

Division of Research
Graduate School of Business Administration
The University of Michigan

October 1973

RECEIVED

JUL 21 1973

BUSINESS AD.
DEAN'S OFFICE

FINANCING REQUIREMENTS OF
NEW, TECHNOLOGY-BASED FIRMS

Working Paper No. 83
by

David J. Brophy
Associate Professor of Finance
University of Michigan
and

William Welch
Assistant Professor of Finance
Florida International University

FOR DISCUSSION PURPOSES ONLY

None of this material is to be quoted
or reproduced without the express
permission of the Division of Research

CONTENTS

Introduction 1

Statement of Problem 2

Methodology 8

Relationships Between NTBF Characteristics and Capital Needs . . . 14

 Size of Firm 14

 Newness of Technology 18

 Type of Business Operations 21

 Early Customer Base 26

 Stage of Product Development and Sales 29

 Earnings Stage 38

Conclusions and Implications 42

 Conclusions 42

 Implications 45

TABLES

1. Firms Classified by Product Types During First Years After Incorporation	9
2. Ann Arbor Firms Product Type During the First Year After Incorporation and In 1972	11
3. Capital Needed by Size of Firm	15
4. Capital Needed by Asset Size of Firm and Reason for Need. . . .	17
5. Amount of Capital Needed, First Year After Incorporation, by Newness of Technology at Start-up and Reason for Need. . .	19
6. Amount of Capital Needed by Reason for Need and by Type of of Operation During First Four Years, Ann Arbor and Boston Areas	23
7. Capital Needs First Year, by Early Customer Base During First Year.	27
8. Amount of Capital Needed, by Type of Standard Product Develop- ment Cycle, From Incorporation to First Standard Product Prototype	30
9. Amount of Capital Needed, by Type of Standard Product Develop- ment Cycle, After First Standard Product Prototype and Prior to First Sales of Standard Product	31
10. Amount of Capital Needed, by Type of Standard Product Develop- ment Cycle, After First Sale of Standard Product	32
11. Capital Needs by Earnings Stage and Reason for Need	39

FIGURES

1. NTBF Capital Market Model: Determinants of Characteristics of NTBF Financial Support 4
2. NTBF Capital Market Model: Hypothesized Relationships Between NTBF Characteristics, Risks Perceived by Financiers, and Characteristics of Financial Support Available to NTBF 5

Introduction

Because of the nation's need for continued technological innovation for beneficial purposes, it is widely felt that a more supportive environment for technological entrepreneurship should be provided within the United States.^{1/} One of the important elements in the process of technology application has been the formation of new, technology-based firms (NTBF).^{2/} These are corporate vehicles through which technological entrepreneurs mobilize resources for the development and marketing of some particular innovation, with profits accruing to the firm and its investors. Along with expediting technology transfer, these firms stimulate and support technology-based industry in general and are, therefore, a source of national and regional economic development.

Recently, concern has been expressed regarding the extent to which lack of adequate financing may be a barrier to formation and successful development of NTBF in the United States. Studies have concluded that the financing problem results from two factors:

1. NTBF are characterized by a degree of risk and uncertainty considered too high to attract funds from traditional sources.

^{1/}James H. Wakelin, Jr., "The Presidential Message on Science and Technology," Survival and Growth of the Small R & D Firm, ed. by J. Johnson (Washington, D.C.: National Science Foundation, 1972), pp. 220-23.

^{2/}Edward B. Roberts, "Entrepreneurship and Technology," Factors in the Transfer of Technology, ed. by Gruber and Marquis (Cambridge: M.I.T. Press, 1969), pp. 219-37.

2. The investment management skills of the professional venture capitalist are in short supply nationally and are concentrated geographically; only a very few areas, Boston and San Francisco, for example, have well-developed venture financing systems and are places where NTBF and other new venture firms thrive.^{3/}

Statement Of The Problem

The authors are presently engaged in research which seeks ways to improve the availability of capital for NTBF founded and located in the State of Michigan.^{4/} This research has led to consideration of the financing problems of NTBF in a broad context which includes the characteristics of the capital-seeking firms and of the potential investors of such capital. This involves analysis of the rapidly developing market for venture capital, an area of finance still relatively new to practitioners and researchers.

There is evidence that a lack of understanding of the venture financing process by both investors and seekers of funds may account for much of the difficulty encountered in NTBF financing.

As a result of its investigations, the Panel on Venture Capital has reached the overall conclusion that a lack of knowledge and communication of the venture capital process, both on the part of the entrepreneur and that of certain intermediaries and capital sources, is the major weakness of the system. The manifestations of this lack of knowledge are evident in almost all facets of venture capital financing.^{5/}

^{3/}U.S., Department of Commerce, Panel on Venture Capital, Financing New Technological Enterprises (Washington, D.C.: Government Printing Office, September, 1970).

^{4/}This research is sponsored by the University of Michigan's Institute of Science and Technology.

^{5/}Financing New Technological Enterprises, p. 3.

In this research, we are attempting to discern the processes by which new, technology-based venture firms obtain capital. The research focuses on the financing experiences of NTBF located in Michigan (primarily the Ann Arbor-Detroit area), a state in which venture financing facilities are considered to be relatively underdeveloped. This paper compares data obtained from these Michigan firms with data obtained from a sample of comparable NTBF located in Greater Boston, an area considered to have highly developed venture financing facilities. On the basis of preliminary research, a model of the NTBF financing process or market has been hypothesized (Figures 1 and 2).

The premise on which the model is based is that the performance of the NTBF, as measured by sales, earnings and employment, is determined by the ability of the firm to acquire continuously the assets needed to support operations. In the early stages of NTBF development, when losses may be substantial, the bulk of these assets must be financed by sources external to the firm. The ability of the firm to advance from "start-up" (product developed, no substantial earnings) to maturity therefore depends upon its ability to obtain amounts of capital for various purposes at particular stages of the firm's development.

The model proposes that the capital needs of NTBF are influenced by the characteristics of the firm. Potential investors of capital view these characteristics and capital needs in the light of their own preferences. The extent to which NTBF characteristics fit the investment preferences of potential capital investors

