A SURVEY OF HIGH TECHNOLOGY FIRMS

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1. SUMMARY RESULTS

Although large established businesses account for a sizable share of industrial innovation in the United States, it is also recognized that small businesses play a special, and some would say crucial role, in the process by which "technological ideas" are ultimately brought to the marketplace.

Having supported several studies on technological innovations and innovating firms, the Small Business Administration has been interested for some time in providing information on the characteristics of firms in high technology sectors, particularly small firms. This research project aims to increase what is known about the activities, problems, and characteristics of small high-technology firms.

The main objective of the project was to create a database and analyze the origins, finance, research and development, and other innovation activities of small firms in high-technology sectors.

The database was developed through a survey of a sample of smaller firms in a set of high-technology sectors. The survey gathered specific information about: origins of the firm, original and current financing of the firm, problems in obtaining financing, technology sources, research and development, research and experimentation (R&E) tax credit, intellectual property practices, technology alliances, innovations by type (product, process, service, management), market size, market share of the innovations.

Survey Results

- The survey resulted in responses from more than two hundred small business enterprises in high-technology sectors. Of the businesses that responded, 198 provided complete and useful information.

- By design, the size of the firms surveyed was quite small. Although the firms were "young" they were not "new." One quarter of the respondents had been in business for less than 10 years, and the average age of the firms responding was 25 years.

- Two-thirds of the founders of these businesses were still owners. Only one-fifth of the founders were no longer associated with the firm, in many cases because they were reported to either be retired or deceased.

- Eighty-seven percent of the companies were independent start-ups, with 44% of the founders establishing the firm in the same industry in which they were previously employed.

- Most of the firms were closely held corporations; less than 10% of the firms had publicly traded stock.

- The firms were started for very traditional reasons. There was a clear perception of a business opportunity through the development of a new product (new processes and services being far less often mentioned as the motivation), coupled with the entrepreneur's quest for both independence and financial reward. Other reasons sometimes cited for starting a new firm such as frustration with current job or the availability of a government incentive through a program to stimulate new business were not frequently cited as significant reasons for founding a new company among survey respondents.

- Most firms had domestic sales that were less than $5 million in 1997. One-hundred fifty-two firms reported foreign sales. However, 80% of those firms had foreign sales of less than $2 million in 1997. About 60% of the firms consider foreign sales to be important.

- The marketing strategy most frequently cited by respondents is either to be the first to the market with a new product or to find a market niche and develop it. Much less frequently do these companies wait for a market to develop and enter it late.

- Respondents to the survey became profitable quickly after they were founded. Nearly 90% of the firms had recorded their first sale within one year of founding. Two-thirds of the firms had profits by the second year of their existence.

- Respondents to the survey indicated that their competitive advantage lay in offering better quality and better service and being more flexible than their competitors. Of interest is that more than half of the firms considered their price equal to or higher than their competitors and 60% reported no advantage in their costs of production.

- Although loans were obtained for many reasons, the most frequent reason was for expanding production or for purchasing equipment. Initial funds were primarily obtained to start the firm or to take a product beyond the prototype to the market. Much less frequently were loans obtained to develop an initial concept or make a prototype.

- About one-third of the firms were initially financed by equity alone and more than 60% of the firms indicated that the owners or managers had contributed over half of the firm's equity. This is consistent with the ownership profile of the companies--most being closely held businesses. Over half of the firms in our survey looked to banks for loans, with just over half of the firms getting short-term loans and just under half of the firms receiving long-term loans from banks. Shareholders and insiders were responsible for the sources of most of the other short and long-term financing. Only 15 firms reported that they had SBA guaranteed loans.

- Most (63%) of the companies did not claim the Research and Experimentation (R&E) tax credit. Only 16 companies reported that the tax credit actually increased their spending on Research and Development (R&D). However, 33 companies reported that it did increase their cash flow. Eighty-five companies said that the R&E tax credit had no effect on their firm. Clearly, these smaller high-technology companies did not report sizable benefits from this tax credit.

- Two-thirds of the companies had four or fewer R&D employees. Nonetheless, most R&D is performed internally. Only 40% of the companies did any contracting-out for R&D. New ideas are either developed internally or may come from suppliers and/or customers. Less frequently do ideas come from trade shows and industrial fairs. Virtually unimportant for these firms are technology and ideas from the government and non-profits. Yet, in contrast, over one-third of the firms did apply for Small Business Innovation Research (SBIR) awards.

- Patents and other formal intellectual property rights appear to be less important than trade secrets and being first to the market. The costs of the patent system were a frequently cited reason for not relying on them, and the problems of patent enforcement also contributed to the lack of importance of patents.

In summary, respondents to the survey appear to have been firms that took on the personalities of the founders/entrepreneurs. They are profitable early, they thrive on serving customers (often providing intermediate goods to other businesses) better than their competitors, and they find the government not a terribly important factor in either their business, R&D efforts, or as a customer. Foreign sales are a surprisingly important element, but still at least one quarter of the firms have only domestic sales. Financing is often a personal commitment of owners and managers, and is rarely available from banks and institutions for the R&D stages of their business. Most often bank loans are obtained for expanding existing production and/or for purchasing equipment; the more traditional and less risky elements of business. Finally, formal intellectual property rights systems appear to be far less important to these firms than their market advantage and their ability to protect property rights through internal secrecy.

2. INTRODUCTION

Many scholars have examined the clear reversal of a long term trend of "upsizing" in the size distribution of industrial firms, including manufacturing, in the developed countries of North America and Europe. Large firms dominated industry for most of this century.[1] From the mid-1970s onwards, however, available data indicate that many countries experienced a rebound in the economic importance of small firms (Acs and Audretch, 1990, 1993; Acs et al., 1993; Karlsson et al., 1993).[2]

The (re)emergence of small firms indicate that they play a significant role in the restructuring of U.S. industry. One needs to be careful, however, before taking the increased share of small business in total employment at face value. In the U.S., for example, the increased employment share may be attributable more to the relative expansion of sectors with traditionally large small business presence (such as services) and contraction of sectors traditionally dominated by large business, such as manufacturing, and less to any lasting advantage of small businesses as a means of organizing production.

We still do not fully understand the distinctive niches occupied by firms of different size in economies like that of the United States, that have become ever-more dependent on the creation of new technological knowledge and its quick implementation in production.[3] On one hand, advocates of the traditional (neo)Schumpeterian argue that technological advantage will require increasingly large R&D and other complementary resources for innovation to be placed under common administrative control.[4] This view was reflected in the debate over the declining competitiveness of the U.S. during the 1980s, partly attributable by many an expert to the smaller size and less integrated organizational form of American firms in important industries such as semiconductors vis a vis their Japanese counterparts (Egelhoff, 1986). This view is reinforced by arguments related

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[1] For this document, large firms are those with 500 employees and more. Small firms are those with fewer than 500 employees.

[2] However, more recent data indicates that the rapid formation of new high tech companies between the mid-1970s and mid-1980s did not continue thereafter. New high tech company formation declined in the second half of the 1980s. The number of annual company formations in the early 1990s averaged only about one third of the number in the second half of the 1980s (NSB, 1996).

[3] For example, in a series of articles Bo Carlsson has argued that the adoption of flexible automation in manufacturing has decreased the minimum efficient scale of production. By shifting the average cost curve to the left, this implies that smaller production plants can now exploit fully economies of scale. It also implies that older studies overestimate the importance of economies of scale for contemporary manufacturing. See Carlsson (1989, 1996) and Carlsson, Audretch and Acs (1994).

[4] Kamien and Schwartz (1982) nicely summarized the neo-Schumpeterian arguments and the (inconclusive) empirical work on these arguments. As they say, "Two broad hypotheses are associated with Schumpeter: (1) There is a positive relationship between innovation and monopoly power with the concomitant above normal profits. (2) Large firms are more than proportionately more innovative than small firms." (p. 22). Cohen (1995) and Cohen and Levin (1989) offer extensive surveys of the neo-Schumpeterian literature and discuss more recent approaches to the study of technological advance.

to the internationalization of markets and technological capabilities and the increasing importance of first mover advantages in introducing new technologies.

On the other hand, there are the arguments, most of them recent, that small sized firms generate more technological innovation. Using Small Business Administration (SBA) data that allow the measurement of innovative output directly, for example, Acs and Audretch (1990) argued strongly against the (neo)Schumpeterian view.[5] They found that innovative activity is hindered, not promoted, by industrial concentration. They also found that small firms have important advantages in highly innovative industries which utilize significant numbers of skilled labor, even though such industries may be dominated by large firms. Large firms were found to have a larger innovative advantage in industries that are capital-intensive, advertising-intensive, and non-concentrated. In support of the currently prevailing consensus, it was argued that both large and small firms contribute significantly to technological innovation, albeit in different environments.

Still, the study by Acs and Audretch (1990) did little to provide a complete picture of the nature, history, incentives, and modus operandi of those small firms whose role in technological innovation was found to be so important. They were not alone. With the exception of some business case studies, an expanding literature on small innovative firm financing, and an emerging literature on phenomena such as regional industrial clustering conducive to innovation, information about the problems and opportunities of small innovative firms in various industries continues to be relatively sparse. The project described in this report attempts to fill part of this void.

More specifically, having already completed a number of studies on technological innovations and innovating firms,[6] the Small Business Administration has been interested for some time in providing information on the characteristics of firms in high technology sectors, particularly small firms. This research project is aimed at developing a fuller understanding of the activities, problems, and characteristics of high-technology firms.

The main objective of the project was to create a database and analyze the origins, finance, research and development, and other innovation activities of small firms in high-technology sectors.

The database was developed through a survey of a sample of smaller firms in a set of high-technology sectors. The survey gathered specific information about: origins of the firm, original and current financing of the firm, problems in obtaining financing, technology sources, research and development, research and experimentation (R&E) tax credit, intellectual property practices, technology alliances, innovations by type (product, process, service, management), market size, market share of the innovations.

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[5] Rather than the typical input measures of technological change (R&D expenditure), the SBA data creates a direct measure of innovative output, the number of innovations introduced in the U.S. market in 1982.

[6] See, for example, Edwards and Gordon (1984), Bomberger (1982), and Gellman Research Associates (1993).

The remainder of this report is organized as follows. Section 2 briefly reviews the increasing importance of small firms to the U.S. economy and some small business dynamics. Section 3 discusses the set of attributes that distinguish "high-technology" firms from other business enterprises; and Section 4 describes how the survey of high-technology firms was conducted, and presents a summary profile of respondents to the survey. The remaining sections of the report summarize results from the survey dealing with the following issues:

- Innovation and R&D activities;
- Firm origins and entrepreneurship;
- Government policy;
- Intellectual property protection; and
- Technology acquisition.

3. SMALL FIRMS IN THE U.S. ECONOMY

Between 1988 and 1995, the number of businesses in the United States with fewer than 500 employees increased from just over 4.9 million to almost 5.4 million, representing an average annual increase of roughly 1.3% per year.[7] As may seen from Table 1, this average rate of increase masked considerable annual volatility in the annual rate of net business formation.

Table 1: Net Small Business Formation

	1988	1989	1990	1991	1992	1993	1994	1995
Number of Small Firms	4,941,821	5,007,442	5,059,772	5,037,048	5,081,234	5,179,013	5,261,967	5,353,624
Yearly Change		1.33%	1.05%	-0.45%	0.88%	1.92%	1.60%	1.74%
Small Firm Births &Deaths			**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**
Firm Births			584,892	541,141	544,596	564,504	570,587	594,369
Firm Deaths			531,400	546,518	521,606	492,551	503,563	497,123
Net Change			53,492	-5,377	22,990	71,853	67,024	97,245

Recent industrial restructuring in the U.S. has increased the economic role of small business. It appears that two forces are at work. There is considerable empirical evidence that the employment share of traditionally large-business-dominated industries is declining and that of traditionally small-business-dominated industries is increasing. The former primarily involves manufacturing whose share in non-farm civilian workforce dropped from 33 percent in 1950 to 16 percent in 1993. With 35 percent of its workforce now in small firms, and rising, manufacturing may soon shift from a large-business-dominated sector to one that cannot be characterized by either large or small firms.[8,9] The traditionally small-business-dominated category primarily involves services whose share in nonfarm civilian workforce increased from 12 percent in 1950 to 27 percent in 1993. Employment

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[7] This section draws heavily on data available from the Office of Advocacy, Small Business Administration (1998).

