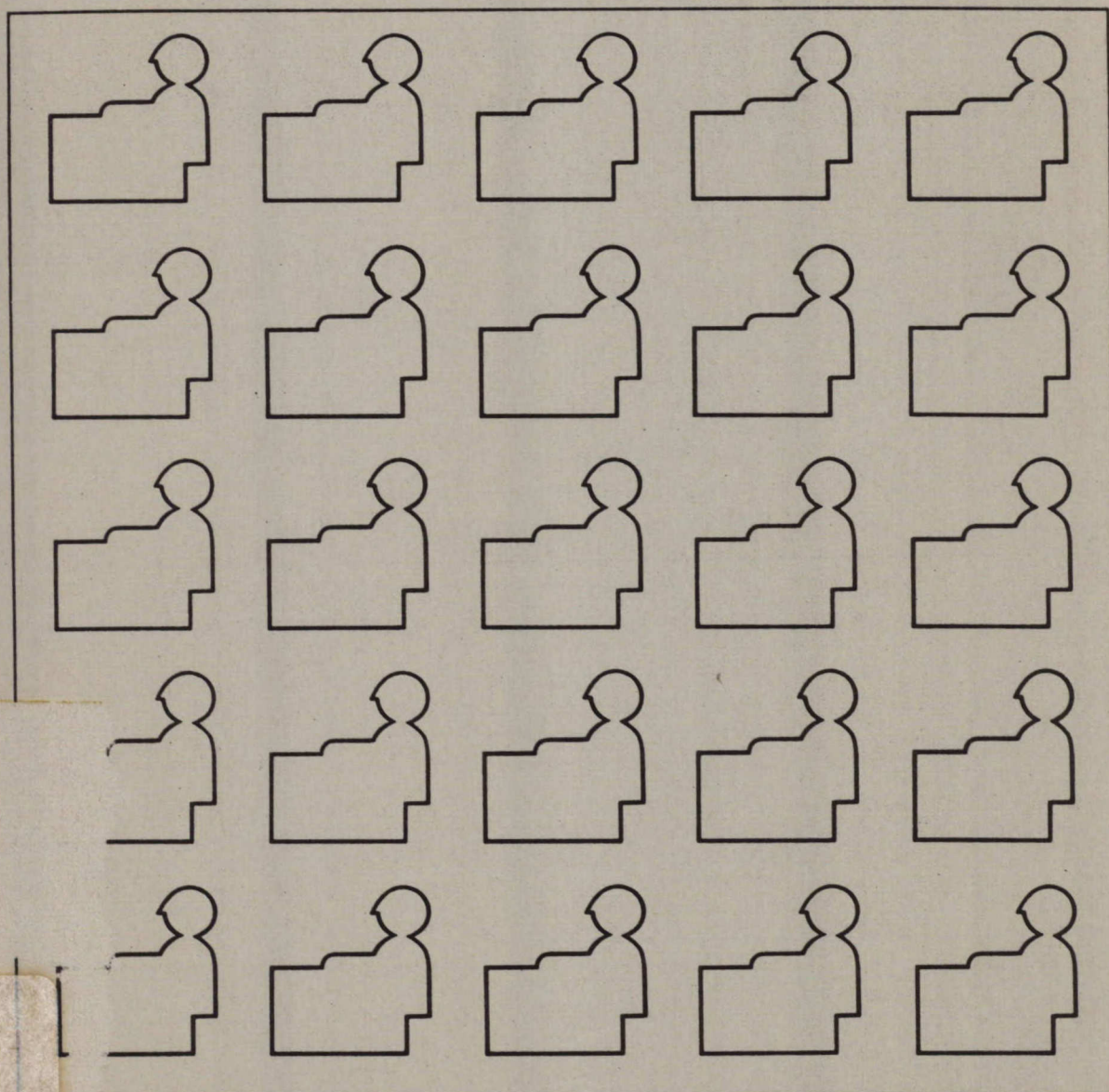


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THE PERSONAL COMPUTER INDUSTRY

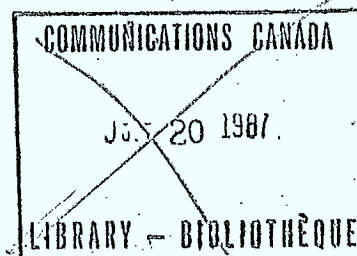


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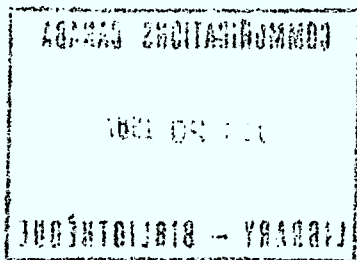
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THE PERSONAL COMPUTER INDUSTRY

An Industrial Organization Assessment
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This paper represents exclusively the author's investigations and observations. The paper does not necessarily reflect the viewpoint of the Department of Communications.

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The Personal Computer Industry
An Industrial Organization Assessment

1. INTRODUCTION

A new industry has emerged and strives to come of age: the personal computer industry. This industry practically did not exist until 1975 when the first personal computer appeared on the market. Today, there are more than 600,000 personal computers in the world and their number is increasing 40% per year. Also, where there were only a handful of manufacturers in 1975, there are now in excess of 100 producers of personal computers mainly based in the United States of America, and their products are distributed world-wide.(1)

Clearly there is an enthusiastic and growing population of personal computer buyers. But are we seeing the leading edge of a true consumers' market? Will the growth peak as it has for other electronic gadgets, like amateur radio? Is the personal computer here to stay? Who is buying these computers? What are they going to do for us? If we like what they are going to do - or do not like it - what should we do about it?

All of these questions are the topic of this paper which examines the personal computer industry within the framework of industrial organization theory. Specifically, this paper will produce a brief review of personal computer technology, applications, societal impacts, industrial structure, economical impacts and industrial performance as well as some preliminary analysis of representative public policy issues.

2. PERSONAL COMPUTERS DEFINED

The personal computer may be defined as "... a stand alone computer, containing a microprocessor, and capable of general purpose information processing which is affordable by an individual ..."(2).

The term 'personal computer' may be taken literally, e.g. a computer that is used by an individual for personal applications - whether for solving engineering problems, doing accounting or simply balancing a checkbook. However, for this to happen, the personal computer must satisfy a basic requirement: affordability.

An affordable price is a basic condition that must exist for this industry to prosper. Price is also the distinguishing characteristic between larger computers and the personal computer, which together with a reasonable set of application programs (software), costs anywhere from \$300 (or less) to \$5,000. The price relationship between the personal computer and other types of computers is depicted in figure 1.