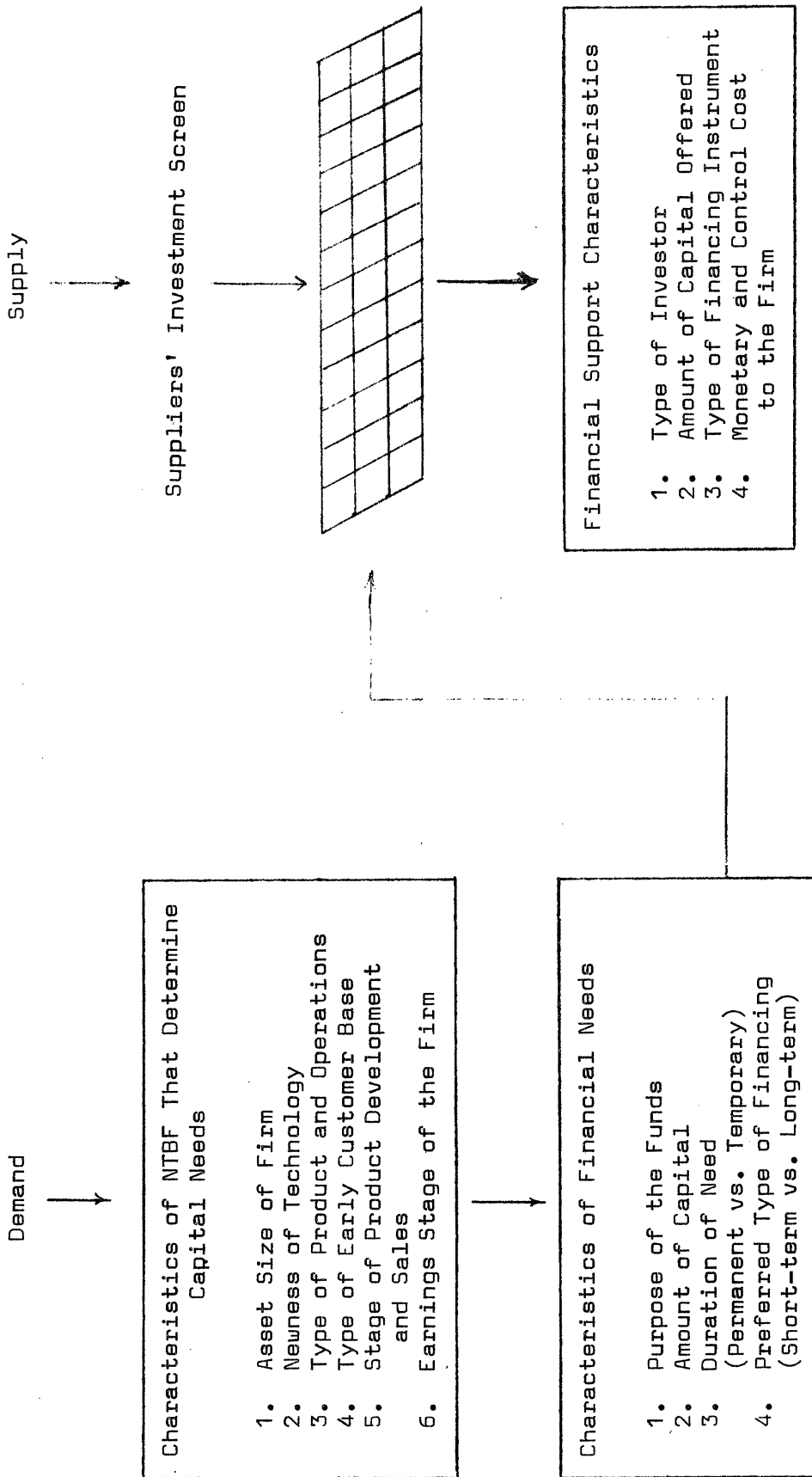


Fig. 1. NTBF Capital Market Model: Determinants of Characteristics of NTBF Financial Support.

I. NTBF CHARACTERISTICS

A. Size of Firm



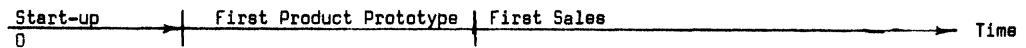
B. Newness of Technology



C. Type of Product



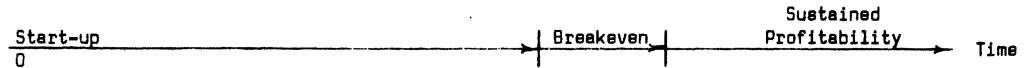
D. Stage of Product Development and Sales



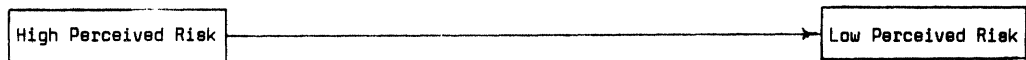
E. Type of Customer



F. Earnings Stage

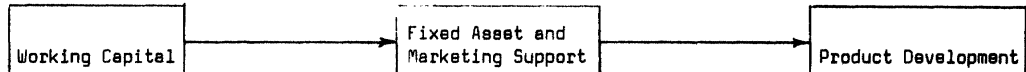


II. RELATION BETWEEN NTBF CHARACTERISTICS AND FINANCIERS' PERCEIVED RISK

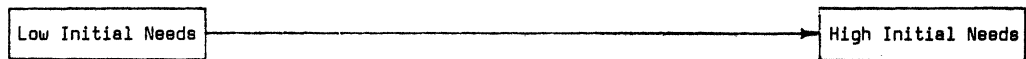


III. RELATION BETWEEN NTBF CHARACTERISTICS AND NTBF FINANCING NEEDS

A. Purpose of Funds Needed by New Firm

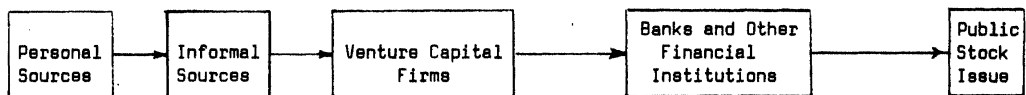


B. Amount of Funds Needed by New Firm

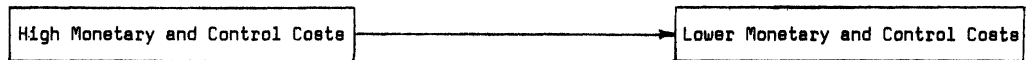


IV. CHARACTERISTICS OF FINANCIAL SUPPORT OFFERED TO NTBF

A. Type of Supplier



B. Capital Costs



C. Type of Financing Instrument

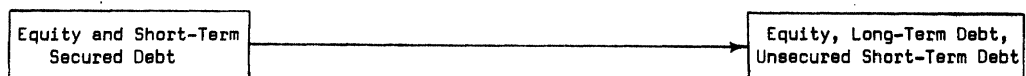


Fig. 2. Capital Market Model: Hypothesized Relationships Between NTBF Characteristics, Risk Perceived by Financiers, and Characteristics of Financial Support Available to NTBF.

determines the financial support available to the firm, and this, in turn, affects the firm's performance.

Figure 1 shows that on the demand side of this market are NTBF, which possess certain observable characteristics: size of firm's total assets, newness of technology, particular type of product and type of operations, specific type of early customer base, and development cycle stage as represented by the extent to which levels of product development, sales, and sustained profitability have been reached. It is hypothesized that these characteristics specifically influence the characteristics of NTBF financial needs in terms of amount of capital needed, the purpose or reason for the need, and the timing of the needs during the early life of the firm.

On the supply side of the market are individual and institutional investors, each type of investor characterized by a set of investment preferences and constraints which derive from past experience and from legal, regulatory and operational limitations. These preferences and constraints condition the investment screens of the potential investors. It is hypothesized that the characteristics of NTBF and their financing needs are passed through these investment screens and, as a result, the characteristics of financial support available to NTBF are determined. These include the likely type of investor (individuals, venture capital firms, banks and other financial institutions, public offering), the amount of financing offered, the type of investment vehicle used, and the terms.

In Figure 2, a set of hypothesized relationships between characteristics of NTBF, their financing needs, and characteristics

of the financiers is presented. These relationships show that NTBF which are small in asset size, engaged in exploration of an established-technology field, involved in R & D, testing and consulting, or are in the "start-up" phase will need capital in relatively small amounts and will need it primarily for product research and development. NTBF characterized by larger asset size, breakthrough technology, and a standard product being produced for sale, and which have attained evident market acceptance and sustained profitability, will need relatively larger amounts of capital and will need the funds for purposes of production, marketing, and expansion.

It is hypothesized that this progression through the developmental cycle of the NTBF alters the risk perceived in the firm by financiers. In the early, higher-risk stage, certain investors are felt to be willing to engage in NTBF financing in particular amounts and on particular terms. As the risk profile is altered through changes in the firm's characteristics and the resolution of uncertainty, various other specified types of suppliers become willing to offer capital at particular terms. The model suggests that as NTBF acquire the stated characteristics, they have available to them an increasing number and variety of financing sources and an increasing volume of funds at relatively better terms.

In this paper we present findings derived from a test of the demand side of this set of hypothesized relationships, and identify NTBF characteristics which influence NTBF capital needs. It is argued here that these needs are not simply and universally a function of time or age of the firm. Rather, it is hypothesized that the amount, purpose,

and timing of NTBF financial support characteristics are demonstrably related to the several important and recognizable NTBF characteristics indicated earlier.

Methodology

Information for the study was developed through intensive analysis of twenty-six NTBF located in the Ann Arbor-Detroit area of Michigan and twenty-six comparable firms in the Greater Boston area. Firms were selected so as to provide a reasonably representative cross-section of the NTBF which had been founded in the Ann Arbor-Detroit area and to permit a fair comparison of firms in the two areas with respect to their characteristics and financing experiences.

All the firms in each sample were founded in the years 1965 through 1970. This period was selected so that a minimum of two years of "start-up" and subsequent capital-seeking experience would have passed and so that there would be a maximum of seven years of business experience for the founders to recall. The median dates of incorporation for the firms were May, 1968 and July, 1968 for the Ann Arbor-Detroit and Boston firms, respectively. The firms in each area were also matched by their product types during their first year after incorporation, as shown in Table 1.