[8] SBA defines an industry with 60 percent or more of its employment in small firms as small-business-dominated. An industry with 40.0-59.9 percent of its employment in small firms is defined as indeterminate, and an industry with 60 percent or more of its employment in large firms is defined as large-business-dominated.

[9] The situation is more pronounced in terms of firm numbers. Manufacturing firms with up to 250 employees were recently estimated to comprise approximately 96 percent of all manufacturers in the United States (Bureau of the Census, 1991).

in the services sector had increased by almost 60 percent in the ten years prior to 1993. In contrast to manufacturing, the average size of firms in services has grown moving the sector in 1992 into the category that also cannot easily be characterized by size of the firm.[10]

In other words, the allocation of employment is changing among major industrial sectors. The pattern of employment change is one of "downsizing" in large-business-dominated industries and "up-sizing" in small-business-dominated industries.

[10] The economies of European countries are even more dependent on small firms than the economy of the United States. In 1993, there were 17 million enterprises in the private, non-primary sector of the European Union (twelve countries), of which 99.9 percent were small firms (Mulhern, 1995).

4. ROLE OF SMALL HIGH-TECHNOLOGY BUSINESSES

Our analysis focuses on characteristics of an important subset of small businesses: small high-technology businesses. The first step in such an analysis is to define main features that distinguish "high technology" firms from other types of business enterprises. There are, however, no definitive criteria for differentiating between firms that are high technology and those that are not (Cordes et al., 1986). Indeed, insofar as manufacturing processes and increasingly the delivery of many services require the application of sophisticated technologies, it might appear that the term "high tech" could apply to many firms in many different industries.

Development of product and process innovations

A commonly used approach to identifying high technology industries focuses on whether developing or applying new technological knowledge plays an integral role in the competitive strategy of the firm. Using this approach, a firm would be classified as high tech if one of its primary assets was the possession of advanced technological knowledge used to develop new products or processes.

While this definition is useful as a starting point, technological knowledge is an intangible asset that is not as readily measured as are tangible assets such as plant and equipment. There are, however, several ways of quantifying the extent of a firm's involvement in the development of new products and processes. Firms have been considered high tech on the basis of: (i) the extent of technology embodied in products and production processes; (ii) the determination that certain types of firms produce disproportionately more innovative outputs than others; and, (iii) relative expenditures on innovative inputs, such as scientific and technical workers, and especially R&D expenditures (Cordes et al. 1986).

Charles River Associates (1976) proposed six criteria for distinguishing between technology-based and non-technology-based firms that combine the above elements. The criteria were: (i) the degree to which a product is proprietary; (ii) how recently the underlying technology was developed; (iii) the extent to which a new market is created or an existing market is substantially transformed; (iv) the extent to which a product was based on scientific research; (v) rapidity of technological obsolescence; and (vi) the size of R&D expenditures required to develop a product. Twenty four-digit SIC code industries were found to satisfy all six criteria. They clustered in the broad industrial groups of electrical equipment, electronic components, chemical and allied products (including pharmaceuticals), professional and scientific instruments, and aircraft and missiles.

Other approaches for identifying high-technology firms that use some, but not all of the attributes proposed by the Charles River Associates study result in similar groupings of high-tech firms. For example, a Congressional Budget Office report used two characteristics to define a high-technology industry: high R&D intensity (ratio of R&D to sales one-third higher than manufacturing average) and rapid growth (ten-year increase in employment above all manufacturing industries average (Webre, 1985). Using these criteria, CBO identified the following eight three-digit SIC industries

as being high-technology: drugs, industrial organic chemicals, computer and office equipment, communications equipment, electronic components and accessories, aircraft and parts, guided missiles, space vehicles and parts, and instruments.

The Organization for Economic Cooperation and Development (OECD) has proposed a definition of a high-technology industry to be applied across all major industrialized countries. The classification was established in 1986 and is based on R&D intensities as measured by R&D expenditures as a percentage of production. Using this criterion six industries were classified as high-technology: aircraft (aerospace), office and computing equipment, communications equipment, drugs and medicines, scientific instruments, and electrical machinery. The classification was reviewed in 1992 with no change (NSB, 1993).

Use of product and process innovations

The approaches summarized above tend to equate high tech with the propensity of a firm to invest in research and development in order to create and apply advanced technological knowledge for product and process innovations. Yet, economists have come to recognize the importance of diffusion of new technologies, products, and processes as well as their creation.

An important source of such diffusion is the use of capital equipment that embodies technological advances. Some firms are likely to play a significant role in the overall diffusion of new technologies as users of new products or processes, even though such firms are not regularly engaged in the initial development of such new products or processes. A good case can be made that firms who make regular use of new technologies to produce their goods or deliver their services should also be considered as part of the high technology sector of the economy, in addition to firms that develop such technologies.

The list of high-tech industries presented in the 1992 report of the U.S. President on the state of small business is broadly consistent with this more expansive definition of what constitutes a high-technology industry (Executive Office of the President, 1993). The report lists the following high-tech industries: computer/data processing services, oil and gas extraction, other chemical and allied products, medical and ophthalmic goods, general industrial machinery, electronic components and accessories, scientific/measuring instruments, construction and related machinery, ordnance and accessories, n.e.c., radio/TV/communications equipment, office/computing equipment, photographic equipment and supplies, drugs, engines and turbines, industrial chemicals and synthetics, aircraft, missiles, and space vehicles, and petroleum refining.

This list includes not only industries classified as high-tech in the Charles River study, the CBO study, and by the OECD, but also a number of industries in service sectors (e.g., computer and data processing services) and the manufacturing sectors (e.g., general industrial machinery) that are significant users of new technologies, but which are not relatively R&D-intensive. Therefore, the list of high-tech industries in the President's report includes users as well as producers of advanced

technology goods. Because of the importance of users as well as developers of high-technology products and processes, we used this more expansive definition of high tech to define the sample of firms examined in the survey.

5. DESCRIPTION OF THE DATA BASE AND THE SURVEY SAMPLE

To learn more about the attributes of small high-technology firms, a survey was sent to a sample of such firms, drawn from the Corporate Technologies database (CorpTech), compiled by Corporate Technology Information Services (CTIS) (1995), which aims to provide comprehensive coverage of high technology industries in the U.S. The tenth edition of the database incorporated information on approximately 36,000 firms, the large majority of which were small firms. Around 90 percent of the profiled firms were private companies, or operating units of larger corporations. According to CTIS, in the sectors surveyed the database covers 99 percent of companies employing more than 1,000 workers, 75 percent of companies with 250-1,000 employees, and 65 percent of companies with fewer than 250 employees.

CorpTech classifies firms according to technology fields corresponding to eighteen "industries": factory automation, biotechnology, chemicals, computer hardware, defense, energy, environmental, manufacturing equipment, advanced materials, medical, pharmaceuticals, photonics, computer software, subassemblies and components, test and measurement, telecommunications, transportation, and holding companies. These industries incorporate 250 "major product groups" which, in turn, incorporate 3,000+ product categories. All 3,000 or so products are high technology manufacturing products.

In addition to the name of company and (if applicable) its corporate parent and the names and titles of company executives, the following information is provided for each company: product line(s): geographical location; size, including sales and number of employees; rate of employment growth in past year; rate of job creation since company formation; percentage of revenue from international activity; type of ownership including public, private, partnerships, government, non-profit, and non-U.S. ownership; current status of the company including year of company formation; government contract status; and SBIR awards won.

Six indexes are incorporated in the database. These are: a company name index that includes alternate and former names; a geographical index organized by state, city and town; a non-U.S. parent company index; a technology index listing around 16,000 technologies with corresponding CorpTech codes and SIC codes; an index relating SIC codes to CorpTech codes; an index relating all companies involved in each of the 3,000+ CorpTech product codes.

Survey Methodology

(i) The Initial CorpTech Sub-Sample

After consulting with CorpTech, 19,000 of the 43,000 firms in the CorpTech database were selected for inclusion in the initial sample. The selection was randomly based on firms that had provided complete information to CorpTech, and was reduced from their full database in order to keep costs within budget. According to CorpTech, this process did not introduce any significant bias to our sample.

We then selected six industries (as defined by CorpTech) for our study of small firms. Five were high-technology: Biotechnology, Advanced Materials, Subassemblies, Testing and Measurement, and Telecommunications. The sixth industry was Factory Automation, which was selected because it is an industry that purchases and uses high technology products.

(ii) The Mail Survey

A random set of 175 firms with fewer than 500 employees from each of the six industries was selected to be surveyed. Our actual sample was 1053 firms.

A letter from the SBA was sent to each firm introducing the study (see attachment). Two weeks later, we mailed the questionnaires (including a letter of explanation on George Washington University stationery) and requested a response within six weeks. Approximately 140 small firms responded by returning questionnaires. However, only 10 large firms responded.

Two months after the original questionnaire was sent, we contacted the non-responding firms by telephone rather than send another letter and questionnaire. (After consultation with SBA, we agreed that a phone reminder would be superior to sending another letter and questionnaire to all non-respondents.) The phone "script" is attached in the appendix. We offered to fax or mail a new questionnaire to the firm at that time. We could not contact 84 small firms (didn't answer phone, phone disconnected, etc.). Message were left with another 241 firms. And, the survey was sent to 508 firms on the second iteration.

Survey Response

We received completed surveys from a total of 198 small firms and 13 large firms. 77 small firms declined to be part of the survey and 17 large firms declined. Thus, the total responses (completed plus declined) was 373 small firms (25.9%) and 30 large firms (15.0%).

It is important to note that the quality of the surveys that were returned was excellent. Those companies that did respond took the time to fully answer this rather lengthy survey. Thus, although

we did not achieve as high a rate of response as had been requested by the SBA (80%), we did receive a large and useful set of data.

It should also be noted that other similar surveys of small high-tech businesses have had the following response rates: Cahners Research 1996 survey conducted for *Research and Development* magazine (mailing to 4,000 individuals selected from the readership circulation list) reported a 15.3% response rate, which they state is "in line with previous studies of this type." [Basic Research, A Survey conducted for: *R&D*, Cahners Research, Des Plaines, IL, 1997]. The Gellman Research Associates Study for the SBA, *A Survey of Innovative Activity*, July, 1993, surveyed a sample of 6000 small firms and 750 large firms. They received responses (using an initial mailing and a follow-on mailing to non-respondents) from 228 small firms and 15 large firms, which corresponds to a response rate of 3.8% for small firms and less than one percent of large firms. In Firm Size and External Research Relationships, Albert Link and John Rees, July, 1992, (a study for the SBA under contract SBA-89-989), 1046 firms with employment were surveyed by mail. They received 209 complete responses, a rate of 20%. Finally, another SBA study, Survey of Small Business Use of Intellectual Property Protection, MO-SCI Corporation, Rolla, MO, 1990, surveyed 1054 businesses. Their response rate from a multistage mailing and phone effort for the small firms in their sample was 31%.

General Attributes of Respondents

Before summarizing responses to the survey questions, it is helpful to provide a general profile both of the firms surveyed, and of respondents.

- Respondents to the GW University survey were remarkably consistent across the industries. Response rates ranged from a low of 15% in telecommunications to a high of 22% in testing & measuring.

Table 2: Distribution of Sample Among High-Technology Sectors

Industry	Total Firms in Sample	Completed Survey Returns	Percent
Automation	179	37	21%
Biotechnology	174	36	21%
Materials	175	32	18%
Subassemblies	175	29	17%
Testing & Measurement	175	38	22%
Telecommunications	175	26	15%

- As reported by CorpTech, firms in the sample of 1053 firms were 8.8% public and 91.2% privately owned. This distribution was mirrored among enterprises that returned completed questionnaires, of which only 9% responded that they had publicly-traded stock and the rest (91%) were either closely-held corporations, or proprietorships.