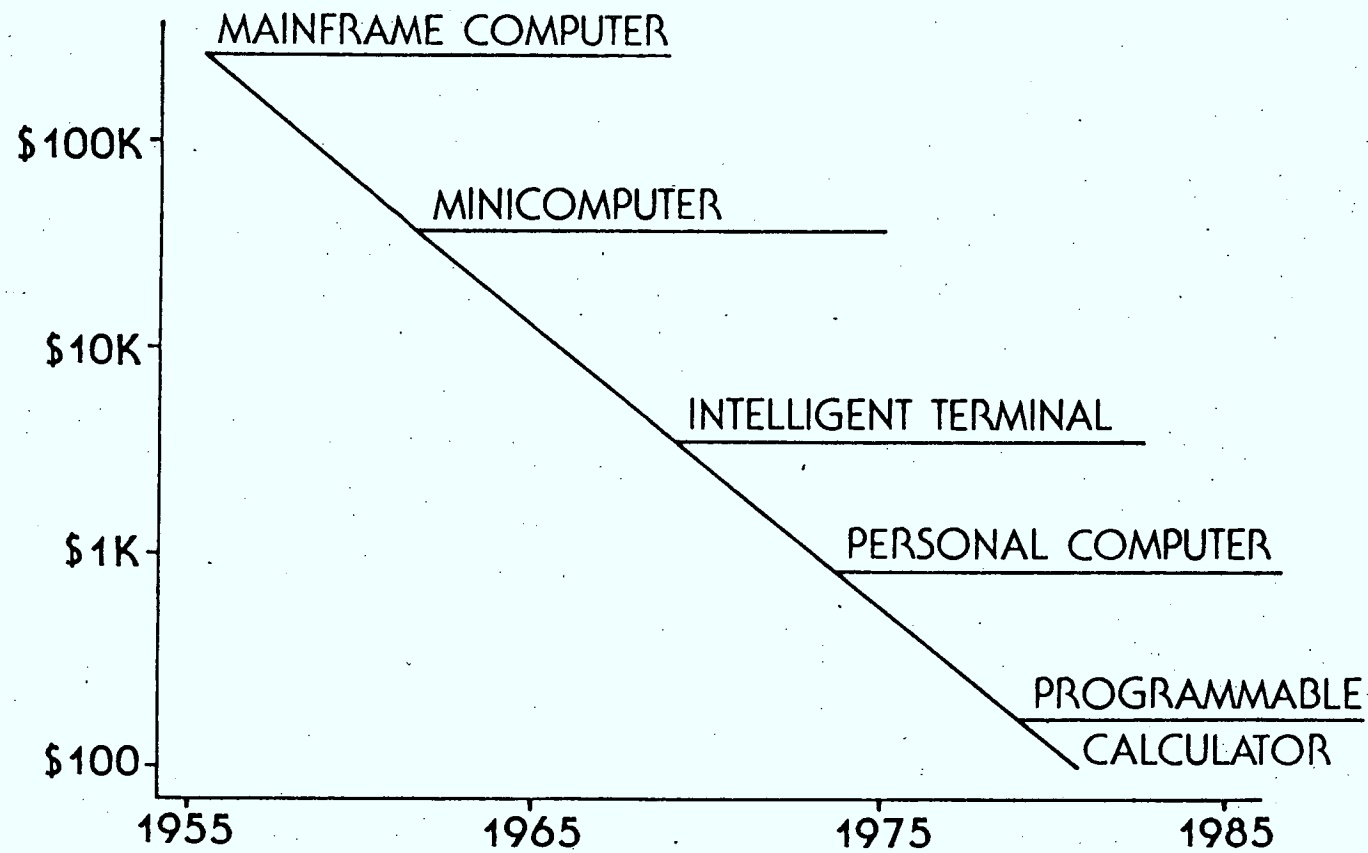
The above definition of the personal computer is not fully satisfactory. In technical terms, the definition does not sufficiently delineate the personal computer from other types of computers. While the boundaries are blurred between the low-end minicomputer and the personal computer, the former contains design features that restrict their use more specifically. The low-end minicomputer emphasizes speed, computational power, interconnectivity to other units and is more sophisticated in these respects than personal computers.

Another ambiguity of the above-mentioned definition concerns the economics of personal computers. It is not clear where the trade off can be made between an "affordable" computer and an "unaffordable" computer. Nor is it clear that personal computers are solely owned by an individual.

Researchers at the University of Southern California have published a somewhat better definition, as follows:

"The personal computer is a stand alone general purpose computer system, containing one or more microprocessors (calculator on a microelectronic chip), which is purchased and/or operated by an individual or a small group of individuals. It requires interaction at a conversational level between it and its operator(s) at least part of the time it is functioning. Its cost is such that the individual owner can justify its purchase on the basis of personally received benefits, financial or otherwise. The individual owner need not be a computer professional nor need the computer be used solely for recreational, educational or business purposes."(3)

COMPUTER PRICE/PERFORMANCE EVOLUTION



Source: Future Computing Inc.

FIGURE 1

3. STATISTICAL SOURCES FOR THE PERSONAL COMPUTER INDUSTRY

It is extremely difficult to obtain accurate hard data about the personal computer industry. Available reports on this industry are proving unreliable and inconsistent. Some critical data is unavailable altogether such as precise industry shipments and imports in Canada. Part of the difficulty is the overlap between small and larger computing machines and the level of dissagregation in government-released statistics. For instance, Statistics Canada's surveys do not provide a separate classification for this industry and information about the industry's performance is buried in unfathomable office equipment data.

Thus the data presented in this paper is imprecise and largely of U.S. origin. For the purpose of this paper, it is the major trends and the order of magnitude that are important.

4. BASIC CONDITIONS

4.1 Surviving a Personal Computer Market Shift

The personal computer industry has had a short and phenomenally successful history, great hopes and growing pains. It started in 1975 with the first make-it-yourself computer kit. Early descriptions of personal computer applications in the popular literature appealed to the well-heeled enthusiast, the "computer nut" and tended to be of the "gee whiz" variety, although this industrial sector has "matured", if one can consider a seven-year-old industry to have reached any stage of maturity. More attention is being paid now to the practical aspects of personal computers. Mass marketing of personal computers, by their distribution through major national general retailers, is beginning to occur as the personal computer is increasingly being used in the household market, the small business market and the professional occupation market by engineers, statisticians and accountants.

The initial market for personal computers emerged with computer buffs who embraced personal computing as a logical extension and branch of the technology used in larger computers. This early group of users, called the hobbyists, purchased personal computers primarily for "home brew" experimental applications in which the requirement to demonstrate economic benefits was of little concern. While the hobbyist market has not gone away completely, it is no longer growing. Makers of personal computers are now eagerly surveying and penetrating the professional, educational and business markets for their newer products.

As the basic commercial exploitation of personal computers shifts dramatically, one of the most significant barriers to professional and business adoption of personal computers will be the difficulty of confirming operational/financial benefits. The answer does not spring readily to mind, but a brief discussion on this matter appears later in this paper.