Brief descriptions of each of the four specific types of product follow:

1. Computer services. Firms preparing and marketing computer programs or systems analysis, and those operating computer service bureaus, or consulting in the area of computer software.

TABLE 1
 FIRMS CLASSIFIED BY PRODUCT TYPES DURING
 FIRST YEAR AFTER INCORPORATION

Product Type During First Year	Firms Included in Sample	
	Boston	Ann Arbor-Detroit
Computer Services	5	6
Computer Hardware	3	4
Electronics Components	5	3
Instrumentation	11	12
Other	<u>2</u>	<u>1</u>
Total	26	26

2. Computer hardware. Firms manufacturing and marketing computer equipment and computer peripheral equipment. Some programming and system support may accompany the hardware, but is supportive to and secondary to the equipment.
3. Electronics components. Firms fabricating all types of components used in the manufacture and fabrication of electrical and electronic equipment. Included in this category are manufacturers of diodes, resistors, printed circuits, and semi-conductive materials. Electronics components become part of a final product, e.g., medical instrumentation, and are intermediate products.
4. Instrumentation. Firms fabricating all types of scientific instruments, both mechanical and electronic, for all the noncomputer purposes such as radar equipment, medical research, precision balancing, and pollution control.

Many firms began operations in one line of business and changed at varying speeds to other lines. Since the focus of the research was upon the financial support of the NTBF in their early years, it was decided to control the firms in each area for product type at the beginning of the firms' corporate lives rather than to control for product type at the time of the interview.

In most cases the firms' product-type categorization for the purpose of this research was the same during their first year as in 1972. Table 2 shows the status of the firms in each of the areas during their beginning years and in 1972. This table shows the number of NTBF in each area by their product types during their first year

TABLE 2

FIRMS' PRODUCT TYPE DURING THE FIRST YEAR
AFTER INCORPORATION AND IN 1972

	Product Type During 1972						Total First Year
	Computer Service	Computer Hardware	Electronics Components	Instrumen- tation	Other		
<u>Computer Service</u>							
Ann Arbor	5	1	0	0	0	0	6
Boston	4	1	0	0	0	0	5
<u>Computer Hardware</u>							
Ann Arbor	0	4	0	0	0	0	4
Boston	0	3	0	0	0	0	3
<u>Electronics Components</u>							
Ann Arbor	0	0	3	0	0	0	3
Boston	0	0	4	0	1	0	5
<u>Instrumentation</u>							
Ann Arbor	0	0	1	10	1	1	12
Boston	0	0	0	10	1	1	11
<u>Other</u>							
Ann Arbor	0	0	0	0	1	2	1
Boston	0	0	0	0	2	2	2
<u>Total 1972</u>							
Ann Arbor	5	5	4	10	2	4	26
Boston	4	4	4	10	4	4	26

after incorporation along the left side of the page and, for each product type during the first year, the number of firms by their product types in 1972 along the top of the page.

No comprehensive, detailed, descriptive information was available on the populations of NTBF in the two areas, so the samples were not drawn randomly. Instead, the known NTBF in the Ann Arbor-Detroit area which met the age criteria were categorized by product type during their first year, and twenty-six firms whose founders were agreeable to the study were selected on the basis of their product types so that the sample was representative of the firms in the Ann Arbor-Detroit area. The Boston firms which met the age criteria were selected by product type to match the Ann Arbor-Detroit area sample firms on age and product type. The Boston sample is not intended to be representative of Boston area NTBF but is intended to be a sample of Boston NTBF similar in age and product characteristics to the Ann Arbor-Detroit sample for the purpose of comparing the operating characteristics and financial histories of firms from each area.

Various references were used to select the firms in each area. These included directories of firms compiled by the area's Chamber of Commerce and lists of new, technology-based firms compiled by the University of Michigan's Institute of Science and Technology and by the Massachusetts Science and Technology Foundation, and the personal knowledge of the researcher.

A structured interview schedule was designed and pretested on founders of four NTBF in the Ann Arbor-Detroit area. The interview questionnaire allowed each respondent to open up the story of his firm's

founding, as well as to respond to specific closed-end questions. Founders of each firm were interviewed for periods ranging from an hour to four hours. Questions were asked concerning the firm's early operating characteristics--e.g., sales, income, employment, etc.--its capital raising activities, the terms of its financial support, founders' personal and professional characteristics, and respondents' opinions and suggestions concerning their own firm's experiences and their experiences with other NTBF. The interview information was supplemented with data gathered from Dun and Bradstreet reports, the firms' articles of incorporation, and the firms' annual statements of financial position to their state governments.

The data representing operating and capital need characteristics of the NTBF were cross-tabulated for analysis and where appropriate, the hypothesized relationships were investigated statistically. Since the sample size was small, it was not feasible to investigate more than two characteristics with any test. Consequently, it was not feasible to isolate statistically all of the interaction of the operating characteristic variables. However, efforts were made to determine the important relationships for each variable at different levels of other variables. These relationships, although not supported statistically, provide insights which are meaningful given the constraints of the data base and the sample size.

Relationships Between NTBF Characteristics and
Capital Needs

To determine the influence on the amount, purpose, and timing of NTBF capital needs of the NTBF characteristics noted on the demand side of the model (asset size, newness of technology, type of product and operations, early customer base, stage of product development, sales and profitability), respondents were asked to categorize their capital needs at specific times under the following headings:

1. Product development needs. Capital to purchase special equipment and materials, hire personnel, pay for consulting and all expenses related to the development of procedures and processes necessary to produce products.
2. Working capital needs. Capital to be used for the acquisition and production of inventory, accounts receivable, financing salaries of support personnel not directly involved in marketing and product development.
3. Marketing needs. Capital to finance development and execution of marketing programs, including the preparation and distribution of promotional material.
4. Fixed asset needs. Capital to purchase fixed assets, e.g., plant and equipment that is used in the production of goods and services for revenue but not for the purpose of product development.

Size of Firm

The model hypothesizes that smaller firms have lower capital requirements and need funds predominantly for product development and general working capital purposes; larger firms are felt to need greater amounts of capital, with greater proportions allocated to market and production needs.

Data which show these relationships between the sampled firms are presented in Table 3. Since asset size at the end of one year was

TABLE 3

CAPITAL NEEDED, BY SIZE OF FIRM

Year After Incorporation	Firm's Total Assets at Beginning of Year											
	Less Than \$100,000	\$100,000- 250,000	\$250,000 500,000-	\$ 500,000- 1,000,000	\$1,000,000- 2,000,000	\$2,000,000- 3,000,000	Over \$3,000,000					
<u>Second Year</u>												
Number of Firms	7	7	11	11	7	5	2					
Total Capital Needed	\$725,000	\$1,155,500	\$2,840,000	\$4,100,000	\$3,750,000	\$4,230,600	\$2,600,000					
Mean Need	103,600	165,100	258,200	372,700	535,700	846,100	1,300,000					
Median Need	75,000	110,000	240,000	350,000	450,000	579,600	1,300,000					
<u>Third Year</u>												
Number of Firms	4	6	8	11	7	5	2					
Total Capital Needed	\$500,000	\$2,725,300	\$4,240,000	\$4,362,400	\$3,500,000	\$4,632,000	\$2,000,000					
Mean Need	125,000	454,200	530,000	396,800	500,000	926,400	1,000,000					
Median Need	125,000	325,300	433,300	375,000	400,000	800,000	1,000,000					
<u>Fourth Year</u>												
Number of Firms	2	3	5	6	3	2	2					
Total Capital Needed	\$250,000	\$820,000	\$2,450,000	\$3,060,000	\$2,150,000	\$1,220,000	\$1,000,000					
Mean Need	125,000	273,300	490,000	510,000	716,700	610,000	500,000					
Median Need	125,000	200,000	425,000	460,000	550,000	610,000	500,000					

used to establish firm size for comparison of capital needs in the following year, only three years of experience are used. The number of firms in each size group changed from year to year as some altered their size by raising external capital or by experiencing profits or losses. In general, all firms grew over the four-year period with total assets of the group increasing by nearly 600 per cent.