- Among respondents to the survey, the corporate form of organization was clearly dominant as shown in Table 3.

Table 3: Distribution of Respondents by Organizational Form

Form of Organization	Number
"C" Corporations	113
"S" Corporations	53
Limited Liability Corporations	2
Corp. with publicly traded stock	18
Sole Proprietorships	10
Partnerships	2

- The distribution of respondents to the survey by age, size, and sales was broadly comparable to the distribution of these attributes in the initial CorpTech sub-sample of 1053 small businesses. As seen from Table 4, there were no statistically significant differences in the average age, employment size, or sales of firms that responded to the GWU survey.

Table 4: Attributes of Respondents and Non-Respondents

	CorpTech Sample: 1053 Small Businesses	GWU Survey: 196 Small Businesses
Mean age of firm	25 years (σ = 19.5)	23 years (σ = 17.2)
Mean employment	57 (σ = 81)	79 (σ = 320)
Mean sales	\$8.4 million (σ = 29.3)	\$5.7 million (σ = 16.7)

- Although the GWU survey asked respondents to provide information on the gender and ethnic background of owners and founders of the firms surveyed, the survey did not pick up enough women or minority owned firms to conduct a meaningful statistical analysis of these returns.

Perhaps this indicates that firms in these high-technology categories have lower rates of minority or women ownership than firms in other industries. However, we have insufficient data to either prove or disprove that hypothesis.

- The size distribution of the firms that responded to our survey tended to be somewhat weighted in favor of firms with 25 or fewer employees.

Table 5: Distribution of Respondents by Business Size	
Business Size	**Number of Respondents**
10 or fewer employees	51 firms
11 to 25 employees	54 firms
26 to 50 employees	37 firms
51 to 100 employees	26 firms
101 to 499 employees	30 firms

- Roughly one-quarter of firms responding had been in business for less than ten years, while approximately one-half were more established in the sense that they had been in business for more than twenty years.

Table 6: Distribution of Respondents by Age of Business	
Age of Business	**Number of Respondents**
10 years or less	43 firms
11 through 15 years	47 firms
16 through 20 years	25 firms
Over 20 years	81 firms

Large Firms

We have decided not to attempt to analyze or compare the responses we received from the large firms. The response rate was low, often due to the reluctance of the personnel receiving the

questionnaire to fill out the return--either because it was too long and gave the impression that it was time consuming, and/or the fear of disclosing confidential information without getting approvals in the chain of command. The latter required significant effort that they were unwilling to initiate. Since the survey of large firms was not structured by industry (it was taken from the general CorpTech data base), an analysis of small and large firms from this survey would not reveal a good statistical comparison with our responses from the survey of small firms.

Quality of Responses

The quality of the data we received from the 198 respondents was excellent. Most firms that chose to respond gave us a fully completed questionnaire. Therefore, given that our response rate corresponds to that of other similar studies, that the distribution among industries of respondents is very close to the distribution chosen from the sample population, and that other significant profile variables such as age of the firm and employment and sales fall within one standard deviation of the sample population, we are confident that the data we analyze in this study are of good quality and are comparable to other studies of small business enterprises.

6. SMALL FIRM INNOVATION & COMPETITIVE STRATEGIES

Part of the void in empirical information concerning the role of small firms in technological innovation has been filled by various reports sponsored since the early 1980s by SBA's Office of Advocacy. A summary of the main findings of those reports was included in *The State of Small Business* (1995, ch.3). The first subsection below recounts some basic findings.

Previous Results

A large scale empirical study, which identified 8,074 innovations (first market introductions) in 1982 in 362 industries (Edwards and Gordon, 1984), found that small firms accounted for about 55 percent of those innovations. This result indicates that small firms are a major source of innovation, and demonstrates the importance of such firms in technology commercialization in the United States. Small firms were estimated to produce about 2.38 times as many innovations per employee as large firms. About the same time, another study produced a similar estimate: small firms were found to have produced 2.45 times as many innovations per employee as large firms (Bomberger, 1982).

The large fraction of innovations attributable to small firms needs to be reconciled with the fact that larger firms spend much larger sums on research and development. For example, a survey of 284 small firms and 32 large firms in upstate New York showed that only 28 percent of firms with fewer than 50 employees had at least one employee devoted full-time to R&D compared with 94 percent of firms with more than 500 employees (Link and Bozeman, 1987). Extensive annual industry surveys by the Bureau of the Census for the National Science Foundation also show that large firms spend much more own of their funds on R&D as well as receive more government money for R&D. While absolute numbers of R&D performers are on the side of small firms (more of them perform R&D than large firms), the sums involved are relatively much smaller for small firms.

Not only is the absolute amount of dollars lower; small firms also perform R&D with less resources per R&D scientist or engineer. This may, in fact, reflect different types of R&D. It has been estimated on the basis of the NSF data, for example, that small firms are more likely to perform basic research than large firms. Basic research is the cheapest type of R&D; the earliest phase research, in fact, carries the lowest price tag of all activities involved in innovation (Fusfeld, 1994).

Another survey sponsored by SBA, however, found that per dollar of sales, the R&D intensity of small technology-based firms is greater than the R&D intensity of large firms (Koen, 1991). This study also found that both large and small firms ranked patents as the most important form of intellectual property protection, followed by trade secrets.[11] Small firms have also been found to

[11] This finding, however, is at odds with the widely quoted results of Levin et al. (1987). A major survey of firms in more than one hundred four-digit SIC industries found exactly the reverse. Trade secrets and being first to the market were found to be the most important forms of intellectual property protection. On the

obtain more patents per sales dollar, even though large firms are more likely to patent (Hansen, 1989).

Large firms have been found to be more likely to become involved in technology alliances than small firms. Large firms are more likely to license technology to others. Both types of firms valued associations with universities primarily as a way of attracting future employees among the students and less for product development, problem solving, and the research capabilities of the university in general (Link and Rees, 1992).[12]

Whereas it has been argued that small high-tech firms are disproportionately more dependent on federal procurement to support their R&D (Obermayer, 1980), small firm participation in R&D procurement (about 3.7% in 1991) is less than small firm participation in private sector R&D activity (about 10.2% in 1991). This discrepancy seems to indicate barriers to small firms in entering and winning federal competitions for R&D projects such as large project size, lesser ability to enter multiple competitions and, possibly, prejudice against small firms by public administrators due to perceptions of higher risks in dealing with small firms.

Finally, as mentioned in the introduction, a widely cited book by Acs and Audretch (1990) paints a positive picture of the role of small firms in technological innovation. Their results are at odds with the neo-Schumpeterian hypothesis that technological change requires increasingly large quantities of R&D marshaled by increasingly large corporations. Acs and Audretch's results imply instead that there is an important role for both small and large firms in technological change. This, in fact, reflects current consensus among scholars who argue that the role of small firms in innovation is different than the role of large firms and this reflects their relative strengths and weaknesses (Rothwell, 1989). Furthermore, given that the strengths and weaknesses of small firms vis-a-vis their larger counterparts are often complementary, the role of the two types of firms may well be complementary too (Rothwell, 1983; Rothwell and Zegveld, 1985).

The advantages of small firms tend to be organizational and to reflect the capabilities of their personnel. These advantages include the ability to respond quickly to changing market demand, organizational flexibility (lack of bureaucracy), and efficient internal communications depending on informal channels. The relative advantages of larger firms are to a large extent material and reflect the ability to: maintain sophisticated management teams; attract highly skilled technical specialists; support large R&D facilities; amass financing to support parallel R&D programs; easily connect to external sources of finance and technical expertise; benefit from scale and scope

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whole, patents were low on the list of effective mechanisms of IPR protection. Exceptions included a small number of chemicals and pharmaceuticals related industries.

[12] This must vary very much across industries, however, as has been convincingly demonstrated by the same extensive survey study mentioned in footnote 8 (Klevorick et al., 1995). That is, firms in a few industries are much "closer" to universities than others in terms of making use of academic research.

economies due to size and diversification. Complementary strengths and weaknesses, then, create the basis for survival of both types of firms, often side by side.[13]

Survey Results

A series of questions were asked about several factors relating to the innovative activities of respondents to the sample. Though the data do not explicitly allow for a comparison of the innovative activities of small vs. large firms in high-technology sectors, they do provide considerable insight about how small firms innovate, and how they perceive their distinctive market niches.

R&D Effort

- There was a high concentration of small, R&D-intensive companies among the respondents to the survey.

85% of the respondent firms had up to 100 employees; and more than half had 25 employees or less. Half of the 177 firms reporting on R&D employees had employed one to four R&D personnel (full-time equivalent) during the previous year and 18% had no R&D employees. Only 5% reported employing more than 50 R&D personnel during that time period (Table 7).

On the other hand R&D is important to the firms. Over two-thirds of the responding firms estimated that R&D expenditures had accounted for 3% or more of annual sales. Almost three out of ten firms responding to the question reported ratios of R&D to sales in excess of 10%. (Table 8)

[13] The observation that firms of very different characteristics and size operate in the same industry runs against the typical view of the firm in neoclassical economics as an organization which simply reacts to external (contextual) stimuli and has little, if any, discretionary power for differentiation (Nelson, 1994). The nascent organizational theory is trying to bridge this chasm. For a discussion see Menard (1996).

Table 7: Number of Employees Engaged in R&D		
Number of Employees	**Number of Respondents**	**Percent of Respondents**
None	32	18.1%
1-4	88	49.7%
5-9	26	14.7%
10-49	22	12.4%
50-99	5	2.8%
100 or more	4	2.3%
Total Responding	177	100.0%

Table 8: Ratio of R&D to Sales		
R&D as a Percent of Sales	**Number of Respondents**	**Percent of Respondents**
0	25	14.5%
1-2	28	16.2%
3-10	70	40.5%
11-20	27	15.6%
21-50	14	8.1%
50 or more	9	5.2%
Total Responding	173	100.0%

- A majority of businesses responding preferred to undertake their R&D in-house.

As shown in table 9, three-fifths of the responding 161 firms had not contracted out any R&D at all. Only about 17% of the respondents had contracted out significant amounts of R&D (more that 10% of total R&D expenditure).

Table 9: Propensity of Businesses to Undertake R&D In-House

Percent of R&D Contracted-Out	Number of Respondents	Percent of Respondents
0	98	60.9%
1-10	38	23.6%
11-20	5	3.1%
21-50	13	8.1%
51-75	4	2.5%
> 75	3	1.9%
Total Responding	161	100.0%

Perceived Competitive Strategies

The majority of the respondents considered their competitive edge to relate more to product quality, strategic flexibility and quick reaction to customer needs, and speed of introducing new products, than to competition in terms of price. (Table 10).

- 82% of these firms thought that the quality of their products was higher than the quality of the products offered by their main competitors;

- 81% thought that they offered better customer services than the main competitors;

- 83% thought that they tended to respond faster to their customer needs than the main competitors;

- 54% thought that they were doing better than the main competitors in terms of introducing new products (and/or) services to the market.

Product range, production cost, and product price were reportedly of relatively lesser importance in defining small firm comparative competitive advantage.

- 50% of the respondents thought that they compared favorably to their main competitors in terms of product range; about another 25% thought that they faired about the same with their main competition in this respect.

- 39% reported lower cost of production than their competitors; another 34% estimated to have similar production costs to their competitors.

- 45% reported offering better prices than their main competitors; about 37% more could offer similar prices.

Table 10: Perceived Competitive Strategies		
Perceived Innovative Niche	**Number of Respondents**	**Percent of Respondents**
Product Quality		
Somewhat Better	65	34.9%
Much Better	87	46.8%
Total Responding	186	
Customer Services		
Somewhat Better	77	41.6%
Much Better	72	38.9%
Total Responding	185	
Respond to Customer Needs		
Somewhat Better	58	30.9%
Much Better	98	52.1%
Total Responding	188	
Introducing New Products		
Somewhat Better	57	30.6%
Much Better	44	23.7%
Total Responding	186	
Product Range		
Somewhat Better	55	29.7%
Much Better	37	20.0%
Total Responding	185	
Product Cost		
Somewhat Better	48	26.2%
Much Better	24	13.1%
Total Responding	183	
Product Price		
Somewhat Better	55	29.6%
Much Better	29	15.6%
Total Responding	186	

Strategies for Introducing New Innovations

- Over 70% of the 195 firms that responded to the survey indicated that they had introduced at least one new product during the prior year. A similar percentage reported that they introduced improved products. (Tables 11 and 12).