In addition to the evolving professional/business markets, makers of personal computers are preparing to fend off assaults on the potential for consumer business. Consumer-oriented personal computers were first introduced in 1979, but fewer than 100,000 units were sold in North America during the first three years of commercialization. Based on this performance relative to other segments of the personal computer market, the outlook for a large-ticket consumer-durable good is not encouraging. A Datamation article suggests that three events must take place for the consumer market to realize its potential (4):

- the personal computer must move from the narrow appeal, luxury market to a broad appeal, necessity market through the creation of primary demand (vs. replacement demand);
- personal computers must make the transition from entertaining to functional uses;

- personal computers must move from high cost, limited application products to lower cost, broad applications products.

What will it take for personal computers to reach the heart of a consumer market? First and foremost, the retail price must continue to decrease. Industry opinions point to a retail price of \$300 or less. The consumer can already get interactive TV games for less than \$200, sophisticated hand-held calculators for \$150 and chronographic watches for less than \$50. Technology is available today to produce a \$300 personal computer. It is widely recognized that no major technological breakthroughs are necessary at this stage before a fairly substantial market can be exploited although some innovations in peripherals such as low-cost printers and inexpensive mass memories will yet have substantial favourable retail price effects.

What appears to be missing is a more tangible volume of demand that would justify the manufacturing investment.

If cheaper personal computers are produced, how might over a million units per year reach a broadly dispersed consumer market that buys on impulse? If consumer demand builds quickly, as is likely, there is only one distribution channel capable of responding to the challenge - existing retail mass merchandisers. To use this channel, however, the personal computer must virtually become self demonstrating and self-selling, a condition which does not yet exist.

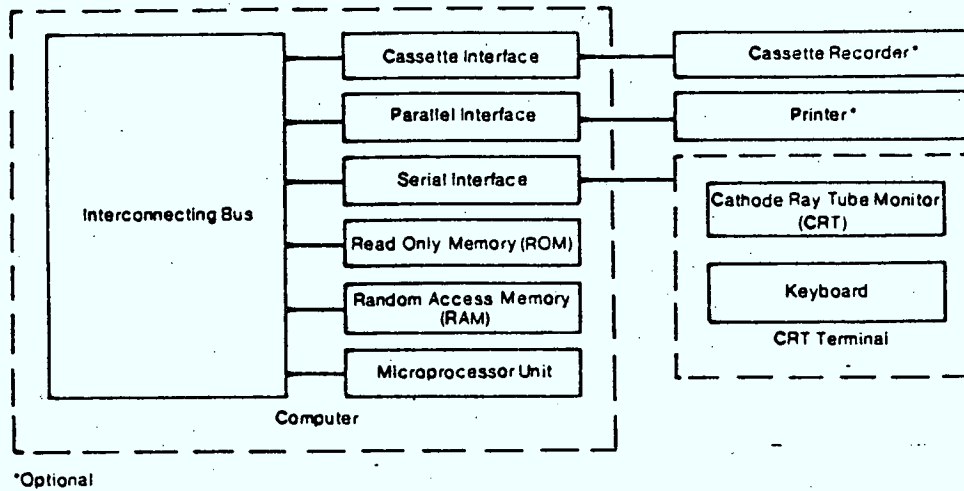
In summary, there is considerable uncertainty about the course of events for the personal computer as the market demand shifts from one segment of users to the next. Each group of users has its own objectives, behavioural characteristics and yardstick of affordability. The projections of future market demand are based on faith in yet-to-be-discovered consumer appeals and untested distribution channels. Others might argue that the consumer market for personal computers will continue to be typified by high-priced goods offered to a select group of people and that a high-volume consumer market will not evolve for another four to five years.

4.2 Technological Aspect

In this section the technological aspect of the industry is examined in terms of its influence on the rate of diffusion of personal computers among the general populace.

Personal computers are a by-product of the electronics revolution, a direct outgrowth of the Large Scale Integration (LSI) in semi-conductor technology. LSI allows for the entire computer to be mounted on a single chip called the microprocessor - hence the compactness of the machine. All personal computers use essentially the same hardware, consisting of the microprocessor, a memory, interface devices, a power supply and peripherals such as cassette/disk storage, keyboard and display. The interconnection of these components forms a system with basic characteristics suitable for most personal computer applications. Figure 2 shows a schematic diagram of a typical system. Although the basic technology is identical in all units, the personal computer is actually a highly

SCHEMATIC OF A TYPICAL PERSONAL COMPUTER SYSTEM



Source: SRI International

FIGURE 2

differentiated product as personal computers may be configured in a variety of ways with respect to memory sizes, number of interfaces, type of peripherals, etc. subject to the end-user performance requirements and price as shown in figure 3. Figure 4 identifies typical price ranges of well-known personal computers for three classes of hardware levels, namely the entry system, useful system and typical system. The typical system is one in which the majority of conventional add-ons such as disk drives for storage, a printer, a cassette recorder and a color TV monitor have been included in the configuration.

The steady increase in LSI chip density and the continuously improving cost performance of computer peripherals, which has occurred in the past decade, are expected to continue for the foreseeable future and will have price-lowering effects on personal computers, provided, of course, that market conditions remain favourable relative to demand.

In section 4.1, it was indicated that no technological breakthrough would be necessary before a substantial market can be developed for personal computers. That statement dealt primarily with the hardware capability and does not apply to the most obvious technical shortcoming of a personal computer which is in the software area (programs).