Amount and timing of need

As hypothesized, the larger firms needed more capital than the smaller firms; however, the needs of the smaller firms were larger relative to their asset size than were the needs of the larger firms. For example, in the second year, firms that began the year with less than \$100,000 in assets claimed a median need of \$75,000. NTBF with assets between \$2 million and \$3 million expressed a median need of \$579,600 and firms with assets over \$3 million claimed a median need of \$1.3 million. These higher capital needs of the smaller firms grew relative to their size in the third and fourth years. Firms with total assets in the previous year under \$100,000 had a median capital need of \$125,000 in the third and fourth years, and firms with assets between \$100,000 and \$250,000 claimed a median need of \$325,300 in the third year and \$200,000 in the fourth year.

Purpose and timing of need

The relationship between size and purpose of financing is evident in Table 4 and supports the model's hypothesis. Among firms with assets of over \$1 million, needs were greatest in all years for product development funds; as the firms matured, this need receded

TABLE 4

CAPITAL NEEDED BY ASSET SIZE OF FIRM AND REASON FOR NEED

Year After Incorporation	Total Assets Beginning of Year											
	Less Than \$1 Million					Greater Than \$1 Million						
	Product Development Needs	General Working Capital Needs	Marketing Needs	Fixed Asset Needs	Product Development Needs	General Working Capital Needs	Marketing Needs	Fixed Asset Needs	Product Development Needs	General Working Capital Needs		
<u>Second Year</u> Number of Firms Needing Capital Total Capital Need Mean Need* Median Need	15 \$1,711,000 114,100 167,700	30 \$3,757,400 125,200 150,000	19 \$875,000 46,000 50,000	16 \$52,200 59,500 70,000	12 \$7,940,000 661,700 533,300	11 \$1,980,000 180,000 150,000	5 \$526,500 105,300 100,000	9 \$692,000 78,000 78,000	12 \$5,465,500 627,300 550,000	11 \$3,700,000 336,400 300,000	8 \$800,000 80,000 80,000	9 \$2,242,000 280,250 257,700
<u>Third Year</u> Number of Firms Needing Capital Total Capital Need Mean Need* Median Need	17 \$2,300,000 135,000 150,000	25 \$4,934,700 224,300 225,000	21 \$908,500 45,400 45,500	24 \$1,600,000 66,700 75,000	12 \$5,465,500 627,300 550,000	11 \$3,700,000 336,400 300,000	8 \$800,000 80,000 80,000	9 \$2,242,000 280,250 257,700	12 \$5,465,500 627,300 550,000	11 \$3,700,000 336,400 300,000	8 \$800,000 80,000 80,000	9 \$2,242,000 280,250 257,700
<u>Fourth Year</u> Number of Firms Needing Capital Total Capital Need Mean Need* Median Need	10 \$629,500 63,000 100,000	15 \$2,415,000 161,000 165,000	12 \$764,500 63,700 66,700	11 \$750,000 68,200 66,700	6 \$3,279,900 546,650 457,800	5 \$1,250,000 250,000 400,000	5 \$800,000 160,000 150,000	5 \$1,061,100 212,200 200,000	6 \$3,279,900 546,650 457,800	5 \$1,250,000 250,000 400,000	5 \$800,000 160,000 150,000	5 \$1,061,100 212,200 200,000

* Indicates that the difference between the mean total capital needed of the two asset size groups was significant at the 10% level.

and general working capital needs increased along with fixed-asset and marketing needs.

Among firms with assets under \$1 million, median needs for product development and for general working capital purposes were the most important. The absolute size and relative dominance of product-development needs was not nearly so great among the smaller firms as among the larger companies. Furthermore, while median financing needs of the large firms increased in each year, those of the smaller firms declined in the fourth year.

Contrary to the experience of the larger firms, the fixed-asset needs of the smaller firms declined from the second to the fourth year. Marketing needs were the smallest of the four types of need for both size categories but grew in importance over the four year period, particularly for the larger firms.

Newness of Technology

The model proposes that firms attempting to develop a new, or breakthrough, technological innovation, may require a larger amount of initial capital (that is, in the first year of operations) than will firms developing products based on established technology. Table 5 presents the results of a comparison of first-year needs by firms using breakthrough technology, established technology and a combination of the two (mixed technology).

TABLE 5

AMOUNT OF CAPITAL NEEDED, FIRST YEAR AFTER INCORPORATION,
BY NEWNESS OF TECHNOLOGY AT START-UP, AND REASON FOR NEED

Reason for Need	Newness of Technology		
	Breakthrough Technology	Mixed Technology	Established Technology
<u>Product Development</u>			
Number of Firms Needing Capital	14	6	2
Total Capital Needed	\$4,375,500	\$1,289,900	\$700,000
Mean Need	312,500	215,000	350,000
Median Need	306,700	200,000	350,000
<u>Working Capital</u>			
Number of Firms Needing Capital	13	16	17
Total Capital Needed	\$1,550,000	\$1,740,000	\$2,220,000
Mean Need	119,200	102,800	130,600
Median Need	100,000	100,000	120,000
<u>Marketing</u>			
Number of Firms Needing Capital	2	3	7
Total Capital Needed	\$110,000	\$125,000	\$527,500
Mean Need	55,000	41,700	75,400
Median Need	55,000	40,000	77,500
<u>Fixed Asset</u>			
Number of Firms Needing Capital	5	7	15
Total Capital Needed	\$413,000	\$507,100	\$1,127,000
Mean Need	82,600	72,400	75,000
Median Need	80,000	65,000	50,000
<u>Total Firms</u>			
Total Capital Needed	15	18	19
Mean Need	\$6,448,500	\$3,662,000	\$4,574,500
Median Need	429,900	203,400	240,800
Median Need	400,000	182,000	200,000

Amount of capital needed

The total need expressed by breakthrough-technology firms for first-year funds was considerably higher than those of the other two classifications. The median total need (\$400,000) was twice as high for established-technology firms and over twice as high as for the mixed-technology group. In this respect the hypothesis is supported.

Purpose of need

Approximately 70 per cent of the first-year needs of breakthrough-technology firms was for product development. Fourteen of the fifteen breakthrough-technology NTBF expressed a need for product-development capital (median \$306,700), compared to six out of eighteen mixed-technology firms (median \$200,000), and only two of nineteen established-technology firms (median \$350,000).

The majority of firms in all three categories needed working capital. Firms using established-technology developed their products sooner and required the most working capital during the first year (\$2,200,000). Firms using a breakthrough-technology, who took the longest to develop their products, required the least working capital in the first year (\$1,550,000).

Firms using an established technology had the highest marketing capital needs during their first year. Seven of nineteen such firms claimed a median need of \$77,500 compared to only two of fifteen breakthrough-technology firms with a median need of \$55,000.

A majority of established-technology firms claimed fixed-asset capital needs. Fifteen of nineteen such firms claimed fixed-asset capital needs in the first year for a median need of \$50,000, while

only five of the fifteen breakthrough-technology firms needed fixed-asset capital in their first year. However, the five breakthrough-technology firms which did need fixed-asset capital had the highest median need (\$80,000) of all three types of NTBF. Much of the fixed-asset needs of breakthrough-technology firms were for testing, monitoring, and computing equipment that was used during the firm's first year for product development, rather than for production.

In terms of purpose of need, the newness of the NTBF technology did influence the capital needs of the NTBF as hypothesized. Firms exploiting breakthrough technology expended considerable effort in developing the feasibilities of their technology, as well as their product applicabilities, and these firms needed significantly more capital for product-development purposes. With the exception of two firms, established-technology firms brought their products to market sooner, and needed the most working capital and fixed-asset capital. The capital needs of firms in the mixed-technology category were between those of the established- and breakthrough-technology firms but were closer in magnitude to the needs of established-technology firms, especially for working capital.

Type of Business Operations

The sampled firms were classified according to general characteristics of the products or services with which they were involved: R & D, testing, and consulting (R & D); custom manufactured products (custom); standard proprietary products with custom changes (modified standard); and standard proprietary products (standard).

The capital needs of the NTBF differed among these classifications, particularly in the first years of operation, as shown in Table 6.