Table 11: Introduction of New Products

New Products	Number of Respondents	Percent of Respondents
None	53	27.2%
At least one new product	142	72.8%
1-3	53	27.2%
4-10	25	12.8%
11-20	7	3.6%
> 20	4	2.1%
Total Responding	195	100.0%

Table 12: Providing Improved Products

Improved Product	Number of Respondents	Percent of Respondents
None	64	32.8%
At least one new product	131	67.2%
1-3	58	29.7%
4-10	20	500.0%
11-20	4	2.1%
> 20	5	2.6%
Total Responding	195	100.0%

Most product innovators introduced 1-3 new or improved products during this year. On the other hand, only about a fifth of the respondents reported introducing new process innovations. A similar percentage had introduced improved processes. Finally, about a fifth reported introducing a new service during this time period (Table 13).

Table 13: Providing New Processes

New Processes	Number of Respondents	Percent of Respondents
None	154	79.0%
At least one new process	41	21.0%
Total Responding	195	100.0%

The vast majority of the innovators replied that these innovations had been developed internally, with 135 firms reporting that all innovations introduced in the prior year had been fully developed internally (Table 14). Only 26 respondents replied that they had depended on licenses from other organizations for 50% or less of the knowledge content of the introduced innovations; only 4 had depended for 75-100% of the knowledge content on such licenses (Table 15).

Table 14: Internal vs. External Development of Innovations

Percent Internal	Number of Respondents	Percent of Respondents
< 20	1	0.6%
20-49	6	3.6%
50-74	10	6.0%
75-99	16	9.5%
100	135	80.4%
Total Responding	168	100%

Table 15: Internal vs. External Development of Innovations		
Percent From Licenses	**Number of Respondents**	**Percent of Respondents**
< 20	11	36.7%
20-49	10	33.3%
50-74	5	16.7%
75-99	2	6.7%
100	2	6.7%
Total Responding	30	100%

Respondents were also asked to identify a number of factors as being particularly important in successfully introducing new products or processes. Listed in order of importance, these were:

- developing the necessary technology;
- marketing; and
- access to qualified technical personnel.

Other factors deemed to be of somewhat less importance than those listed above were:

- securing adequate financing;
- intellectual property protection;
- distribution networks;
- acquiring necessary technology; and
- production startup.

Factors deemed to be relatively unimportant for the successful introduction of new products and processes in most firms were: training; government regulations/legislation; and ease of obtaining a government export license.

- The main strategy of the respondents for introducing new technology involved either identifying specific market niches or being first to the market.

Almost 50% of the respondents indicated that they were "niche players." The vast majority of the rest claimed to follow a first-to-the-market strategy. Only about 7% of the respondents replied that they usually wait to see how the market develops before introducing a new product or service.

7. FIRM ORIGINS & ENTREPRENEURSHIP

Although the entrepreneur has long been a central figure in economist's accounts of how the market system functions, there has been surprisingly little systematic analysis of entrepreneurship (Baumol, 1993).[14] As Baumol (1993, p. 2) notes:

> *The entrepreneur is at once one of the most intriguing and one of the most elusive in the cast of characters that constitutes the subject of economic analysis. Long recognized as the apex of hierarchy that determines the evolving behavior of the firm, the entrepreneur is thereby assigned a heavy responsibility for the vitality of the free-enterprise society. In the writings of the classical economists the appearance of this important figure was frequent, but shadowy, without clearly defined form and function. In the literature of formal theory, at least until very recently, only Joseph Schumpeter and, to some degree, Frank Knight succeeded in infusing this character with life and assigning to him or her a specific area of activity to any extent commensurate with his acknowledged importance. But to do so, they were forced to sacrifice analytic tractability and even substantive mathematical representation. In more recent years, although economic events continue to underscore the significance of his role, the entrepreneur has nonetheless virtually disappeared from the theoretical literature.*

There has, however, been a notable stream of scholarship outside of formal economic theory that has tried to explore the roots of entrepreneurship. This work has attracted attention as a result of the re-emergence of small firms in industrialized economies and the identification of special advantages of small firms in innovation.

Determining the origins of small, technology-oriented firms is a recognized very important, yet extremely complicated, issue for analysis. There are at least two sets of factors to consider here. One has to do with the personal characteristics of the entrepreneur that make him more prone than others to start a company. The other includes the characteristics of the environment in which the entrepreneur operates that play a role in inducing him to start a company.

There appears to be general agreement in the literature about the broad attributes of individual entrepreneurs. Entrepreneurs are characterized as (Hall, 1995, p. 67):

- willing to take risks, both in the sense of degree of uncertainty which the business is taken and of the size of the penalty from making the wrong decision.

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[14] In a critical survey of the economic theory on small firms, You (1995) stresses that theory has not matched the strong policy interest in small firms. "While the microeconomic theory of the firm has been mostly devoted to analyzing the single representative firm, the industrial organization literature has been mostly concerned with large dominant firms (apparently out of the concern about their monopoly power and the consequent misallocation of resources)." (You, 1995, p. 442).

- having a tendency to be innovative, to make changes in the products or services offered, markets served, methods of management, indeed, in most aspects of running her company except, perhaps, in ways that would dilute her personal power.
- instinctively searching for new opportunities and having the energy to try to exploit them.

The first set of factors reflects both "unobservable" psychological characteristics as well as characteristics such as age, education, and previous management experience. Systematic study of the psychological characteristics of entrepreneurs has been sparse, and the results of that research is somewhat contentious. Although some strong statements have been about various psychological motivations -- e.g. need to control, sense of distrust, etc. -- (Kets de Vries, 1977, 1985), these are based almost completely on anecdotal evidence; and to our knowledge, there is no strong evidence that links specific psychological traits to entrepreneurship.

More amenable to interpretation are the results of studies examining the background of owners/entrepreneurs. Age, education, and previous management experience have been singled out as important personal characteristics. Ability to participate and benefit from local contextual networks has also been proposed to be important (Johannisson, 1993). In addition to financial and material resources, contextual network support is posited to include socio-cultural factors.

A more encompassing identification of a set of factors that determine the company formation process, attributable to A. Shapiro, was listed in Rothwell and Zegveld (1982, p. 84):

- *Displacement:* some event whose impact on the entrepreneur precipitates the action.
- *An apparent disposition to act* on the part of the nascent entrepreneur, an individual psychological propensity.
- *Credibility:* the act of forming a company is made credible by example, or is socially acceptable in the local culture.
- *Availability of resources* which make the act economically and technically feasible.

In line with what was said earlier, the "disposition to act" is primarily of a personal nature, "credibility" and "resources" are of an environmental/contextual nature, and "displacement" contains elements of both. These four sets of factors together have been described as encompassing the entrepreneurial function.

Displacements relevant to company formation can be negative (push)--for example, getting fired, being frustrated with previous job, and being at an age that one feels one needs to do something. They can also be positive (pull)--for example, suddenly being able to raise funds or being lured away from an old occupation into a new venture. Disposition to act takes into account that some people are more prone to act as a result of displacement than others. The personal characteristics mentioned earlier (psychological traits, background) are relevant here. Credibility relates more to the contextual network factors referred to above. Before setting off to establish a new business

under the desire to be independent, the entrepreneur needs some reassurance that the move is credible. Reassurance may be provided by the example of others, with whom the entrepreneur can identify, or may be provided by the local culture (e.g., holding entrepreneurship in high esteem).

Availability of resources includes the factors that have attracted most attention by economists. It may be so because these factors are the most amenable to quantification. There is, by now, significant evidence that the availability of local financial, technical and other institutions responsive to new firm creation is instrumental in determining the chances of an area to create and retain new enterprises.

Survey Results

Table 16 shows tabulations of the series of survey questions that asked respondents to indicate the importance of various motives for founding the firm. The results provide evidence that displacement, in the form of "pull" rather than "push," played a major role in the decision of entrepreneurs to establish new firms.

- Roughly five out every six respondents identified the perception of a market opportunity as either an important or very important reason for establishing the firm; while only one out of every five respondents listed frustration with a previous employer as being an important or very important.

The other major motivation for founding a new firm was personal independence, which was cited by two out of three respondents as important or very important. Respondents to the survey generally did not consider other factors, such as inducement from a larger corporation or government programs, to have been important reasons for becoming entrepreneurs.

Table 16: Reasons for Founding the Firm		
Motivation for Founding the Firm	Very Important or Important (Number Responding)	Very Important or Important (Percent)
Perceived Market Opportunity	155	83.8%
Personal Independence	124	67.0%
Frustration with Previous Employer	36	19.5%
Availability of Government Programs	17	9.2%
Encouragement by Previous Employer	14	7.6%
Other Reasons	25	13.5%

8. FINANCING

Economists have long argued that uncertain activities, such as innovation, may face special obstacles in securing needed financing when suppliers of debt and equity capital must contend with problems posed by asymmetric information and adverse selection (Arrow, 1962; Stiglitz and Weiss, 1981). There is a common presumption that the severity of such problems must increase in the case of small, high tech firms which hold most of their value in growth opportunities and scientific and technological knowledge, thus having little collateral value to offer in exchange for external funding.[15]

To the extent that it is difficult to secure outside financing for many innovative activities, one might expect that small innovative firms will need to rely heavily on internal funds because the nature of R&D and related innovation-based physical investment often makes it very difficult for outsiders to appraise value accurately. Himmelberg and Petersen (1994) did, in fact, find evidence of an important role for internal finance in explaining both the R&D and physical investment expenditures of 179 small, high tech firms. Oakey et al. (1988) also found significant evidence of the failure of external investment to penetrate small producers of instruments and electronics in the United States and Great Britain. A full 81 percent of the surveyed American firms in 1986 and 69 percent of the surveyed British firms in 1985 relied on internal profits as a main source of investment capital.

A pervasive reason for the reluctance of small firms to turn to external financing was reported to be concern about the relatively stringent terms demanded by the external lenders. Although the managers/owners of the surveyed firms realized that obtaining external financing could enable the business to grow faster, they generally preferred to move forward at a slower pace determined by the flow of profits into the business. Indeed, the term "finance gap" is often used in the literature to describe the limited debt funding opportunities for small firms. The reason for the gap is that the cost of debt for small firms is significantly higher than the cost for large firms (Holmes and Kent, 1991).

The willingness to receive external financing is one thing; however, the ability to access such financing is another. The stage of development of the technology-oriented firm plays an important role in the ability to receive external financing. If the development of a firm is divided into stages, from formation to maturity, it is clear that it is in the early stages where the entrepreneur will, by and large, depend on his or her own resources. Occasionally, the entrepreneur will receive partial financial assistance from an "incubator" organization that may be a (local) government agency, university, or the previous employer of the entrepreneur. Only in the later stages of development is it possible at all for the entrepreneur to access traditional sources of funds such as banks and equity investment.

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[15] Banks try to partially alleviate this problem by striking long term relationships with firms. There is empirical evidence that small firms with long term relationships with banks are able to access cheaper credit; they also need collateral less than small firms with no such relationships (Berger and Udell, 1995).

It is widely believed that the investment gap in the earlier stages of technology-oriented small firms is smaller in the United States. than in other countries due to the existence of the "venture capital" market. Still, there is some scattered evidence that venture capitalists have tended to concentrate their financing to established business and more known technologies in anticipation of a successful initial public offering (IPO) in the stock market rather than new firms (Economist, 1996a,b). Overall, the functioning of a system of risk capital is a complicated matter depending on financial, fiscal, cultural, technical, and local factors for its success.

Survey Results

To gain insight into the sources of financing for small innovative firms, respondents to the survey were asked an extensive series of questions about the mix of financing, as well as the sources and uses of financing.

Mix and Sources of Financing

The first finding, which confirms the results of other research on the financing patterns of small business is that small innovative firms rely more heavily on equity than debt to finance their activities.