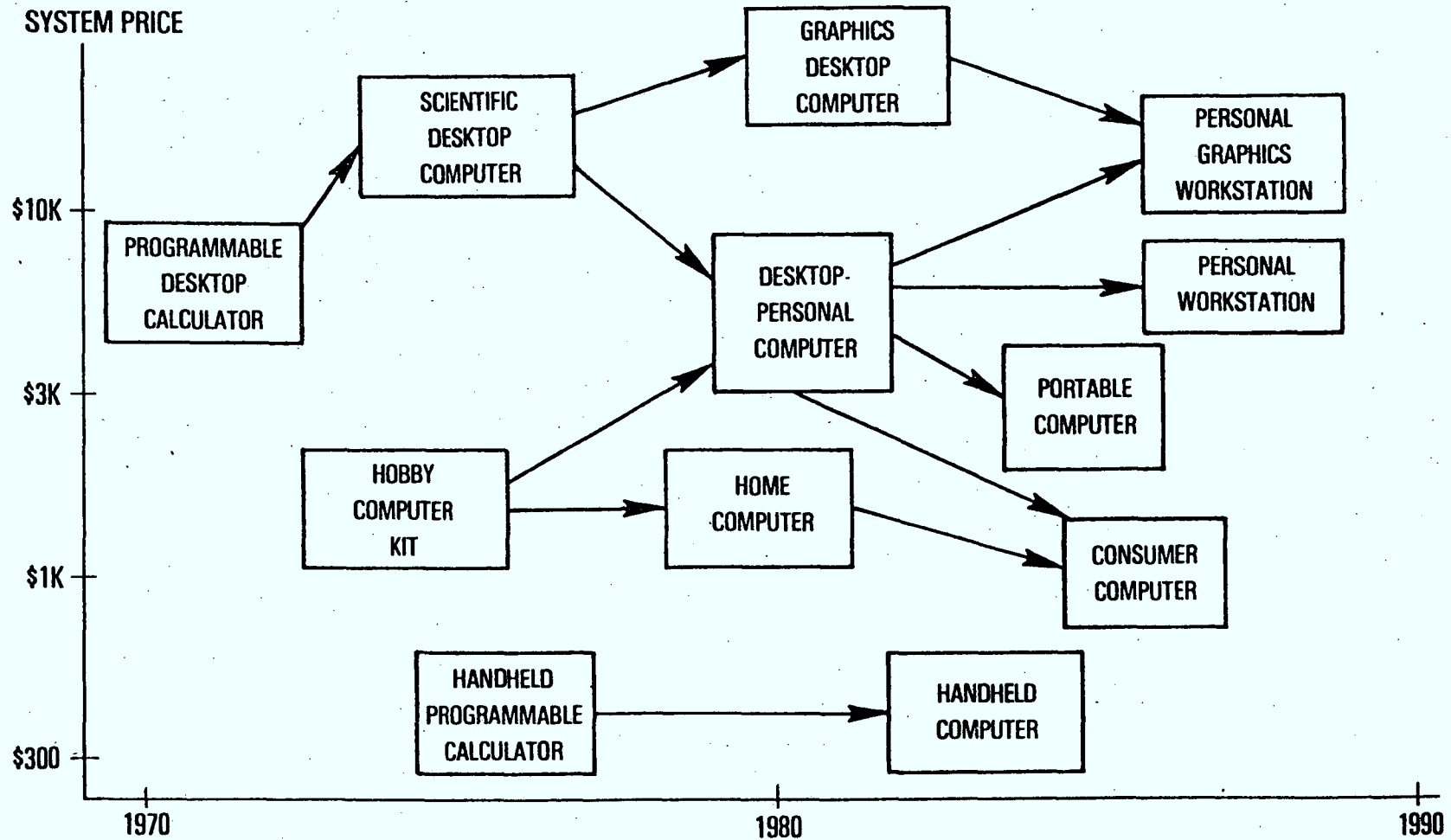
Personal computers are not like pocket calculators. Potential customers need to be equipped and told how to use them simply and usefully if they are to be tempted to buy. For most people, having a personal computer without adequate software is like having a super stereo player without records. (5).

Few personal computers on the market today come with an adequate set of software, the long list of commands or instructions that tell the computer what to do. The computer has to be told, in agonizing detail, exactly what steps to perform to convert its raw power into useful applications. (6)

The software bottleneck did not matter much in the past. The first generation of personal computers, introduced about six years ago, was bought largely by computer buffs who could, and often did, open their machines to make repairs and add improvements. They also wrote the software needed and make the hardware they had bought start solving problems.

The personal computer industry has outgrown the computer buff. It is having to aim its products to a broad a marketplace, as was noted earlier, particularly small businessmen, educators, and individual consumers, the majority of whom are blind to the pitfalls and intricacies of writing software. In effect, the sophistication of writing software remains the largest stumbling block in the broad diffusion of personal computers to a mass market. A recent article on this matter declared that "... the usefulness of personal computers increases in inverse proportion to how much individuals must know in order to use them ...". (7)

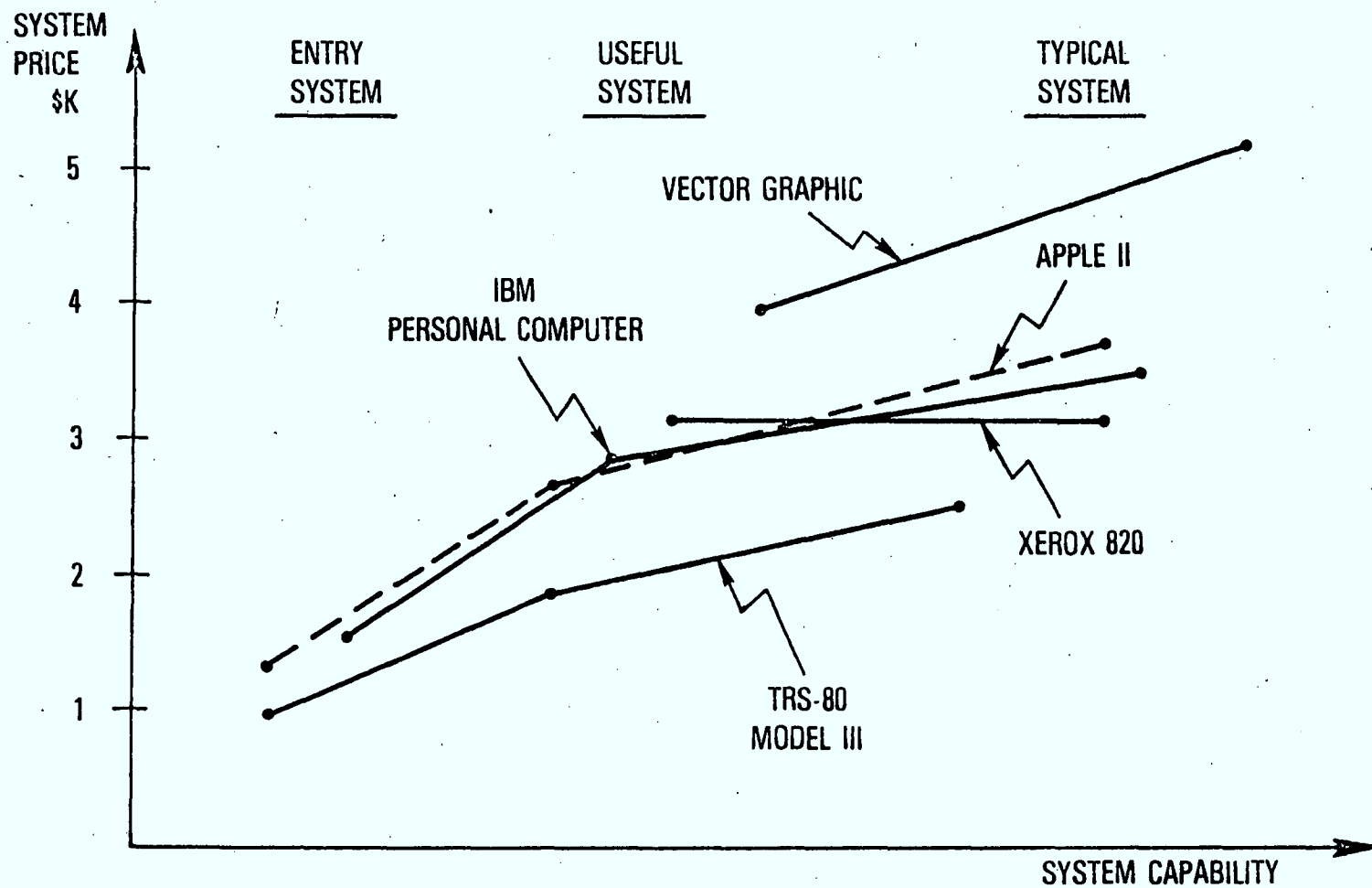
EVOLUTION OF PERSONAL COMPUTER PRODUCTS



Source: Future Computing Inc.