Brief descriptions of each of these types of operation follow:

1. R & D, testing, and consulting. Firms whose primary operation consists of the marketing of expert services. Included are, for example, firms which conduct anti-radar device research for the Department of Defense, testing of such equipment, and consulting on the implementation and use of it.
2. Custom product manufacturing. Firms which fabricate products to the specifications of particular customers and manufacture such products in large volume. This category included, for example, firms which produce printed electrical circuits for use in electrical and electronic equipment.
3. Standard products with custom changes. Firms characterized by the use of standard proprietary products or processes to produce standard products modified to meet the special requirements of different customers. An example would be a computer service firm which finds it necessary to fit its proprietary programs to the needs of particular customers.
4. Standard proprietary product manufacturers. Firms who produced standard proprietary products to meet the needs of customers without modification.

Amount and timing of need

In each of the first four years standard firms expressed need for the largest volume of funds. The ranking and proportional differences among the remaining three groups was stable over the four-year

period; modified standard firms required the second largest amount of funds, followed by custom firms and R & D firms. The data tend to support the model's hypothesis regarding this characteristic.

Purpose and timing of need

The purpose or reason for the firm's capital needs also varied significantly by the firm's type of operation. This variation indicates why standard firms needed the most total capital. During their first four years, standard firms experienced the highest product-development needs of all the firms with these needs increasing each year. In the first and third years, modified standard firms had higher total product-development needs than all the other firms combined. As might be expected, product development represented the largest proportion of the total needs of these firms, accounting for over half the capital needs of the firm.

The median amounts of capital needed over the firms' four years increased for all four NTBF classifications. The largest increase occurred for R & D firms whose median needs for all purposes increased by approximately 125 per cent over the four years. Much of this increase came from a relatively large increase in product-development needs as these companies evolved from R & D to manufacturing. In the first year, only two of fifteen such firms needed a total of \$150,000 in product-development capital, compared to two of five of such firms in the fourth year for a product-development need of \$200,000.

Product-development needs also grew steadily for firms producing modified standard products. In the first year, six of

eleven such firms expressed a median need of \$167,000. By the fourth year, five of six such firms had a median need of \$178,000. There was also a large increase in importance of product-development capital for custom product firms, with five of sixteen such firms claiming a median need of \$125,500 in their first year, compared to four of six such firms with a median need of \$176,700 in their fourth year.

Working-capital needs were generally the second most important type of need, among R & D and custom product firms, however, working-capital needs were particularly important. During the first year of operations working capital accounted for 75 per cent of the total capital needs of R & D firms.

Marketing needs represented the least important need for all but the R & D firms in the first year but grew in importance thereafter, especially for the standard product firms. In the first year, two of ten standard product firms needed a median of \$94,000 marketing capital compared to six of six such firms with a median need of \$100,000 in the fourth year.

Fixed-asset needs were most important for custom product firms, with eleven of sixteen such firms needing capital in the first year (median \$48,500). By the fourth year, five of six such firms had a median need of \$70,000. These needs were least important for R & D firms but did grow in importance over their first four years. Only two of fifteen such firms needed fixed-asset capital in the first year (median of \$20,000); by the fourth year, the median fixed-asset needs had risen to \$50,000 for three of five such firms.

Analysis of the data supports the hypothesis that the amount, purpose, and timing of capital needs of NTBF differ according to the types of product and operations of the firms. Total capital needs of all the NTBF grew during the first four years. Standard product firms needed the most capital for each of the purpose categories, and R & D firms needed the least for each category. Standard product firms needed most of their capital for product-development purposes while R & D firms needed funds primarily for working-capital purposes. Capital for marketing and fixed assets was relatively unimportant in the early years of nearly all the firms, but grew in importance over their development cycle.

Early Customer Base

Analysis of the two geographic area samples showed that Boston NTBF relied more heavily upon government agencies, particularly the Department of Defense, as their largest source of customers during early life than did the Ann Arbor-Detroit firms. The latter group relied primarily on commercial customers, especially in the automotive industry.

The model proposes that firms selling primarily to government agencies require less capital during their early years because of the contractual nature of their work and the progress payment system. Table 7 shows for the first year of operation the amount of capital needed and purpose of need for NTBF classified by customer type.

TABLE 7

CAPITAL NEEDS FIRST YEAR, BY EARLY CUSTOMER BASE DURING FIRST YEAR

Reason for Need	Boston		Ann Arbor-Detroit	
	Government As Largest Customer	Commercial Customers As Largest Customers	Government As Largest Customer	Commercial Customers As Largest Customers
<u>Product Development</u>				
Number of Firms Needing Capital	2	8	1	11
Total Capital Needed	\$ 200,000	\$2,737,400	\$150,000	\$3,058,000
Mean Need	100,000	342,200	150,000	278,000
Median Need	100,000	255,000	150,000	228,000
<u>Working Capital</u>				
Number of Firms Needing Capital	9	13	3	21
Total Capital Needed	\$ 760,000	\$1,658,000	\$320,000	\$2,630,000
Mean Need	84,000	127,500	106,700	125,200
Median Need	78,700	125,000	100,000	125,000
<u>Marketing</u>				
Number of Firms Needing Capital	2	5	0	5
Total Capital Needed	\$ 65,000	\$ 380,500	0	\$ 317,000
Mean Need	32,500	76,100	0	63,400
Median Need	32,500	52,500	0	50,000
<u>Fixed Asset</u>				
Number of Firms Needing Capital	4	7	2	13
Total Capital Needed	\$ 213,500	\$ 681,000	\$160,000	\$ 915,100
Mean Need	53,400	197,300	80,000	70,400
Median Need	27,500	76,000	80,000	63,200
<u>Total Firms</u>	9	16*	3	23
Total Capital Needed	\$1,238,500	\$5,456,900	\$630,000	\$6,920,000
Mean Need	137,600	341,100	210,000	300,900
Median Need	90,000	286,700	150,000	275,000

*One Boston Firm did not respond to the questions regarding early customer base.

Amount needed

As hypothesized, firms whose first-year sales were primarily to commercial customers needed more capital for all reasons than did firms whose early customer base consisted of government agencies. The total median need of Boston firms which relied upon commercial customers was over three times as large as the median need of firms selling primarily to government agencies, and in Ann Arbor-Detroit the median need was almost twice as large.

Purpose of need

The capital needs of firms whose largest source of customers was commercial were greater for each type of need than for firms relying on sales to government agencies. One exception to this was for fixed-asset needs among Ann Arbor-Detroit firms: two of the three firms selling to government agencies claimed a larger median need (\$80,000) than did the thirteen of twenty-three firms selling primarily to commercial customers (median \$63,200).

The larger needs of commercial-customer NTBF were especially evident for product-development and marketing needs. Approximately one-half of all commercial-customer NTBF claimed product-development needs in their first year compared to approximately one-third of the government-customer NTBF. The median product-development needs for commercial-customer NTBF were approximately double the median needs for government-customer NTBF. A larger proportion of firms depending on commercial customers also needed more marketing capital--approximately 70 per cent more in terms of median amount.

The analysis of the relationships between early customer base and the capital needs of NTBF supports the hypothesis that firms which rely upon commercial customers from the outset need more capital in their first year as well as needing capital for product development and marketing.

Stage of Product Development and Sales

New, technology-based firms follow different patterns of development over time, and, it is hypothesized, their capital requirements vary accordingly over time. Product development represents a significant portion of the NTBF early efforts. Three stages in the NTBF early product development and sales histories are hypothesized as significant for determining the early capital needs of those NTBF which are developing standard products. These stages are:

1. The span of time from incorporation to first standard product prototype.
2. The span of time from first standard product prototype to first sales of standard product.
3. The time after first sales of standard product.

Tables 8, 9 and 10 indicate the amounts of capital needed by product development and sales cycle stage and by reason for need during each of these three stages.