149 respondents indicated relying on at least some equity as a financing source, compared with 97 and 78 respondents who indicated varying degrees of reliance on short-term and long-term debt financing, respectively. Moreover, among those who relied on at least some equity finance, 56 percent indicated that it accounted for at least three-quarters of their financing. Though not shown in Table 17, fully one-third of those that relied on equity relied on equity for 100 percent of their financing needs.

Table 17: Mix of Financing						
Percent of Total Funds	Equity		Short-Term Debt		Long-Term Debt	
	Number	Percent	Number	Percent	Number	Percent
<25%	20	13.4	55	56.7	34	43.6
26 - 50%	27	18.1	20	20.6	22	28.2
51 - 75%	18	12.1	8	8.3	9	11.54
76 - 100%	84	56.1	14	14.4	13	16.67
Number of firms responding*	149	100	97	100	78	100

(*Note: The remainder of the firms in the survey either did not respond to the question or, by implication, did not use the particular type of financing: equity, short-term debt, or long-term debt.)

A second important set of findings pertains to the sources of financing. The largest share of equity financing appears to be in the form of contributions from managers of the firm.

- 111 respondents indicated that managers were a source of equity capital for the firm. Of these, just over half indicated that managers provided more than three-quarters of the firm's equity capital.

Table 18: Source of Internal Equity Finance				
Percent of Equity	Managers		Employees	
	Number	Percent	Number	Percent
< 20%	29	26.1%	16	76.2%
21 - 50%	14	12.6%	2	9.5%
51 - 75%	12	10.8%	0	0.0%
76 - 100%	56	50.5%	3	14.3%
Number Responding	111	100.0%	21	100.0%

By comparison, external sources of equity finance, such as banks, outside investors, and venture capitalists were described as playing a more modest role.

- 47 respondents identified unaffiliated outside investors, 45 respondents identified banks, and an even smaller 22 respondents identified venture capital companies as providing equity capital. Among these respondents, the percentage of equity capital provided by these outside investors tended to be rather modest. Other sources of external equity financing identified with considerably less frequency included: a parent firm (6 responses), other businesses (7 responses), government agencies (8), and other (33 responses).

Table 19: Sources of External Equity Financing

Percent of Equity	Unaffiliated Individuals		Venture Capital Companies		Banks	
	Number	Percent	Number	Percent	Number	Percent
1- 25%	15	31.9%	7	31.8%	10	22.2%
26 - 50%	11	23.4%	8	36.4%	10	22.2%
51 - 75%	4	8.5%	2	9.1%	4	8.9%
76 - 100%	17	36.2%	5	22.7%	21	46.7%
Number Responding	47	100.0%	22	100.0%	45	100.0%

Debt Financing:

As might be expected, external lenders in the form of banks were the most important source of debt financing for respondents.

- 106 and 88 respondents indicated that banks were a source of short-term and long-term debt, respectively. Moreover, a significant majority of those who identified banks as a source of external financing reporting relying on banks for more than three-fourths of both short-term and long-term debt. In comparison with banks, both unaffiliated individuals and venture capital companies were relatively unimportant as a source of debt finance. (Tables 20 and 21). Although not shown in the tables below, other sources of external debt financing, such as the Small Business Administration, were not identified as providing significant sources of debt-financing. (Only 15 respondents indicated receiving any long-term debt financing from SBA.)

- Internal sources of debt financing were less important, although it is interesting to note that stockholders were mentioned with some frequency as providing both short-term and long-term debt. (Tables 22 and 23).

Table 20: Sources of External Loans: Short-Term Debt

Percent of Debt	Unaffiliated Individuals		Venture Capital Companies		Banks	
	Number	Percent	Number	Percent	Number	Percent
1- 25%	3	33.3%	1	25.0%	3	2.8%
26 - 50%	2	22.2%	2	50.0%	16	15.1%
51 - 75%	1	11.1%	0	0.0%	11	10.4%
76 - 100%	3	33.3%	1	25.0%	76	71.7%
Number Responding	9	100.0%	4	100.0%	106	100.0%

Table 21: Sources of External Loans: Long-Term Debt

Percent of Debt	Unaffiliated Individuals		Venture Capital Companies		Banks	
	Number	Percent	Number	Percent	Number	Percent
1- 25%	0	0.0%	1	16.7%	8	9.1%
26 - 50%	1	20.0%	2	33.3%	11	12.5%
51 - 75%	1	20.0%	1	16.7%	6	6.8%
75 - 100%	3	60.0%	2	33.3%	63	71.6%
Number Responding	5	100.0%	6	100.0%	88	100.0%

Table 22: Source of Internal Loans: Short-Term Debt				
Percent of Debt	Insiders		Stockholders	
	Number	Percent	Number	Percent
1-25%	9	32.1%	10	23.8%
26 - 50%	5	17.8%	12	28.6%
51 - 75%	2	7.1%	2	4.8%
76 - 100%	12	42.9%	18	42.9%
Number Responding	28	100.0%	42	100.0%

Table 23: Sources Internal Loans: Long-Term Debt				
Percent of Debt	Insiders		Stockholders	
	Number	Percent	Number	Percent
1- 25%	0	0.0%	4	12.9%
26 - 50%	4	17.4%	5	16.1%
51 - 75%	3	13.0%	2	6.5%
76 - 100%	16	69.6%	20	64.5%
Number Responding	23	100.0%	31	100.0%

Ease of Obtaining Financing

On one hand, roughly three out of every five respondents (115) indicated that they had not encountered difficulty securing needed financing. Yet two out of every five respondents (79) indicated that they had experienced obstacles. Table 24 summarizes the kinds of difficulties that were encountered; and Tables 25-27 indicate why respondents felt they encountered difficulties in obtaining financing.

Table 24: Barriers to Financing		
Type of Barrier	**Number of Respondents**	**Percent of Respondents**
High Interest Rate		
No	53	67.1%
Yes	26	32.9%
Total Responding	79	
Limitations on Loan Size		
No	44	55.7%
Yes	35	44.3%
Total Responding	79	
Short Repayment Periods		
No	68	86.1%
Yes	11	13.9%
Total Responding	79	
Loan Rejection		
No	50	63.3%
Yes	29	36.7%
Total Responding	79	
Difficulty Placing Pvt. Offering		
No	54	68.4%
Yes	25	31.6%
Total Responding	79	
Difficulty Placing Public Offering		
No	68	86.1%
Yes	11	13.9%
Total Responding	79	
Lack of Underwriter		
No	74	93.7%
Yes	5	6.3%
Total Responding	79	100.0%

Table 25: Reasons for Difficulty in Securing Financing: Equity		
Reason	**Number of Respondents**	**Percent of Respondents**
Lack of Financial Track Record		
Important	6	10.5%
Very Important	20	35.1%
Total Responding	57	
Lack of Tangible Assets		
Important	8	14.5%
Very Important	19	34.5%
Total Responding	55	
Lack of Profitability		
Important	9	15.8%
Very Important	18	31.6%
Total Responding	57	
Investor Concern About Ability to Protect Market Advantage		
Important	6	11.1%
Very Important	9	16.7%
Total Responding	54	
Investor Reluctance to Take Risk		
Important	9	16.7%
Very Important	28	51.9%
Total Responding	54	

Table 26: Reasons for Difficulty in Securing Financing: Short-Term Debt		
Reason	**Number of Respondents**	**Percent of Respondents**
Lack of Financial Track Record		
Important	7	11.9%
Very Important	22	37.3%
Total Responding	59	
Lack of Tangible Assets		
Important	10	16.9%
Very Important	21	35.6%
Total Responding	59	
Lack of Profitability		
Important	15	23.4%
Very Important	23	35.9%
Total Responding	64	
Investor Concern About Ability to Protect Market Advantage		
Important	7	12.7%
Very Important	4	7.3%
Total Responding	55	
Investor Reluctance to Take Risk		
Important	20	31.3%
Very Important	26	40.6%
Total Responding	64	

Table 27: Reasons for Difficulty in Securing Financing: Long-Term Debt		
Reason	**Number of Respondents**	**Percent of Respondents**
Lack of Financial Track Record		
Important	7	11.9%
Very Important	21	35.6%
Total Responding	59	
Lack of Tangible Assets		
Important	7	11.7%
Very Important	24	40.0%
Total Responding	60	
Lack of Profitability		
Important	12	19.0%
Very Important	25	39.7%
Total Responding	63	
Investor Concern About Ability to Protect Market Advantage		
Important	8	14.0%
Very Important	4	7.0%
Total Responding	57	
Investor Reluctance to Take Risk		
Important	16	25.0%
Very Important	26	40.6%
Total Responding	64	

9. TAX AND OTHER POLICIES

Survey Results

Survey respondents were also asked questions relating to the role of several government programs that are intended to encourage innovation.

Tax Credit for Research and Experimentation

One such policy is that the tax credit for research and development, which at the time of the survey had temporarily expired, but which has since been renewed. The results indicate that this tax incentive had a rather modest effect on the incentive of small firms to innovate.

- Five out of eight respondents indicated that they had not claimed the R&E credit in recent years.

- Among those who did not claim the credit, almost seven out of ten indicated that they did not qualify for the credit either because they lacked sufficient taxable income, or because they had failed to exceed the base amount of R&D spending required to be eligible for the credit.

Respondents' opinions about the effects of the credit were mixed.

- Over half of respondents believed the credit had no measurable effect on the firm.

- 33 respondents indicated that the credit's main effect was to increase cash flow.

- Other aspects of the firm's behavior that might be affected by the credit received fewer positive responses. For example, only 28 firms reported that the credit had stimulated them to increase R&D spending by an amount equal to or more than the amount of the credit.

SBIR Program

The other government program given explicit attention was the Small Business Innovation Research program. (This is a program where each participating Federal Agency competitively awards funding for research and development in small firms that have commercial potential. The awards are made in phases, with the second and third phase of funding tied directly to the potential for commercial applications.) Respondents indicated that the program had a modest, though measurable effect.

- 34% of the firms in our sample had submitted proposals for a Phase I SBIR and 24% had received a SBIR Phase I award.

- Twenty percent had submitted proposals for a Phase II SBIR and 16% had received an award

Table 28: Effects of the Tax Credit for Research & Experimentation		
	Number of Respondents	**Percent of Respondents**
Claimed R&E Tax Credit?		
Yes	71	36.6%
No	123	63.4%
Total Responding	194	
Reason for Not Claiming Credit		
Failed to exceed base	56	48.3%
Too complicated	24	20.7%
Insufficient taxable income	17	14.7%
Total responding	116	
R&E Credit Affected Behavior?		
No	112	56.9%
Yes	85	43.1%
Total Responding	197	
Increased Cash Flow?		
No	164	83.2%
Yes	33	16.8%
Total Responding	197	
Increased R&D		
No	8	19.5%
Less than amount of Credit	5	12.2%
By the Amount of the Credit	12	29.3%
More than amount of the credit	16	39.0%
Total responding	41	
Changed Timing of R&D		
No	186	94.4%
Yes	11	5.6%
Total responding	197	

9. TECHNOLOGY ACQUISITION

During the past few decades, an increasing number of theoretical and empirical economic appraisals of technological innovation have contributed to building a consensus among analysts that the most important factors for successful technological innovation are to be found in:

- The technological opportunities in an industry and the ability of a firm to exploit them
- The market environment
- The conditions for appropriating the results of R&D.

The first factor -- technological opportunity -- has often been argued to be a rather important component in innovation. Our survey attempted to gain insight about the first two groups of factors by asking respondents both to indicate the relative importance of a list of possible sources for new ideas and technical knowledge and to indicate the effectiveness of alternative methods for obtaining new technological knowledge. The responses for the first questions are tabulated in Table 29.

The overwhelming majority of the respondents (83% of 194 respondents) declared their customers to be a very important source for new ideas and technological knowledge. In addition to customers, sources internal to the firm were rated to be important or very important by 74% of 174 respondents.