FIGURE 3

PERSONAL COMPUTER PRICE-PERFORMANCE



Source: Future Computing Inc.

FIGURE 4

The importance of software cannot be overemphasized if the personal computer industry is to reach its potential. Personal computer makers spend large sums on developing "packaged" or "canned" software. These off-the-shelf packages automate specific chores such as accounting and word processing, as is shown in figure 5. Standard packages have the same disadvantages as do any other standard products in that the package is rarely an exact fit and the user either has to modify his application or customize the software himself. However, the use of canned software is the only way for users, particularly small businessmen, to hold down the cost of computing because the job of writing software is very labour-intensive. Most first time personal computer buyers spend about 50% more for software than the basic hardware.

4.3 Nature of the Market Environment and Use Assessment

As was noted earlier, personal computers are finding a niche in three major market segments: hobbyist, business/professional and consumer. This section describes these user groups and the applications they are finding for personal computers.

The Hobbyist Market

Several studies have been published in the United States regarding this market segment which has existed, as was noted earlier, since 1975. The characteristics of the hobbyist market are therefore well known and summary descriptions are provided below.

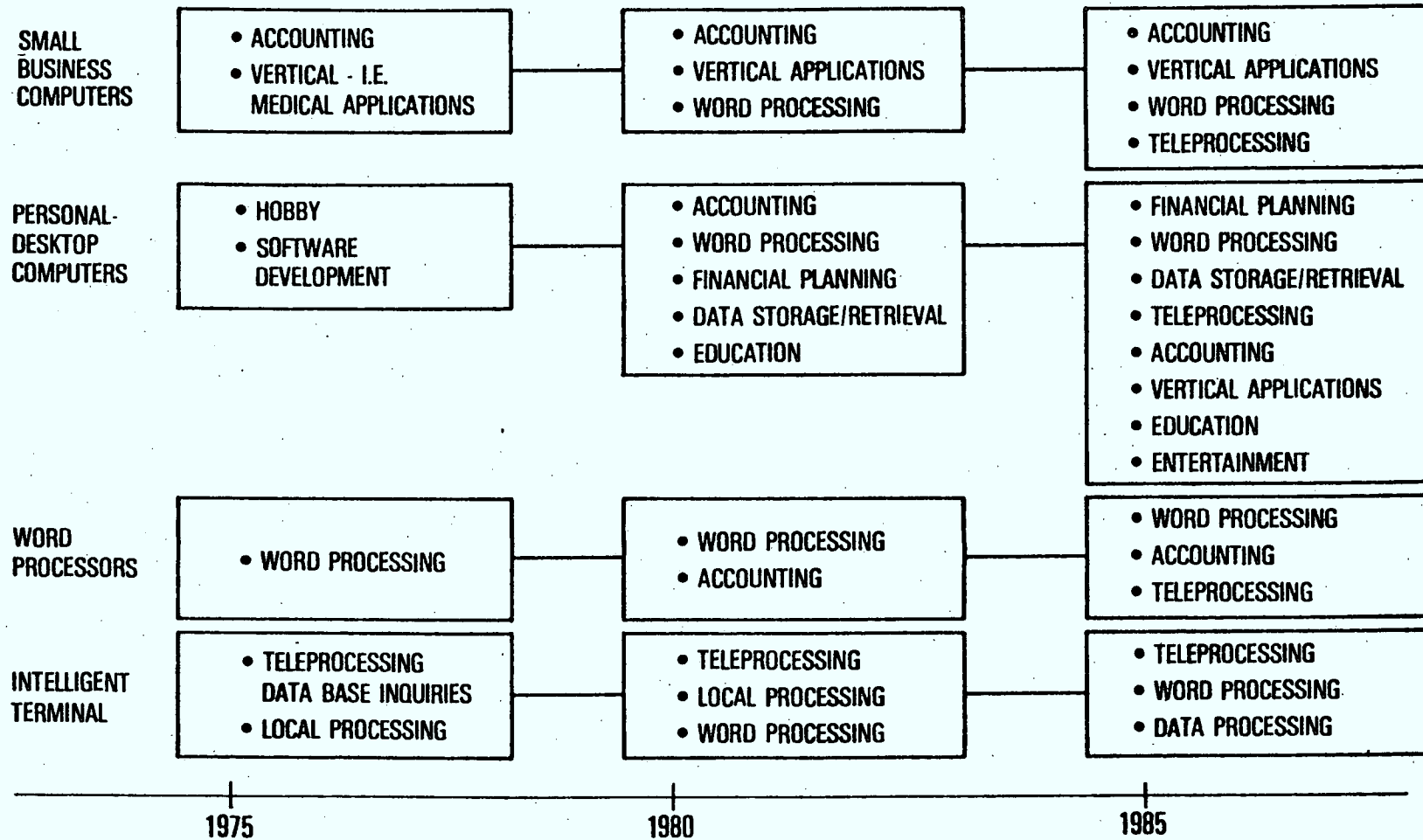
Hobby computer users are typically computer professionals, engineers, students and other electronic buffs. Figure 8 shows a breakdown of hobbyists by occupation from a survey carried out by DATAMATION magazine. In contrast to other users, hobbyists generally prefer to purchase computer kits and assemble them at home in order to customize and experiment.

Hobbyists do not require their personal computers to "do" anything to justify their cost. They develop programs for their own amusement or to share with friends in computer clubs.

User surveys indicate that computer hobbyists have the following characteristics:(8)

- o they are experimentalists and are involved primarily in non-specialized developmental activities, primarily in game applications;
- o they devote a large amount of time to their hobby. 45% of 1,500 users surveyed indicated that they spend 15 hours weekly on this activity;
- o they adapt computers to other hobbies such as radio communications, photography and chess;
- o they derive their computer knowledge mostly from self training (40%) and undergraduate college courses (35%);

APPLICATION SOFTWARE EVOLUTION



Source: Future Computing Inc.