Amount needed

The median span of time from incorporation to prototype development was six months for firms whose primary effort after incorporation was development of a standard product; eleven months for firms whose beginning product-development effort was secondary

TABLE 8

AMOUNT OF CAPITAL NEEDED, BY TYPE OF STANDARD PRODUCT DEVELOPMENT CYCLE,
FROM INCORPORATION TO FIRST STANDARD PRODUCT PROTOTYPE

Reason for Need	Type of Standard Product Development Cycle		
	NTBF Developing Standard Product As Primary Effort At Beginning (Median Span of Time = 6 Months)	NTBF Developing Standard Product At Beginning, Secondary to R&D and Custom Product Sales (Median Span of Time = 11 Months)	NTBF Beginning With R&D or Custom Product Sales, Later Developing Standard Product (Median Span of Time = 27 Months)
<u>Product Development</u>			
Number of Firms Needing Capital	10	6	10
Total Capital Needed	\$3,177,000	\$1,275,500	\$1,835,400
Mean Need	317,700	212,000	183,500
Median Need	260,000	200,000	165,000
<u>Working Capital</u>			
Number of Firms Needing Capital	9	15	10
Total Capital Needed	\$2,315,500	\$2,625,000	\$4,300,000
Mean Need	257,300	175,000	430,000
Median Need	225,000	150,000	400,000
<u>Marketing</u>			
Number of Firms Needing Capital	3	4	7
Total Capital Needed	\$ 73,000	\$ 250,000	\$1,110,000
Mean Need	24,300	62,500	158,600
Median Need	18,000	50,000	150,000
<u>Fixed Asset</u>			
Number of Firms Needing Capital	8	7	6
Total Capital Needed	\$ 875,000	\$ 415,000	\$ 829,000
Mean Need	109,400	59,300	138,200
Median Need	100,000	55,000	125,000
<u>Total Firms</u>	11	17	10
Total Capital Needed	\$6,440,500	\$4,565,500	\$8,074,400
Mean Need	585,500	268,600	806,400
Median Need	500,000	200,000	655,000

TABLE 9

AMOUNT OF CAPITAL NEEDED, BY TYPE OF STANDARD PRODUCT DEVELOPMENT CYCLE,
AFTER FIRST STANDARD PRODUCT PROTOTYPE AND
PRIOR TO FIRST SALES OF STANDARD PRODUCT

Reason for Need	Type of Standard Product Development Cycle		
	NTBF Developing Standard Product As Primary Effort At Beginning (Median Span of Time = 4 Months)	NTBF Developing Standard Product At Beginning, Secondary to R&D and Custom Product Sales (Median Span of Time = 2 Months)	NTBF Beginning With R&D or Custom Product Sales, Later Developing Standard Product (Median Span of Time = 2 Months)
Product Development			
Number of Firms Needing Capital	8	5	6
Total Capital Needed	\$1,290,000	\$1,100,000	\$ 950,000
Mean Need	161,300	220,000	150,300
Median Need	143,300	175,000	150,000
Working Capital			
Number of Firms Needing Capital	6	12	6
Total Capital Needed	\$ 950,000	\$1,837,500	\$ 725,000
Mean Need	158,300	153,100	120,800
Median Need	125,000	145,000	117,500
Marketing			
Number of Firms Needing Capital	8	14	9
Total Capital Needed	\$ 650,000	\$ 880,000	\$ 727,700
Mean Need	81,300	62,900	80,900
Median Need	52,000	40,000	60,000
Fixed Asset			
Number of Firms Needing Capital	8	10	9
Total Capital Needed	\$ 525,000	\$ 600,000	\$ 730,000
Mean Need	65,600	60,000	121,700
Median Need	57,500	50,000	100,000
Total Firms	11	17	10
Total Capital Needed	\$3,415,000	\$4,417,500	\$3,132,700
Mean Need	310,500	259,500	313,300
Median Need	226,700	175,000	235,000

TABLE 10

AMOUNT OF CAPITAL NEEDED, BY TYPE OF STANDARD PRODUCT DEVELOPMENT CYCLE,
AFTER FIRST SALE OF STANDARD PRODUCT

Reason for Need	Type of Standard Product Development Cycle		
	NTBF Developing Standard Product As Primary Effort At Beginning (Median Span of Time = 28 Months)	NTBF Developing Standard Product At Beginning, Secondary to R&D and Custom Product Sales (Median Span of Time = 22 Months)	NTBF Beginning With R&D or Custom Product Sales, Later Developing Standard Product (Median Span of Time = 13 Months)
<u>Product Development</u>			
Number of Firms Needing Capital	8	14	7
Total Capital Needed	\$ 5,800,000	\$ 7,451,400	\$ 4,822,000
Mean Need	725,000	532,200	688,900
Median Need	425,000	461,000	342,000
<u>Working Capital</u>			
Number of Firms Needing Capital	11	17	10
Total Capital Needed	\$ 3,460,000	\$ 4,178,000	\$ 1,410,500
Mean Need	314,500	245,800	141,100
Median Need	300,000	225,000	120,000
<u>Marketing</u>			
Number of Firms Needing Capital	9	14	7
Total Capital Needed	\$ 435,000	\$ 513,800	\$ 287,000
Mean Need	48,300	36,700	41,000
Median Need	38,000	26,700	35,000
<u>Fixed Asset</u>			
Number of Firms Needing Capital	6	11	6
Total Capital Needed	\$ 2,019,000	\$ 2,602,900	\$ 870,000
Mean Need	336,500	236,600	145,000
Median Need	275,000	180,000	127,500
<u>Total Firms</u>	11	17	10
Total Capital Needed	\$ 11,714,000	\$ 14,746,100	\$ 7,389,500
Mean Need	1,064,900	867,400	739,000
Median Need	850,000	746,000	635,000

to R & D and custom product sales; and twenty-seven months for firms that began business as R & D and custom-product firms and only later engaged in standard product development.

In spite of the shorter period of time involved, the median total need for the firms whose initial effort was product development was larger than the median need for firms whose initial product-development effort was secondary to R & D and custom product sales. In terms of the median need per month during the span from incorporation to first standard product prototype, the needs of firms whose initial operations primarily involved product development were much larger than they were for the firms that were developing standard product as an initial but secondary effort--approximately \$83,000 per month, compared to approximately \$18,000 per month. The third group of firms, those that began with R & D or custom product sales, and later developed standard product, had median monthly needs for product development of approximately \$24,000 during the stage of product development prior to product prototype.

The median span of time from standard product prototype to first sales of standard product was four months for firms whose primary initial effort was standard product development, two months for firms whose initial product-development effort was secondary, and two months for firms that began standard product development later in their lives. During this period, a total of \$3,415,000 was needed by the first group of eleven firms over the median four-month span; \$4,417,500 by the second group of seventeen firms over the median span of time of two months; and \$3,007,700 by the ten

firms which did not develop standard products until later in their lives over their median span of two months.

After the firms made their first sales of standard product, the median span of time from first sales of standard product to the end of the study time period was twenty-eight months for firms developing standard product as a primary effort from their incorporation, twenty-two months for firms whose initial product-development effort was secondary, and thirteen months for firms that began product-development effort later in their lives.

The first group of firms needed median product-development capital of \$850,000 during this stage for an approximate median monthly need of \$30,000. This represented a considerable decline from the median monthly needs in the earlier stages of product sales and product development. Firms initially developing standard product as secondary activity needed a median of \$746,000 during this last stage in their product-development and sales cycle, for a median monthly need of approximately \$34,000. This represented an increase in the monthly need over previous stages. The last group of firms, those that began development of standard product later in their lives, experienced the largest increase in total capital needs. Their median needs during this last stage were \$635,500 for a median monthly need of approximately \$49,000 compared to \$24,000 during the preprototype stage.

Purpose of need

Analysis by purpose of need reveals some causes of the differences over the firms' three stages of sales and product

development. The major product-development needs of firms developing standard products as their primary effort declined in the later stages of the product-development and sales cycle. During the stage prior to prototype these firms needed a median of \$260,000 for a monthly median need of approximately \$52,000. This declined to a median need of \$143,300, or a median monthly need of \$35,000, in the second stage after prototype and before first sales of standard product. In the third stage of the cycle, median product-development needs declined to \$425,000, approximately \$15,000 per month.

Product-development needs increased over the cycle for firms that began business with a product-development effort secondary to R & D or custom product sales. Prior to product prototype, median product-development need was \$200,000, a monthly need of \$18,000. Median product-development needs were \$175,000 in the second stage, representing a rise to a monthly need of \$85,000; in the third stage, median need were \$461,000, for a monthly median need of \$21,000.