The dependence on customers agrees with prior findings in the literature. As multiple business case studies have shown before, small firms depend very much on their customers for incentives to innovate and for new ideas and technological knowledge. It is almost certain that, for a significant percentage of the smaller of these companies, customers means a small number of large, technically advanced corporations that buy a lot of their output and that regularly subcontract to them technically demanding jobs (Vonortas and Xue, 1997). If so, there are significant policy implications here concerning the desirability of a diversified economy where big, technically advanced corporations serve as technology drivers to cohorts of smaller firms that are flexible and capable of meeting demanding requests for product specifications. Internal capabilities must be kept to a maximum in order to both meet high standards and to serve as a source of new ideas and technological knowledge that will allow the firm to diversify and grow.

A second set of sources for new ideas and technological information, rated as less important than the two just discussed included (in order of perceived importance): competitor firms, industrial shows, and suppliers. A third group included trade publications, professional and scientific journals, professional societies and meetings, universities and colleges, and consultants. The latter group was rated as important by 20-25% of the respondents, depending on the case. Finally, very few firms rated government laboratories, other government sources and publications, and nonprofit organizations as very important sources of new ideas and technological knowledge.

The fact that competitors were rated as a very important source of ideas and new technological knowledge by 43% of the respondents should not be surprising given that the surveyed firms tend to operate in quite competitive industries where monitoring competition is imperative. The work of von Hippel (1988) and his students would lead one to expect the significant percentage of firms that rated suppliers as an important source of ideas and new technology. We think, however, that this finding also reflects the fact that some of the surveyed industries, particularly those that better fit to the supplier dominated industries of Pavitt (1984). Machine tools is a good example. Firms in the same industries may also account primarily for the high ratings of industrial shows as a source of new technologies.

The low percentage rankings of rest of the sources for ideas and new technologies is in line with prior findings in the literature. Perhaps, the relatively poor showing of government laboratories and other government sources stands out in view of the widespread support for active government involvement in helping out industry with new technologies and technology transfer especially for the case of small firms.[16] On the contrary, the government can be a significant buyer of the products of such firms (see earlier section), and thus help them grow, a role that various federal agencies have played successfully in the past.

The tabulated answers for in the second question are shown in Table 30.

- Nine-tenths of the responding 183 firms rated R&D performed within the firm to be an important or very important method for obtaining new technology).

One should be careful with the interpretation of this outcome in conjunction with the answers in the previous question. Internal R&D is not only important for creating new technological knowledge. It is also extremely important in order to be able to understand what others are doing--e.g., customers, suppliers, competitors, academic researchers--and to benefit from their work (extend it and apply it) (Cohen and Levinthal, 1989).

No other method for obtaining new technological knowledge was ranked as very important by more than one third of the firms. In this less-frequently-mentioned category, publications, technical meetings, hiring away employees from competitors, contracting out R&D, and participating in cooperative R&D agreements were rated as very important methods for acquiring new technology by more than one fifth of the respondents.

[16] This should not be confused with the discussion on manufacturing extension programs which serve a completely different purpose and which aim primarily at a different population of SMEs than those surveyed here.

Table 29: Source of New Ideas and Technical Knowledge		
Source	**Number of Respondents**	**Percent of Respondents**
Customers		
Important	44	22.7%
Very Important	114	58.8%
Total Responding	194	
Internal Sources		
Important	52	29.1%
Very Important	80	44.7%
Total Responding	179	
Competitors		
Important	49	26.1%
Very Important	32	17.0%
Total Responding	188	
Suppliers		
Important	36	19.1%
Very Important	20	10.6%
Total Responding	188	
Universities		
Important	26	14.4%
Very Important	11	6.1%
Total Responding	181	
Government Laboratories		
Important	15	8.3%
Very Important	3	1.7%
Total Responding	180	

It should also be noted out that very few firms considered patent disclosures a very important method for acquiring new technology. This is important for two reasons. First, this result can be combined with the results of the previous section to indicate that only a subsection of the surveyed small firms consider patents very important. They primarily consider patents a defensive action (protect knowledge from infringement). The knowledge-disseminating role of patents (which was a very basic consideration for the institutionalization of the patent system in early times) seems to be less important for small firms. However, caution is again warranted here. The lack of reported importance may reflect the unwillingness/inability of small firms to scan patents regularly for technological information rather than the usefulness of this information per se.[17]

[17] Some recent findings in Holland by MERIT researchers point in that direction.

Finally, it is worth mentioning that reverse engineering was rated a very important method for acquiring new technologies by a relatively low percentage of respondents. Possible reasons for this could be related to the specific competitive environments faced by the surveyed firms.

Table 30: Methods of Obtaining New Ideas and Technical Knowledge		
Method	**Number of Respondents**	**Percent of Respondents**
Own R&D		
Important	45	24.6%
Very Important	117	63.9%
Total Responding	183	
R&D Contracted Out		
Important	22	12.3%
Very Important	17	9.5%
Total Responding	179	
Cooperative Agreements		
Important	23	86.1%
Very Important	12	7.0%
Total Responding	172	
Licensing Technology		
Important	29	17.0%
Very Important	15	8.8%
Total Responding	171	
Hiring Competitor's Employees		
Important	10	5.5%
Very Important	5	2.8%
Total Responding	181	
Reverse Engineering		
Important	21	12.9%
Very Important	8	4.9%
Total Responding	163	

10. THE ROLE OF TECHNOLOGY ALLIANCES

Earlier in this report it was noted that large and small firms seem to have complementary strengths and complementary roles in technological innovation. The existence of complementary strengths can also create incentives for cooperation among firms of different size. (Dodgson, 1993; Pisano et al., 1988; Rothwell, 1991; Rothwell and Dodgson, 1991). Possible forms of collaboration may include: contracting-out R&D, research joint ventures (RJVs), collaborative development of products, licensing agreements, production joint ventures, manufacturing subcontracting agreements, marketing relationships, acquisitions for know-how, sponsored spin-outs, and venture nurturing. Long term supplier-customer relationships are also considered forms of informal interaction that is very useful as a source of innovation for small firms.[18]

Previous Results

Empirical evidence on the relative involvement of SMEs in technical alliances in industrialized countries has been relatively scarce. Barring anecdotal information, there have been a few accounts of small firm involvement in RJVs. For example, the European Commission has reported that small firms account for a relatively small percentage of all participations in "shared-cost actions" (cooperative R&D ventures) of the European Framework Programmes on research and technological development.[19] Small firms accounted for 18 percent of participations and 19 percent of the Community finance in the second Framework Programme (1987-1991), for example; they accounted for a similar percentage of participations and 21 percent of finance in the third Framework Programme (1990-1994).[20] Small firms primarily participated as associate partners of large firms. The percentage of small firm participations in EUREKA projects has been similar.[21]

Vonortas (1997) has reported the participation of small firms in U.S.-based RJVs registering with the U.S. Department of Justice and the Federal Trade Commission during 1985-1995 under the auspices of the National Cooperative Research Act (NCRA) of 1984 (575 RJVs registered between 1985 and 1995). Table 31 shows the memberships of identified business participants in these RJVs

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[18] See Von Hippel (1976, 1988) for the importance of customers to the innovation process of small suppliers of advanced equipment. Vonortas and Xue (1997) provide evidence concerning the extremely important influence of large sophisticated customers on the rate of process innovation in small manufacturing firms.

[19] The term shared-cost action is used to denote shared funding by the Commission of the EU and the participants.

[20] European Commission (1994). The numbers for the third Framework Programme are preliminary and they do not include the special project CRAFT. Overall, the number of small firm participations in the third Programme were expected to be higher than the second.

[21] EUREKA is a European but not an EU program. It had 22 members in 1994 13 of which were accounted for by the European Community itself which participates as an independent body and its (then) 12 country members. The three most recent members of the Community also participated as well as Hungary, Iceland, Norway, the Russian Federation, Switzerland and Turkey. EUREKA projects are much more applied than Framework Programme projects and focus on the development of products, processes and services.

that had also declared primary industry and employment. It is shown that in the earlier years the share of total memberships accounted for by small firms is lower in the United States than that reported in Europe.[22] In more recent years, the membership share of small firms has crept up to similar levels to those for Europe (about one fifth of all reported RJV memberships).

Table 31: Participation in Research Joint Ventures by Firm Size: NCRA RJVs

	FIRM SIZE BY NUMBER OF EMPLOYEES			
Year	**100 or fewer**	**101 to 500**	**500 or more**	**% Small Firms in Total**
1985	9	11	252	7
1986	4	3	151	4
1987	1	8	150	6
1988	17	20	234	14
1989	22	25	380	11
1990	25	20	328	12
1991	36	32	493	12
1992	39	42	416	16
1993	55	67	507	20
1994	50	43	417	18
1995	65	75	614	19

Source: Vonortas (1997), chapter 10.

As expected, it was also found that only a very small number of small firms have participated more than once in NCRA RJVs (table 32). This contrasts with the situation of large identified firms in

[22] The difference between the two regions is not necessarily a matter of concern because of the selection bias in the NCRA-RJV database. The RJVs registering in the U.S. tend to be those which might pose antitrust concerns implying that small firms may be underrepresented in the sample. Moreover, the unidentified entities as well as those with insufficient data are expected to belong overwhelmingly in the small firm category.

the database a significant percentage of which have participated in at least five RJVs.[23] The different behavior may reflect less diversification and smaller administrative resources available to small firms necessary to coordinate diffuse activities.

[23] Approximately 8.2 percent of all identified business participants involved in five or more RJVs during the examined eleven-year period. These firms were large almost with no exception.

Table 32: Number of Memberships in Joint Ventures Held by Small Business: NCRA RJVs			
Memberships in NCRA RJVs	Memberships	Small firms	% of Small Businesses
1	380	380	75.8%
2	180	90	18.0%
3	69	23	4.6%
4	20	5	1.0%
5	5	1	0.2%
6	6	1	0.2%
9	9	1	0.2%
Total	669	501	100.0%

Source: Vonortas (1997), chapter 10.

Table 33 breaks down small firm participation on the basis of the technical area of the RJV they participate using the CorpTech classifications used in the survey.[24] Interestingly, small firms were found to favor different RJVs than larger firms, with the exception of telecommunications. Environment, advanced materials, energy, and transportation RJVs were found much less favorite with small firms than larger firms. In contrast, small firms tended to favor much more software RJVs and RJVs in factory automation. In terms of SIC classification, small firms tended to concentrate on RJVs in chemicals (SIC 28), machinery and computer equipment (SIC 35), electronic and electrical equipment (SIC 36), communications (SIC 48), software (SIC 73), and business services (including R&D and testing labs) (SIC 87).

[24] See section 5 for a discussion of CorpTech industrial classification. The CorpTech database was used to draw the sample of firms surveyed in this project.

Table 33: Joint Venture Participation of Small Business by Technical Area: NCRA RJVs			
Technical Areas of Research Joint Ventures	**Number of Research Joint Ventures**	**Memberships Held by Small Business**	**% of Memberships**
Computer Software	18	180	26.9%
Telecommunications	28	173	25.9%
Manufacturing Equipment	6	86	12.9%
Subassemblies and Components	8	79	11.8%
Factory Automation	12	28	4.2%
Chemicals	13	24	3.6%
Advanced Materials	7	17	2.5%
Environmental	8	15	2.2%
Energy	4	14	2.1%
Biotechnology	6	12	1.8%
Medicals	7	11	1.6%
Photonics	6	10	1.5%
Computer Hardware	4	7	1.0%
Transportation	4	6	0.9%
Test/Measurement	3	4	0.6%
Pharmaceutical	1	2	0.3%
N/A	1	1	0.1%
Total	136	669	100.0%

Source: Vonortas (1997), chapter 10.

Finally, two groups of small firms were identified with respect to their strategies concerning cooperative R&D (Table 34). One group prefered the one-to-one relationship in RJVs with only two members. Invariably, in all 30 such NCRA RJVs a small firm joined forces with a large firm.[25] The second group, which makes up the majority, participated in RJVs with long membership lists. Small firms participated in all but one of the most populous RJVs (with more than 50 members).

[25] It should be stressed that the NCRA RJV database4 is biased toward joint ventures that are in danger of antitrust implications. Antitrust concerns is the main reason for registering. Thus, one would not expect to find many registered RJVs with, say, only two firms.