FIGURE 5

- o they typically have invested \$1,000 to \$5,000 in their personal computers. More than a third has invested over \$2,000 but only 10% have invested in excess of \$4,000;
- o the majority of hobbyists (80%) spend more than 10% of their annual income in personal computer activities;

The hobbyists were the first group of users to embrace personal computing. The hobbyist is primarily a learner and is willing to invest considerable time in education and experimentation, which for him/her appears to be a form of recreation. Personal computer sales to the hobbyist market have levelled recently and this market is no longer regarded as affording a wide potential.

The Business/Professional Market

To compete successfully in the small business and professional market segment, the personal computer is emerging as a cost effective, professional productivity improvement tool.

For some time now, businesses have grown accustomed to the use of computers to create, manipulate and analyse information to assist and perpetuate high-quality business decisions. While managers and professionals are becoming comfortable with computer resources, many have also become impatient with traditional data processing methods on account of their poor responsiveness, inflexibility and high cost. Professionals are becoming increasingly convinced that they can become more productive with their own personal facilities.

Business and professional users are generally attracted to personal computers for the following reasons:(9)

- o they need to improve their professional productivity;
- o they need a specific task performed;
- o they need to save time and money on business operations and make well-informed decisions;
- o they need pre-programmed application software;
- o they need completely assembled, stand alone systems with keyboards, printers and memory storage.

Management and professional adoption of personal computers will not occur without substantial shortcomings. In the software area, professionals are not inclined to develop their own programs and very small business users have little of the expertise and interest needed for software development. While the introduction of canned programs has helped to alleviate the problem, there will be increased demand for software quality rather than quantity. Some personal computer manufacturers have taken a passive approach to this situation and have done nothing more than becoming clearinghouses of software developed for their equipment by early users. If the personal computer is to succeed in this market, the manufacturers will have to make large up-front investments in providing adequate software.

Another barrier to large-scale adoption of personal computers by business users is the difficulty of confirming operational benefits and organizational effectiveness. Management productivity gains are hard to measure in quantitative terms. In fact, the results of management decision-making are rarely it ever, measurable, until some time has elapsed since the actions were taken. Businessmen who invest in personal computers for productivity gains do so largely on faith.

The Consumer Market

The consumer market may well stimulate the personal computer industry from an embryonic to a rapid growth stage and all market forecasts make this assumption. While the potential of this market is undoubtedly immense, there is still considerable uncertainty that the industry will succeed in establishing an effective product distribution strategy and that a bona fide high-volume consumer demand really exists.

The consumer segment of the market for personal computers is developing relatively fast at present, but the total installation base remains small. It appears that the outlook for a consumer market will look considerably more promising when the following events occur:(10)

- o the products become aesthetically more acceptable;
- o prices for complete systems fall below \$500;
- o the machines are easily operated by people without knowledge of computers;
- o the computers fulfill useful and practical in-home activities such as entertainment, personal financial management, education, energy management and home security;
- o products must be pre-assembled, ready for immediate use and delivered with better documentation;
- o operating instructions can be learned within a few hours. (It takes typically forty hours or more to get fluent with a personal computer).

5. MARKET AND INDUSTRY STRUCTURES

5.1 Size of Markets

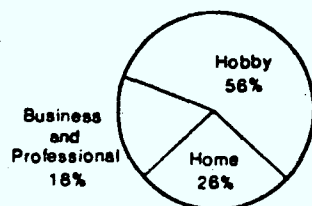
It was noted earlier that if the personal computer market were to be limited to hobbyists and computer enthusiasts, it could not be expected to grow substantially beyond its present size. Nor would the size of the market be sufficient to attract major manufacturers into the industry or allow existing manufacturers to grow to a size where substantial, learning-curve-induced economies of scale might be achieved with a concomitant reduction in unit cost. For all practical purposes, the hobbyist share of the market will shrink drastically as shown in figure 6 and total base of installations will not exceed 300,000 units in five to eight years. The business and professional segments are expected to grow significantly as enhancements are made to make the personal computer uniquely useful and economically justifiable for business purposes. Early estimates of the market potential indicate a large-scale penetration in the small business and professional offices which by the mid to late eighties will number in excess of 1.6 million units installed in North America(11). In addition, the personal computer will increasingly be used in large organizations where it will appear as the work horse in the "office of the future", replacing the familiar electric typewriter.

Office workers in larger organizations, represent a vast untapped market for personal computers. It is expected that there will be roughly 55 million office workers in the mid to late eighties in North America(12). For various reasons, some of these workers will not have a continual need for computers, although perhaps as much as one third of them will. This provides us with a market of 18 million possible users at the saturation level. Because of rapid technological evolution in microelectronics, we can expect a three-year replacement cycle for personal computers in business applications. Roughly speaking we can estimate that some six million personal computer units will be sold to office workers in the late eighties.

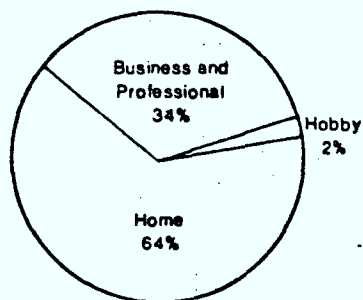
A similar approach can be used to estimate the number of households in which there would be personal computers. It is conservatively estimated that there are over 80 million households in North America(13). Perhaps as much as half of the households will have a personal computer at the end of the eighties. This amounts to 45 to 50 million units. Simple arithmetic - 50 million households times \$500 per computer - shows a potential consumer market of \$20 billion for personal computers.

Another approach to market assessment is to measure educational trends, e.g. number of high school and college graduates, and to note that many if not most students will have had some exposure to computers by the mid-eighties. This portion of the population, together with those individuals whose computer exposure occurs through business, is likely to grow to include at least half of the total population by 1990. Researchers have found that prior exposure to computers is highly correlated with eventual ownership of a personal computer.(14)

**PROJECTED CHANGE IN MARKET
COMPOSITION**



1977
Total Sales: \$95 million



1985
Total Sales \$1537 million

Source: SRI International Inc.

FIGURE 6

If sales of personal computers reach the level of pervasiveness indicated in the above market assumptions, the market potential is clearly very large and estimated personal computer sales and shipments for North America are shown in figure 7.

Figure 8 sketches the industrial structure for the personal computer industry. The major paths of product flow and the interrelationships between complementary firms has been indicated by arrows. Some other linkages exist but are omitted for the sake of clarity.

It was noted before that few manufacturers of personal computers have developed complete hardware and software solutions internally. In fact, as the diagram indicates there is a high degree of corporate relationships, coalescence and loose partnerships. This supply structure is particularly appropriate for smaller hardware manufacturers which specialize in hardware production while leaving to others application software development, sales and distribution, and maintenance. Additional details are provided in section 6.2.