The third group also experienced increased product-development needs over the cycle. In the first stage, median product-development needs for R & D and custom product firms that began standard product development late in their lives were \$165,000, a monthly need of \$6,000. In the second stage median need was \$150,000, but the median monthly need had risen to \$75,000. In the third stage, median product-development needs rose to \$342,000 for a median monthly need of \$26,000.

The relatively high product-development needs during the period after first product prototype but before first sales were explained by respondents who commented that, although development

of a standard product prototype did resolve questions regarding the product's technological feasibility, major additional product-development efforts were necessary to make the product ready for market.

While the product-development needs explain a major portion of the variation in total financial needs of the firms over the product development and sales cycle, working-capital needs were similar in profile over the three stages of the cycle. The median monthly working-capital needs for firms initially developing standard product as a primary effort declined from approximately \$38,000 in the first stage to \$31,000 in the second stage and \$11,000 in the third stage.

For firms whose initial product development effort was a secondary activity, monthly working-capital needs increased from approximately \$13,000 in the first stage to \$72,000 in the second stage and then declined to \$12,000 in the third stage. Firms developing standard products later in their lives experienced a similar working-capital need profile. Their median monthly working-capital needs rose from \$15,000 in the first stage to \$58,000 in the second stage and fell to \$9,000 in the third stage.

Marketing needs were relatively unimportant for all firms except during the stage from prototype to first sales, when the firms were preparing major marketing efforts for new standard products. During this stage firms that developed standard products later in their lives experienced the highest median monthly marketing needs (\$30,000), and firms that had been developing standard products as

their primary effort from the beginning experienced the lowest monthly needs (\$13,000).

During the first stage of the cycle fixed-asset needs were the most important for the first group of firms. These firms had a median monthly need of \$17,000, compared to \$5,000 for the firms who were initially developing standard products as a secondary effort, and \$5,000 for the third group of firms.

The first group's median monthly fixed-asset needs declined to \$13,000 in the second stage of the cycle and to \$10,000 in the third stage. Fixed-asset needs of the other two groups of firms were highest from prototype to first sales. Firms whose initial product development was secondary to R & D and custom product sales experienced a monthly fixed-asset need of \$20,000 during the second stage, and firms that began with R & D or custom product sales and later developed standard products had the highest monthly fixed-asset needs (\$30,000) during the second stage.

The analysis of the relationships between the stages of the NTBF product-development and sales cycle and the NTBF's financial needs supports the hypothesis of the model. Generally the total capital needs of the firm increased as the firm moved through the three stages of the cycle. With respect to the changes in purpose of need over the cycle, firms that were concentrating most of their initial effort toward the development of a standard product experienced much larger product-development needs during the stages prior to prototype and prior to first sales of standard product. These needs declined thereafter, and since product development represented such a large portion

of their total requirements their total needs also declined. One conclusion which the analysis suggests, however, is not entirely consistent with the model. Capital needs relative to the cycle were highest in the period from prototype to first sales of standard product, the second stage of the cycle. Many respondents mentioned this period as one of very rapid change for the firm. Firms needed large amounts of capital to prepare their new standard products for market, and these needs were for working capital and fixed assets to start production and for funds with which to initiate a marketing program for their new standard products.

Earnings Stage

The model hypothesizes that the amount of capital needed by NTBF varies with the earnings stage of the firm. This proposition rests on the notion that profitability may be achieved only after substantial asset growth has already occurred; exploitation of a market opportunity after it is proven to be profitable is felt to require even greater input of capital. Table 11 shows the total capital needs of the firms categorized by their attainment, or failure to attain, sustained break-even.

Amount needed and timing of need

In the first year after incorporation the sixteen break-even firms expressed a need for a median of \$250,000 compared to \$225,000 for the firms that had not attained break-even status. This difference increased in the second year with break-even firms needing a median of

TABLE 11
CAPITAL NEEDS BY EARNINGS STAGE AND REASON FOR NEED

Year After Incorporation	NTBF Sustaining Losses						NTBF with Sustained Breakeven					
	Product Development Needs	Working Capital Needs	Marketing Needs	Fixed Asset Needs	All Needs		Product Development Needs	Working Capital Needs	Marketing Needs	Fixed Asset Needs	All Needs	
First Year												
Total Firms = 52												
Total Firms with Sustained Breakeven = 16												
Number of Firms	12	34	9	16	36		10	12	3	11	16	
Needing Capital												
Total Capital Needed	\$3,855,400	\$3,806,000	\$525,000	\$1,287,100	\$ 9,473,500		\$2,510,000	\$1,704,000	\$237,500	\$ 760,000	\$5,211,500	
Mean Need	321,300	114,900	58,300	80,400	256,500*		251,000	142,000	79,200	69,100	325,700	
Median Need	285,000	100,000	50,000	57,500	215,000		220,000	125,000	67,500	50,000	250,000	
Second Year												
Total Firms = 50												
Total Firms with Sustained Breakeven = 21												
Number of Firms	17	22	13	18	29		11	19	11	17	20	
Needing Capital												
Total Capital Needed	\$4,561,000	\$3,175,000	\$725,000	\$1,200,000	\$ 9,661,000		\$5,100,000	\$2,572,400	\$656,500	\$1,420,200	\$9,749,100	
Mean Need	268,300	144,300	55,800	66,700	333,100*		463,600	135,400	59,700	83,500	487,500	
Median Need	222,000	112,500	42,000	58,500	200,000		400,000	125,000	50,000	75,000	390,000	
Third Year												
Total Firms = 43												
Total Firms with Sustained Breakeven = 19												
Number of Firms	20	20	16	18	24		16	16	13	15	17	
Needing Capital												
Total Capital Needed	\$4,565,500	\$5,359,700	\$885,500	\$1,922,000	\$12,732,700		\$3,200,000	\$3,275,000	\$823,000	\$1,920,000	\$9,218,000	
Mean Need	228,300	268,000*	55,300	106,800	530,500		200,000	204,700*	63,300	128,000	524,200	
Median Need	156,700	217,500	40,000	100,000	446,700		175,000	175,000	53,000	122,000	448,000	
Fourth Year												
Total Firms = 23												
Total Firms with Sustained Breakeven = 12												
Number of Firms	7	9	8	7	11		9	11	9	9	11	
Needing Capital												
Total Capital Needed	\$1,229,000	\$2,807,000	\$635,500	\$ 723,300	\$ 5,394,800		\$2,680,400	\$1,915,000	\$929,000	\$1,087,800	\$6,612,200	
Mean Need	175,600	311,900	79,400	103,300	490,400		297,900	174,100	103,200	120,900	601,100	
Median Need	155,000	260,000	56,600	83,300	390,000		250,000	175,000	75,000	100,000	500,000	

* Indicates that the Differences between the mean needs for the NTBF that had attained sustained breakeven and the NTBF that had not attained sustained breakeven were significant at the 10% level.

\$390,000 compared to a median need of \$200,000 for non-break-even firms. In the third year this difference narrowed, and in the fourth year the median need of break-even firms was \$500,000 compared to \$390,000 for non-break-even firms.

Purpose and timing of need

The proportion of firms that needed product-development capital increased over the four years both among the firms that attained sustained break-even and among the firms that had not attained break-even. The product-development needs for the firms that had not attained break-even declined gradually over the four years from a median need of \$285,000 for ten of sixteen such firms in the first year to \$155,000 for nine of twelve such firms in the fourth year. The median product development needs of break-even firms increased slightly over this time from \$220,000 in the first year for twelve of thirty-six such firms to \$250,000 in the fourth year for seven of eleven such firms.

The proportion of firms in both groups needing working capital was high (75 per cent and 94 per cent) throughout the four years. Working-capital needs did increase somewhat more rapidly over the four years for firms that had not attained break-even than for break-even firms.

The proportion of break-even firms that needed capital for marketing purposes increased from three of sixteen such firms in the first year to nine of twelve such firms in the fourth year. The proportion of non-break-even firms that needed such capital increased from nine of thirty-six in the first year to eight of twelve in the

fourth year. For both groups of firms the median marketing needs did not fluctuate greatly over the four years, and in each of the years the median marketing need was larger for the break-even firms than for the non-break-even firms.