These RJVs tend to pursue generic research or research of interest to a large variety of members such as research on process innovations.

Table 34: Size of Joint Ventures with Small Firm Participation: NCRA RJVs

No. of Partners in Joint Venture	No. of Joint Ventures With Participation by Small Firms	Percent
2	30	20.0%
3	5	3.3%
5	6	4.0%
6 to 10	20	13.3%
11 to 20	10	6.7%
21 to 30	11	7.3%
31 to 50	34	22.7%
Over 50	34	22.7%
Total	150	100.0%

Source: Vonortas (1997), chapter 10.

Overall, then, the available data indicates that small firms have not been exceptionally active in R&D cooperation. They seem to be making up less than a quarter of RJV memberships in both the U.S. and Europe. As expected, they tend to participate fewer times than their larger counterparts and be more focused: more often their primary industry corresponds to the industrial focus of the RJV. The industrial focus of RJVs with small firm participation has tended to differ from the overall population of RJVs. Finally, during the examined time period, small firms have tended to participate more in large (reported) RJVs.[26]

The question, of course, is what kinds of small firms are captured in these numbers. Quite possibly, only members of a small firm minority that lead their technological areas, possess significant R&D capabilities, and which thus are interested in and can benefit from RJVs. Most small firms are not like these, however. A second group consists of firms which may be innovative in the sense of Acs and Audretch (1990) -- introduce innovative products-- but do not undertake any significant amount of long term R&D. There is also a third group, and this incorporates the vast majority of small firms, which may need significant help to even "stay with the pack". They need financial assistance, technological assistance, and informational assistance. They are the ones targeted by technology extension programs (Shapira, 1990, 1992; Reddy, 1993). The appropriate technological linkages for the latter two groups will be very different than those offered by either the NCRA RJVs or the European Framework Programmes. The appropriate linkages, for example, might involve

[26] These results are, in many respects, in line with previous findings (Dodgson, 1993).

much more applied and probably less advanced technologies. The appropriate linkages might be different altogether involving, for example, close ties with sophisticated large customers.

Survey Results

Responses to the survey provide significant insight about the importance of participation in a variety of strategic alliances by small high-technology firms.

- Although only 20% of the responding 195 firms rated cooperative R&D agreements a very effective method to obtain new technology, more than half had entered one or more such agreements during the five years prior to the survey (Table 35).

Table 35: Participation in Cooperative R&D & Joint Ventures

Number	Number of Respondents	Percent of Respondents
None	95	48.7%
1-4	82	42.1%
5-9	13	6.7%
10-24	5	2.6%
Total Responding	195	100.0%

Respondents were also asked to differentiate between three types of cooperative R&D agreements including: (a) alliances for basic and/or precompetitive research, (b) alliances for downstream (pre-production) technology development, and (c) production and/or marketing alliances which also involve technology. The third type of cooperative agreement was used relatively more frequently than the other two. As shown in Table 36, *customer/supplier linkages* were the most popular in this category. This agrees with the earlier finding that the vast majority of the surveyed firms considered customers a very important source of new ideas and technology. It also agrees with the finding that the most important customers of the majority of the surveyed firms were other companies. In addition, significant portions of the responding firms had: (i) concluded licensing agreements; (ii) joined forces with non-competitors; and (iii) joined forces with foreign firms. All these point to the role of complementarity in strategic alliances: firms seem to join to access complementary resources and exploit complementary strengths. A similar picture, but with an overall lesser activity, emerged for pre-production technical alliances. (Table 37).

TABLE 36: PRODUCTION ALLIANCES INVOLVING TECHNOLOGY		
	Number of Respondents	**Percent of Respondents**
Customer/Supplier Agreements		
No	116	59.2%
Yes	80	40.8%
Total Responding	196	
Licensing Out or in		
No	157	80.1%
Yes	39	19.9%
Total Responding	196	
Second-Sourcing Agreement		
No	187	95.4%
Yes	9	4.6%
Total Responding	196	
Joint Ventures w. Competitors		
No	184	93.9%
Yes	12	6.1%
Total Responding	196	
Joint Ventures w. Noncompetitors		
No	160	81.6%
Yes	36	18.4%
Total Responding	196	
Alliance w. Foreign Firms		
No	155	79.1%
Yes	41	20.9%
Total Responding	196	

Table 37: Pre-Production Technology Development		
	Number of Respondents	**Percent of Respondents**
R&D w. Competitor		
No	186	94.9%
Yes	10	5.1%
Total Responding	196	
R&D w. Noncompetitor		
No	166	84.7%
Yes	30	15.3%
Total Responding	196	
R&D w. Supplier		
No	126	64.3%
Yes	70	35.7%
Total Responding	196	
Cross-Licensing		
No	171	87.2%
Yes	25	12.8%
Total Responding	196	
Joint Ventures w. Government		
No	182	92.9%
Yes	14	7.1%
Total Responding	196	
Alliance w. Foreign Firms		
No	167	85.2%
Yes	29	14.8%
Total Responding	196	

Finally, in basic and pre-competitive research, a larger number of companies had chosen to collaborate with other companies than they had with universities and the government. Again, about 15% of the respondents had collaborated with foreign firms (Table 38).

Table 38: Basic and Pre-Competitive Research		
	Number of Respondents	**Percent of Respondents**
University Research Jointly Funded		
No	166	84.7%
Yes	30	15.3%
Total Responding	196	
Research Sponsored by Industry		
No	183	93.4%
Yes	13	6.6%
Total Responding	196	
Research by Nonprofit		
No	192	98.0%
Yes	4	2.0%
Total Responding	196	
Joint Ventures with Govt. Involvement		
No	172	87.8%
Yes	24	12.2%
Total Responding	196	
Private Sector Joint Ventures		
No	134	68.7%
Yes	61	31.3%
Total Responding	195	
Alliances with Foreign Firms		
No	167	85.2%
Yes	29	14.8%
Total Responding	196	

11. INTELLECTUAL PROPERTY PROTECTION

Rothwell and Zegveld (1982) observed that many innovative small firms are not based on patented inventions. Even when they are, the technical knowledge of the entrepreneur is of greater value than the patent. Patents, it was said, can play both a negative and a positive role. On the negative side, the rights of the incubator organization may hinder a spin-off. On the positive side, a patent may ease the access to external risk capital.

While this may indeed be so, one might expect that the role of intellectual property protection will vary considerably between industries. Indeed, the most comprehensive survey study of technological appropriability to date (Levin et al., 1987) showed that patents were not considered by the business respondents to be the most important mechanism for protecting intellectual property. Lead time, moving quickly down the learning curve, and complementary sales or service efforts were more important. Secrecy was also considered to offer stronger protection than patents for process innovations. But there were wide differences between sectors. Thus, industries like inorganic chemicals, organic chemicals, pharmaceuticals, plastic materials, and petroleum refining rated product patents much more effective than motors, generators and controls, computers, communications equipment, and medical instruments. A rerun of the survey almost fifteen years later found that, if anything, the importance of patents has decreased even more (Cohen, 1997).

As mentioned in an earlier section, however, a survey study of smaller magnitude sponsored by SBA (Koen, 1991) found exactly the reverse. Both large and small firms ranked patents as the most important form of intellectual property protection followed by trade secrets. Small firms have also been found to obtain more patents per sales dollar, even though large firms are more likely to patent (Hansen, 1989). Thus, the results concerning the preferences of small firms for Intellectual Property Rights (IPR) protection mechanisms are currently mixed.

Survey Results

A question in the survey asked respondents to rate the effectiveness of various ways of protecting the competitive advantage gained from developing and introducing new or improved products and processes. This question was intended to collect information relevant to the on-going debate on the desirability of further strengthening the legislation for intellectual property protection and of enforcing it strictly.

Respondents were given a choice between various legal means of intellectual property right protection such as patents, trademarks, copyrights as well as non-legal (informal) means that firms have routinely used to protect their intellectual property such as keeping trade secrets and gaining lead time. Firms were also allowed to differentiate between product and process innovations.

Table 39: Protection of Intellectual Property: Product Innovations

	Number of Respondents	Percent of Respondents
Patents		
Important	38	22.8%
Very Important	46	27.5%
Total Responding	167	
Copyrights		
Important	19	12.1%
Very Important	19	12.1%
Total Responding	157	
Trademarks		
Important	27	16.8%
Very Important	27	16.8%
Total Responding	161	
Trade Secrets		
Important	33	28.4%
Very Important	69	59.5%
Total Responding	161	
Gaining Lead Time		
Important	46	27.9%
Very Important	75	45.5%
Total Responding	165	

Table 40: Protection of Intellectual Property: Process Innovations		
	Number of Respondents	**Percent of Respondents**
Patents		
Important	19	16.5%
Very Important	24	20.9%
Total Responding	115	
Copyrights		
Important	10	9.6%
Very Important	9	8.7%
Total Responding	104	
Trademarks		
Important	13	12.0%
Very Important	14	13.0%
Total Responding	108	
Trade Secrets		
Important	33	20.5%
Very Important	69	42.9%
Total Responding	116	
Gaining Lead Time		
Important	28	23.9%
Very Important	58	49.6%
Total Responding	117	

The pattern of responses shown in Tables 39-40 is quite interesting.

- Informal, rather than the formal, means of IPR protection topped the rating in terms of primary importance to the respondents.

This result held true for both product and process innovations. As is shown on tables 39 (product innovations) and 40 (process innovations), lead-time dominated all other means of intellectual property protection in terms of the number of respondents rating it as important or very important. Keeping trade secrets was rated a very close second for protecting product innovations and, even more, process innovations.

- Patents were ranked behind both lead-time to market and trade secrets by a considerable margin. Thus, only half of the respondents rated patents as important or very important for protecting intellectual property related to product innovations and only 37% of the respondents felt the same about process innovations.

Prior research has also pointed out sharp differences between sectors in terms of patenting behavior (Levin et al., 1987) and we would expect such differences to be present in our sample too. For example, firms in the chemicals-pharmaceutical-biotechnology complex must pay much more attention to their patenting activity than firms in, say, electromechanical engineering. In contrast, firms in the latter technological area much more frequently use informal ways of protecting their intellectual property protection.

Surveyed firms were also asked to indicate the relative importance of a list of possible limitations of patent protection on new products and processes. The most important limitations of patent protection were reported to be (percentage of firms indicating the limitation was important or very important in parentheses):

- High enforcement costs (74%)
- Competitors can legally invent around most patents (72%)
- Portfolio of patents is too expensive to maintain (61%)
- Rapid changes in technology limit patent protection (57%)

The pattern of responses is reasonable, considering the nature and conditions of the responding firms and the environment in which they operate. Small firms would be expected to be particularly sensitive to the issue of cost for maintaining and enforcing patents which, it must be stressed, are usually much higher than simply the cost of obtaining a patent. Small firms with fairly narrow fields of expertise would also be expected to worry very much about their ability to "cover" with a limited number of patents an area broad enough to keep competitors at bay. Finally, many of our subjects operate in extremely competitive environments with rapidly changing technologies. In such environments patents are often maintained as a defensive tool for creating "war-chests" to fend off patent infringement challenges.

But creating these war-chests is not possible for most small firms. In order to create an effective "war-chest" the firm must hold a significant percentage of the patents in an area. This is often beyond the capabilities of the more narrowly-specialized small businesses. In order to maintain this portfolio the firm needs legal expertise and sizable financial resources, again beyond the realities of most small enterprises. Even if the firm has a patent, it is largely useless if one is not determined to enforce it. According to our respondents, this is a major worry. Most probably, they have in mind the deep pockets of larger corporations in the event of a legal dispute.

Another interesting, albeit preliminary, result of our survey then is the finding that a large number of high-tech small firms do not share a sentiment for tougher patent protection. Based on the initial tabulation of the survey results, one comes away with the impression that tightenting of patent regulations is not as important to small high-technology enterprises as it is to large, R&D-intensive corporations that can hope to blanket entire technology areas through a series of patents under consistent, long-term strategies. Such large firms can also afford to maintain extensive patent portfolios, and spend whatever it takes to enforce their legal rights in case of intellectual property problems.

