMICA, DIMMI), scientific parks brochures, districts and incubators for small firms (Bic in Trieste, Gorizia, Terni, Teramo, Campobasso; Tecnoparco of the Verbano lake; the Innovation center of the Scientific Park in Padua, "Polo per le tecnologie avanzate" in Genua – ASSITECH – and TECHNOPSIS in Bari).

¹⁴ See Butchart's (1987) definition of high-tech sectors.

¹⁵ This requirement has been validated by specialized magazines and interviews.

¹⁶ The distinction among macrosectors is derived from an ENEA-CESPRI-Politecnico di Milano (1995) classification. The “Electronics” macrosector is composed of firms producing electromedical engines (2 firms), electronic engines (5), telecommunication engines (4) and electronic components (1). The “Mechanics” macrosector is composed of firms producing mechanical engines (1), industrial automation engines (12) and electromechanical engines (2). The “IT” sector is composed of 17 firms active in several business areas (Internet, multimedia, biomedical, industrial, management and financial software tools).

¹⁷ In order to homogenize the within-stratum sample size, a third size group (besides the two groups defined by the European Commission) was introduced, including firms with sales of less than €1.03 million (ITL 2 billion) and less than 15 employees, namely “very small firms”. It is well known that Italian SMEs are on average smaller than the other European ones (Raffa, 1995).

¹⁸ Among the costs of internal R&D we considered laboratory expenses and costs of new products development; among the costs of external R&D we included the purchase of patents, royalties and other assets, and R&D contracts with external agencies.

¹⁹ Tables report only the most significant data collected in the survey. The complete series of statistics are available upon request to the authors.

²⁰ In this analysis the lead time represents the time needed to imitate the innovation, i.e. the time of temporary monopoly enjoyed by the firm. The data are not reported in Tables.

²¹ For a comparison see Bullock (1983), Hunsdiek and Albach (1988) and Manigart and Struyf (1997).

²² These results do not imply an objective discontent towards banking services experienced by TBSFs with respect to other firms. In order to state that, we should consider another survey made up of non high-tech firms, and compare the differences in the answers; in general all entrepreneurs (not simply those founding high-tech firms) are more optimistic about their own business prospects than the external observer (De Meza and Southey, 1996). Moreover it is unwise to immediately accept these findings at face value, for the reason that we report the views of the entrepreneurs, rather than the financial community.

²³ This result is surprising under several point of views, since these firms are small and a high degree of diffidence is pointed out towards external investors. This group consists of 6 mechanical firms, 3 IT firms e 1 electronic firm. According to the criteria above, 4 firms are classified as “medium-size”, 3 are “small” and 3 are “very small”.

²⁴ For the purpose of analysis and because of the limited sample size, a four point scale was compressed to a two point scale with 0 defining those firms who declared to have experienced “strong difficulties” in financing, or even “to have forgone the innovative project”. The other choices were represented by having experienced “no problems” or “light difficulties”.

²⁵ Namely the variable IMMAT represents the proportion of intangible investments (R&D, search of new markets, competencies driving, etc.) to the total investments in innovative activities.

²⁶ We could not consider a variable related to the prof-

itability of the firms – like the ratio ROE – which could be relevant in the regression model, for this index was not declared by most of the firms in the survey.

²⁷ Problems may occur in the regression analysis, due to the limited size of the available information. In particular, age and size could be themselves correlated; indeed Table I shows that in the electronics sector firms tend to be smaller than in the IT sector, nevertheless older. Therefore we do not detect problems of multicollinearity.

²⁸ Source AIFI.

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