The profile of the fixed-asset requirements over time was similar to that of the marketing needs. The proportion of break-even firms that required fixed-asset capital increased from eleven of sixteen such firms in the first year to nine of eleven such firms in the fourth year. For the non-break-even firms the proportion needing fixed-asset capital increased from sixteen of thirty-six such firms in the first year to seven of eleven such firms in the fourth year. The median fixed-asset needs increased over the four years, especially for the firms that had attained profitability. Their median fixed-asset needs doubled from \$50,000 in the first year to \$100,000 in the fourth year while the median fixed-asset needs of non-break-even firms increased by approximately 45 per cent from \$57,500 in the first year to \$83,000 in the fourth year.

The analysis of the data supports the hypothesis of the model. Total capital needs increased after firms reached a sustained break-even, and marketing and fixed-asset needs increased more for firms that had reached a sustained break-even than for firms that had not attained sustained break-even. Median working-capital needs increased more rapidly for the non-break-even firms than for the break-even firms. Median product-development needs declined for non-break-even firms over the four years and increased slightly for the break-even firms.

Conclusions and Implications

New, technology-based firms combine the risk typically associated with small business firms with the uncertainty attendant to the commercial exploitation of a technological innovation.

This uncertainty derives from questions about several factors: (1) the technical effectiveness of the particular innovation, (2) the accessibility of markets and marketing channels for its profitable sale, (3) the ability of the technological entrepreneurs to provide the management skills with which to produce the product and control the operation of the firm.

Because the success of the firm depends upon the provision of assets to support product development, production, and sales, the procurement and management of capital are critically important aspects of the firm's operations. NTBF founders and managers must, therefore, be familiar with the financial implications of the characteristics of the firm and with the sensitivity of potential suppliers of funds to these characteristics.

Based on these factors, NTBF may be considered a unique subset or group within the small business community. It is not, however, a homogeneous group.

Conclusions

This study shows that there may be important differences among firms which are generally grouped under the classification of new, technology-based firms. These differences are found in total asset

size, the newness of technology, type of product and operations, early customer base, the elapsed time in reaching progressive stages of the product-development and sales cycle, and the attainment of sustained profitability.

These characteristics were found to influence, in the fashion shown in the model, the amount and timing of the need for capital to finance product development, to provide general working capital, and to finance marketing and fixed-asset requirements of NTBF.

Amount of capital needed

The study showed that larger firms had higher capital needs than smaller firms, although the needs of smaller firms were greater in relation to their asset base. Among firms classified by type of product and operations, those attempting to produce and market a standard proprietary product had the highest needs for capital while R & D, testing, and consulting firms had the lowest needs. It was also shown that firms involved primarily with standard product development from inception needed larger amounts of capital than did firms which began operations as R & D, testing, and consulting firms or as manufacturers of custom products and then pursued product development as a side effort. Also, total capital needs were substantially higher for firms attempting to exploit a breakthrough-technology than for those using established technology. The results also show that capital needs were far smaller among firms whose early customer base consisted of government agencies than among firms selling primarily to commercial customers from inception.

With respect to the timing of capital needs over the product-development and sales cycle, two threshold points were shown to be important: the development of a working prototype and the incidence of first sales of standard product. Capital needs in the period from incorporation to first prototype were smaller than in the period from prototype development to first sales. Beyond first sales, the amount of capital needs increased but at a smaller rate than during the period between prototype and first sales. The greatest volume of capital needed in these earlier stages was required by standard product firms utilizing breakthrough-technology.

Another performance milestone for a firm is the attainment of sustained break-even or profitability. While profitability contributes funds to the firm, the timing of break-even usually coincides with extensive production and marketing needs. The results show that the capital needs of NTBF were greater beyond the sustained break-even point than before that point was reached.

Purpose of need

The principal need for NTBF capital was for product development. This was greatest for large firms and those attempting to develop a standard proprietary product; small firms and firms engaged primarily in R & D and custom product manufacture cited working capital as their most significant need, with product-development needs growing as these NTBF evolved toward becoming standard-product firms.

The need for product-development capital was greatest earlier in the cycle, and also greater over the entire cycle for firms attempting

to exploit a breakthrough-technology. It is important to note that these product-development needs remained heavy and increased progressively over the cycle indicating that product development does not end with production of working prototype.

Marketing and fixed-asset needs were low compared to product-development and working-capital needs for all firms. Their significance increased from prototype to first sales and, in particular, from first sales onward.

Implications

The findings of this research concern aspects of technological entrepreneurship and NTBF financing characteristics which are of concern to potential investors of funds, to those involved with developing public policy measures to stimulate and encourage technological entrepreneurship, and to technological entrepreneurs engaged in starting or managing NTBF.

From the viewpoint of the investors of capital, an understanding of characteristic differences between NTBF and the capital-demand implications of these characteristics is important in determining an investment posture with respect to classes of such firms or to individual companies.

The NTBF capital market model discussed at the beginning of this paper assumes that capital investors have preference and constraints which condition their willingness to meet the amount and type of financing need of NTBF at various stages of the firm's cycle. It is hypothesized that the matching of these preferences and constraints

with the operating characteristics of the capital-seeking firms determines the willingness and ability of particular investors of capital to participate in NTBF financing. The capital investor is believed to derive from these characteristics information concerning the risk-and-return potential of specific NTBF investments. For example, the investors might consider the achievement of significant sales of standard product and sustained break-even to be characteristics which lower the perceived risk and improve the expected value of returns.

The findings concerning capital needs for NTBF indicate that capital investors wishing to engage in NTBF financing at an early stage of the NTBF development cycle must recognize that the needs, while smallest in volume at that point, are predominantly required for product development and support of early marketing efforts. These may be considered to represent higher risk to the investor inasmuch as technical and market uncertainty is at its height at that particular stage. The capital needs of NTBF for more conventional business applications (financing receivables, finished goods inventory, fixed assets) occur later in the development cycle, at a point when the uncertainty has been somewhat reduced.

It is also important to recognize that capital needs increase as the NTBF progresses through its cycle. To the extent that provision of adequate funding determines the success of the firm and the performance of the capital suppliers early investment, investors should recognize that they will probably be called on to provide more capital or aid the firm in raising more money from other sources. The sensitivity of various classes of capital investors to these characteristics

has been investigated in an extension of the present research and will be presented in a later paper.

It is reasonable to conclude from the results discussed in this paper that familiarity with the financing implications of NTBF characteristics over the development cycle will enable capital investors to determine more accurately their willingness and ability to engage in NTBF financing, with significant benefits for both supplier and seeker of funds.

The findings also provide insights which might serve as useful guides to public policy measures intended to improve the availability of capital for NTBF. For example, it is significant that the dominant expressed need for funds in the early development stage of standard product-oriented NTBF and for those involved with breakthrough-technology is for product development and general working capital. Our preliminary analyses of the sensitivity of capital investors to NTBF characteristics suggest that product-development financing in the early stage of the NTBF cycle is the most difficult type of funding for the firm to obtain from financial institutions and professional venture capital investment organizations. Because of the uncertainties of technology and market acceptance at this point, NTBF find that individual investors (relatives, personal acquaintances) represent the primary most feasible source of such funding. Because of the importance of this financing need in the development of new applications of technology, it is suggested that public policy efforts might be profitably directed toward improving the availability of funds for this particular purpose.

From the viewpoint of the firm, the study indicates clearly that the characteristic differences among types of NTBF and changes in these characteristics over time strongly influence the amount, purpose, and timing of the funds required to attain corporate goals.

Other phases of our research have shown that technological entrepreneurs often feel that technological considerations in new venture developments far outweigh business, and especially financial, considerations. As a result, the NTBF they form are often characterized by management groups which are imbalanced with scientists.

The results of this analysis indicate the fallacy of this approach. Functional characteristics of the NTBF, primarily determined by technological considerations, have important financial (as well as production and marketing) implications. Given the premise that successful NTBF development requires adequate assets to support operations, it is clear that financial planning and control must be integral parts of NTBF management.