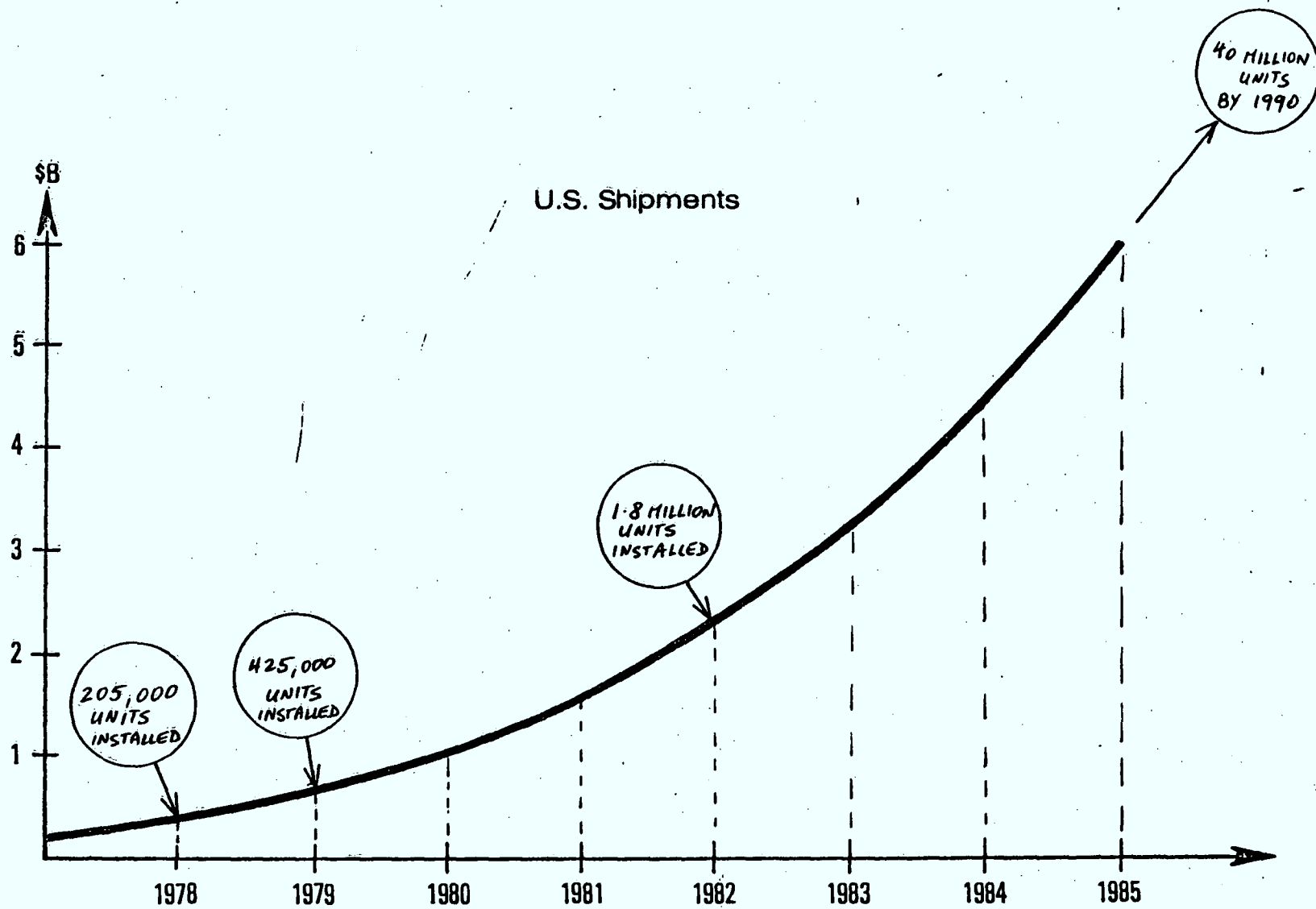
5.2 Sellers' Behaviour and the Quest for Market Share

Within the first year after the introduction of the personal computer in the mid-seventies, approximately 30 manufacturers had entered the market. In 1981, the total of manufacturers was closer to 150, the vast majority of which are U.S.-based. Early manufacturers of personal computers were typically small companies which hopped on the hot new product hoping to ride it to riches. But with the sudden shift from the hobbyist to the business and consumer markets, many of these early starters could not cope with the investment required to remain competitive. Caught in a squeeze, many of the original personal computer makers are seeking new capital or merger partners. By one count, some 30 U.S. companies have vanished or plunged into bankruptcy in the 1977 to 1978 time frame (15). It is also worth noting that 90% of the products offered in 1977 are no longer on the market today. Figure 9 illustrates the high rate of new product introductions.

Radio Shack (a division of Tandy Corp) and Apple Computer Inc. are two prominent U.S. pioneer manufacturers that have survived the wrenching changes of the market. Radio Shack currently leads the pack of suppliers while Apple is a strong number two in the market, followed by Commodore Business Machines as a distant third.

Radio Shack's successful market penetration is due in large part to its well-established distribution network of some 6,700 retail stores world wide. In contrast, Apple relies extensively on independent retail outlets, and its products are carried by such retailers as Computerland, Computer Innovations and Team Electronics. Commodore, while less well known, appeals directly to end-users with a variety of low-priced machines for entertainment and home applications.