This finding is consistent with the reported relative importance assigned by respondents to the following perceived limitations of patent protection.

- Patent documents disclose too much information (46% important/very important)
- Patents not likely to be declared valid if challenged (39% important/very important)
- Court decisions require licensing (26% important/very important)
- Firms in industry generally cross-license (15% important/very important)

Given that most respondents to the survey: (a) follow either a market niche or a first-to-the-market strategy; (b) consider the patent portfolio maintenance costs and the enforcement costs too high; (c) fear that competitors can easily invent around patents; and (d) operate in rapidly changing technological areas, it follows that they may often try to avoid revealing crucial information to (expected) competitors through a patent application and that they would be worried with their capability to win protracted court battles over patent enforcement.

12. BIBLIOGRAPHY

Arrow, K.J. (1962) `Economic welfare and the allocation of resources for invention,' in R.R. Nelson (ed.) *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton University Press for the National Bureau of Economic Research.

Acs, Zoltan J., Bo Carlsson and Roy Thurik (1996) *Small Business in the Modern Economy*, Oxford, UK: Blackwell Publishers.

Acs, Zoltan J. and David B. Audretch (1990) *Innovation and Small Firms*, Cambridge: Cambridge University Press.

Acs, Zoltan J. and David B. Audretch (1993) *Small Firms and Entrepreneurship: An East-West Perspective*, Cambridge: Cambridge University Press.

Baumol, William J. (1993) *Entrepreneurship, Management, and the Structure of Payoffs*, Cambridge, Mass.: The MIT Press.

Berger, Allen N. and Gregory F. Undell (1995) "Relationship lending and lines of credit in small firm finance," *Journal of Business*, 68(3), pp. 351-381.

Bomberger, Earl E. (1982) *The Relationship between Industrial Concentration, Firm Size, and Technological Innovation*, Report, prepared by Gellman Research Associates for the U.S. Small Business Administration, Office of the Advocacy.

Carlsson, Bo (1989) "Flexibility and the theory of the firm," *International Journal of Industrial Organization*, 7, pp. 179-203.

Carlsson, Bo (1996) "Small business, flexible technology and industrial dynamics," in Zoltan J. Acs, Bo Carlsson and Roy Thurik *Small Business in the Modern Economy*, Oxford, UK: Blackwell Publishers.

Carlsson, Bo, David Audretch and Zoltan J. Acs (1994) "Flexible technology and plant size: US manufacturing and metalworking industries," *International Journal of Industrial Organization*, 12(3), pp. 359-372.

Charles River Associates (1976) *An Analysis of Venture Capital Market Imperfections*, Report, prepared for the National Bureau of Standards, U.S. Department of Commerce.

Cohen, Wesley M. (1995) "Empirical Studies of Innovative Activity," in P. Stoneman (ed.) *Handbook of the Economics of Innovation and Technological Change*, Cambridge, U.S.: Blackwell.

Cohen, Wesley M. (1997) "The second `Yale' study," presented at the workshop Industrial Research and Innovation Indicators for Public Policy, sponsored by the Board on Science, Technology, and Economic Policy, National Research Council, Washington, D.C., Feb. 28.

Cohen, Wesley M. and Richard C. Levin (1989) "Empirical Studies of Innovation and Market Structure," in R. Schmalensee and R.D. Willig (eds.) *Handbook of Industrial Organization*, New York: Elsevier Science Publishers.

Cordes, Joseph J., Harry Watson and Scott Hauger (1986) *An Analysis of Domestic and Foreign Tax Treatment of Innovation and High Technology Firms*, prepared by the Applied Concepts Corporation for the National Science Foundation, Washington, D.C., September.

Corporate Technology Information Services (1995) *Corporate Technology Directory 1995*, Woburn. MA.

Dodgson, M. (1993) *Technological Collaboration in Industry*, London: Routledge.

Economist (1996a) "Going for the golden egg", September 28, pp. 89-90.

Economist (1996b) "From labs to riches", November 9, pp. 87-88.

Edwards, Keith L. and Theodore J. Gordon (1984) *Characterization of Innovations Introduced in the U.S. Market in 1982*, Report, prepared by The Futures Group for the U.S. Small Business Administration, Office of Advocacy.

Egelhoff, W.G. (1986) *Business Strategies and Competition in the Semiconductor Industry: A Comparative Study Across U.S., Japanese, and European Firms*, Report, Center for Science and Technology Policy, School of Management, Rensselaer Polytechnic Institute.

European Commission (1994) *The European Report on Science and Technology Indicators 1994*, Directorate-General XIII, Luxembourg: Office for the Official Publications of the European Communities.

Executive Office of the President (1993) *The State of Small Business: A Report of the President: 1992*, Washington, D.C.: U.S. Government Printing Office.

Executive Office of the President (1995) *The State of Small Business: A Report of the President 1994*, Washington, D.C.: U.S. Government Printing Office.

Fusfeld, Herbert I. (1994) *Industry's Future*, Washington, D.C.: American Chemical Society.

Gellman Research Associates, Inc. (1993) *A Survey of Innovative Activity*, Report prepared for the U.S. Small Business Administration, Office of Advocacy.

Hall, Graham (1995) *Surviving and Prospering in the Small Firm Sector*, London, UK: Routledge.

Hansen, John A. (1989) *Utilization of New Data for the Assessment of the Level of Innovation in Small American Manufacturing Firms*, Report prepared for the U.S. Small Business Administration, Office of Advocacy.

Himmelberg, Charles P. and Bruce C. Petersen (1994) "R&D and internal finance: A panel study of small firms in high-tech industries," *Review of Economics and Statistics*, LXXVI(1), pp. 38-51.

Holmes, Scott and P. Kent (1991) "An empirical analysis of the financial structure of small and large Australian manufacturing enterprises," *Journal of Small Business Finance*, 1(2), pp. 141-154.

Johannisson, Bengt (1993) "Designing supportive contexts for emerging enterprises," in C. Karlsson, B. Johannisson and D. Storey (eds.) *Small Business Dynamics: International, National and Regional Perspectives*, London: UK: Routledge.

Kamien, Morton I. and Nancy L. Schwartz (1982) *Market Structure and Innovation*, Cambridge, UK: Cambridge University Press.

Karlsson, Charlie, Bengt Johannisson and David Storey (eds.) (1993) *Small Business Dynamics: International, National and Regional Perspectives*, London: UK: Routledge.

Kets de Vries, M.F.R. (1977) "The entrepreneurial personality: A person at the crossroads," *Journal of Management Studies*, Feb., pp. 34-57.

Kets de Vries, M.F.R. (1985) "The dark side of entrepreneurship," *Harvard Business Review*, Nov.-Dec., pp. 160-167.

Klevorick, Alvin K., Richard C. Levin, Richard R. Nelson, and Sidney G. Winter (1995) "On the sources and significance of interindustry differences in technological opportunities," *Research Policy*, 24, pp. 185-205.

Koen, Mary Seyer (1991) Business Intellectual Property Protection, Report, prepared by MO-SCI Corporation for the U.S. Small Business Administration, Office of Advocacy.

Levin, Richard C., Alvin K. Klevorick, Richard R. Nelson, and Sidney G. Winter (1987) "Appropriating the returns from industrial research and development," *Brookings Papers on Economic Activity: Microeconomics*, 3, pp. 783-820.

Link, Albert O. and Barry Bozeman (1987) *Firm Size and Innovative Activity: A Further Examination*, Report prepared for the U.S. Small Business Administration, Office of Advocacy.

Link, Albert O. and John Rees (1992) *Firm Size and External Research Relationships*, Report prepared for the U.S. Small Business Administration, Office of Advocacy.

Menard, Claude (1996) "Why organizations matter: A journey away from the fairy tale," *Atlantic Economic Journal*, 24(4), pp. 281-300.

Mulhern, Alan (1995) "The SME sector in Europe: A broad perspective," *Journal of Small Business Management*, 33(3), pp. 83-87.

National Science Board (1993) *Science and Engineering Indicators--1993*, Washington, D.C.: U.S. Government Printing Office.

National Science Board (1996) *Science and Engineering Indicators--1996*, Washington, D.C.: U.S. Government Printing Office.

Nelson, Richard R. (1994) "Why Do Firms Differ, and How Does It Matter?", in R.P. Rumelt, D.E. Schendel, and D.J. Teece (eds.) *Fundamental Issues in Strategy*, Boston, Mass.: Harvard Business School Press.

Oakey, Ray P. (1993) "High technology small firms: A more realistic evaluation of their growth potential," in C. Karlsson, B. Johannisson and D. Storey (eds.) *Small Business Dynamics: International, National and Regional Perspectives*, London: UK: Routledge.

Oakey, Ray P., Roy Rothwell and S.Y. Cooper (1988) *The Management of Innovation in High Technology Small Firms*, London: Frances Pinter.

Obermayer, Judith H. (1980) *Case Studies Examining the Role of Government R&D Contract Funding in Early History of High Technology Companies*, Report prepared for the U.S. Small Business Administration, Office of Advocacy.

Office of Advocacy, Small Business Administration, 1998. *Small Business Growth By Major Industry, 1988-95.* Office of Advocacy, Small Business Administration, Washington, D.C.

Pisano, G.P., W. Shan and D.J. Teece (1988) "Joint Ventures and Collaboration in the Biotechnology Industry," in D.C. Mowery (ed.) *International Collaborative Ventures in U.S. Manufacturing*, Washington, D.C.: American Enterprise Institute for Public Policy Research.

Preer, Robert W. (1992) *The Emergence of Technopolis: Knowledge-Intensive Technologies and Regional Development*, New York: Praeger.

Reddy, L. (1993) "Industrial extension," *Technology Review*, July, pp. 54-59.

Rothwell, Roy (1983) "Innovation and firm size: A case of dynamic complementarity," *Journal of General Management*, 8:5-25.

Rothwell, Roy (1989) "Small firms, innovation and industrial change," Small Business Economics, 1(1):51-64.

Rothwell, Roy (1991) "External networking and innovation in small and medium-sized manufacturing firms in Europe," *Technovation*, 11(2):93-111.

Rothwell, Roy and Mark Dodgson (1991) "External linkages and innovation in small and medium-sized enterprises," *R&D Management*, 21(2):125-137.

Rothwell, Roy and Walter Zegveld (1982) *Innovation and the Small and Medium Sized Firm*, London, UK: Pinter.

Rothwell Roy and Walter Zegveld (1985) *Reindustrialization and Technology*, London: Longman.

Saxenian, AnnaLee (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge, Mass.: Harvard University Press.

Scott, Allen J. (1993) *Technopolis: High-technology Industry and Regional Development in Southern California*, Berkeley, CA: University of California Press.

Shapira, P. (1990) "Helping small manufacturers modernize," *Issues in Science and Technology*, Fall, pp. 49-54.

Shapira, P. (1992) "Lessons from Japan: Helping small manufacturers," *Issues in Science and Technology*, Spring, pp. 66-72.

Stiglitz, Joseph E. and Andrew Weiss (1981) "Credit rationing in markets with imperfect information," *American Economic Review*, 71, pp. 393-410.

U.S. Bureau of the Census (1991) *Statistical Abstract of the United States*, 111th Edition, Washington, D.C.: Government Printing Office.

Von Hippel, Eric (1976) "The dominant role of the user in the scientific instrument process," *Research Policy*, 5(4), pp. 212-239.

Von Hippel, Eric (1988) *The Sources of Innovation*, Oxford: Oxford University Press.

Vonortas, Nicholas S. (forthcoming) *Cooperation in Research and Development*, Kluwer Academic Publishers.

Vonortas, Nicholas S. and Lan Xue (forthcoming) "Process innovation and small firms: Case studies on CNC machine tools," *Technovation*.

Webre, P. (1985) *Federal Financial Support for High Technology Industries*, Natural Resource and Commerce Division, Washington, D.C.: Congressional Budget Office.

You, Jong-Il (1995) "Small firms in economic theory," *Cambridge Journal of Economics*, 19, pp. 441-462.

APPENDIX A

QUESTIONNAIRE

Note that the questionnaires are not included here and can be order with this report from the National Technical Information Service (1-800-553-6847).