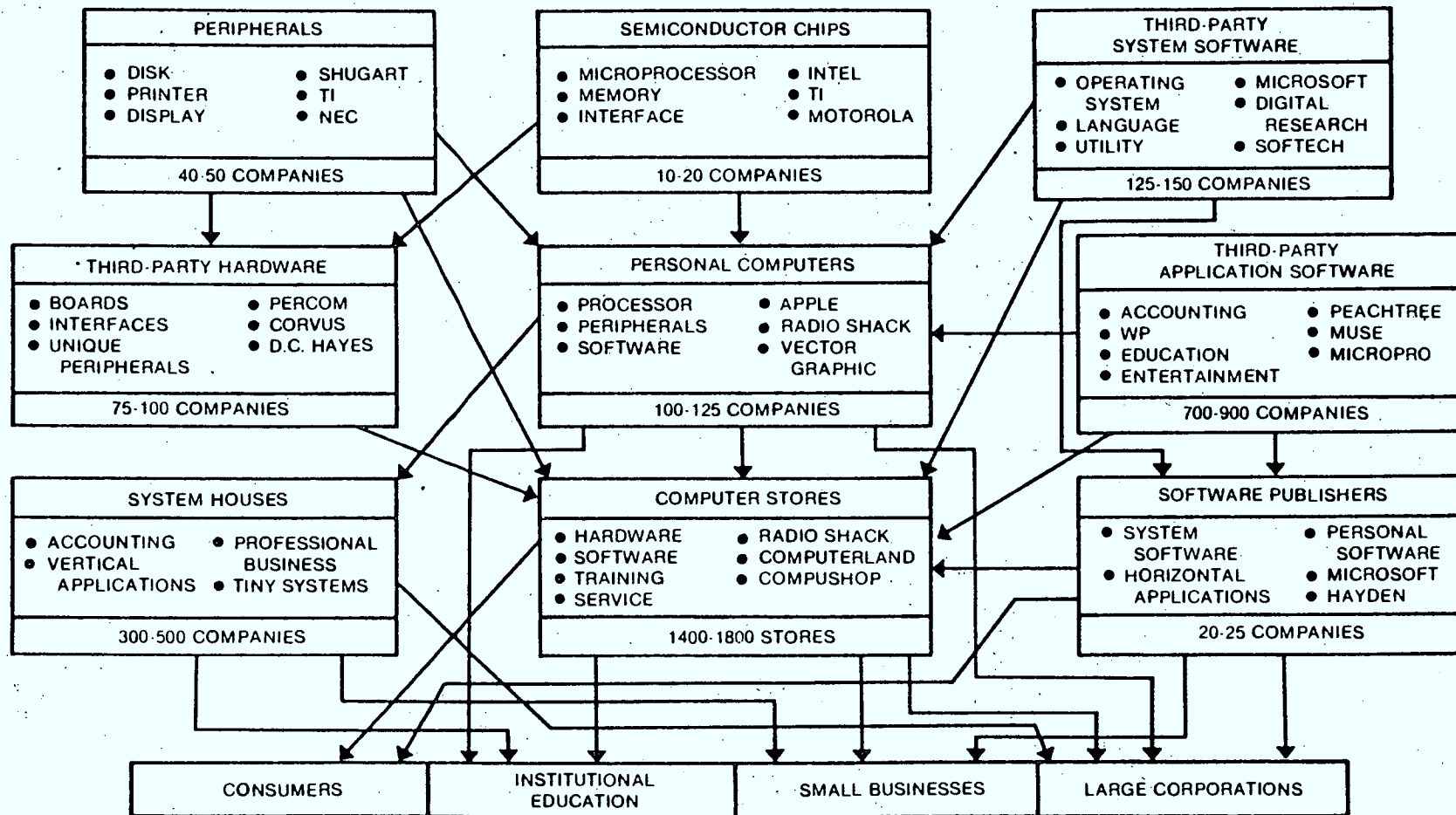
Of all the companies that owe their existence to the personal computer phenomenon, Apple has emerged with the strength to become the sales leader in personal computers over the next several years. The company enjoys high brand recognition, is reputed for the quality of its products and is well entrenched in the infant consumer market. Apple's current strategy is to achieve an equally strong position in the business/



Source: Future Computing Inc. and Author

FIGURE 7

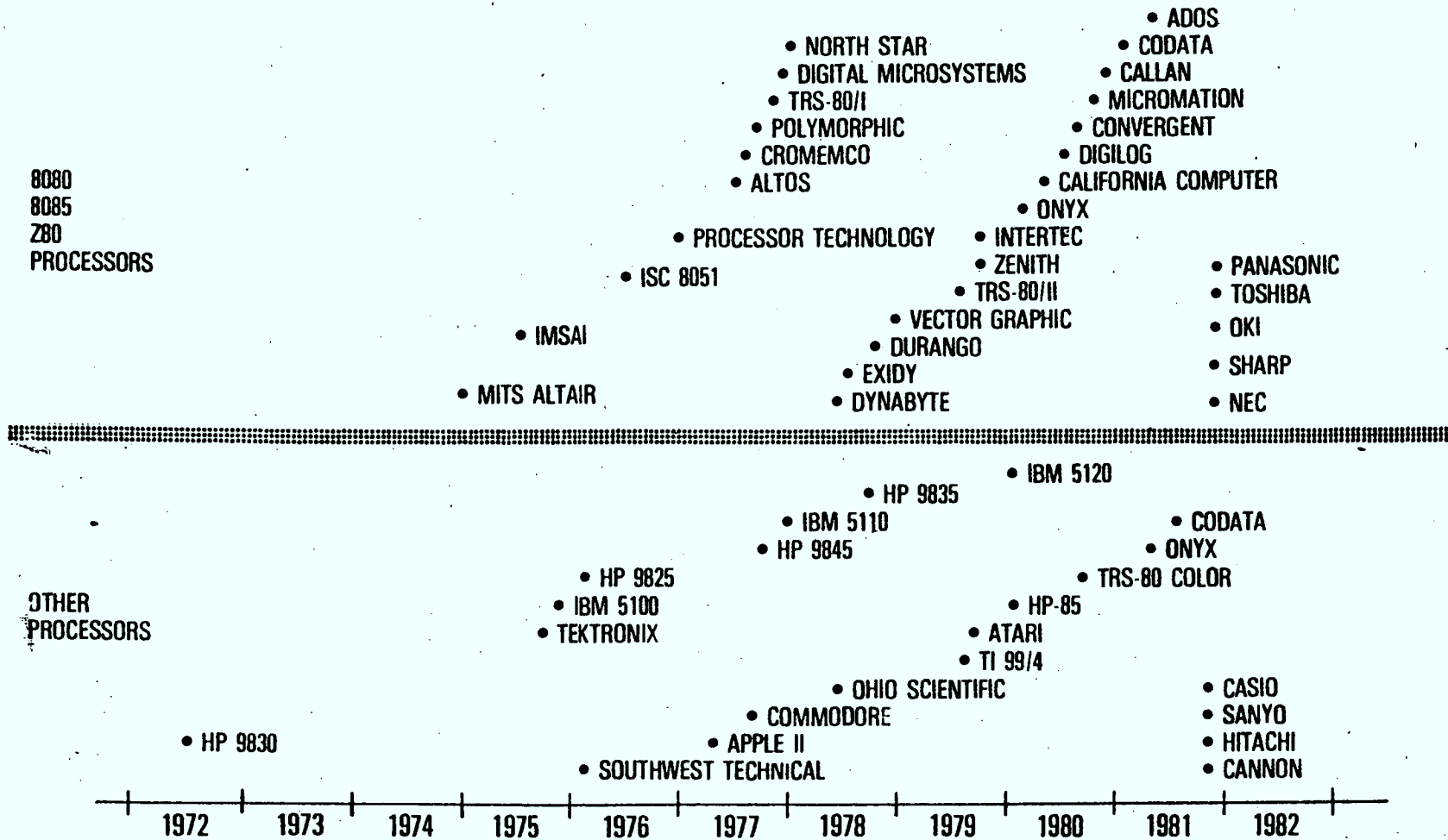
PERSONAL COMPUTER INDUSTRY STRUCTURE



Source: Future Computing Inc.

FIGURE 8

INTRODUCTION OF PERSONAL COMPUTERS



Source: Future Computing Inc.

FIGURE 9

professional markets where price is less important than performance and quality software. To this end, Apple is pouring more resources in to software development and more than half of its technical staff is composed of software specialists.

Traditional makers of small business computers such as International Business Machines (IBM), Digital Equipment Corp (DEC), Xerox and Hewlett Packard (HP) have been slow in reacting to the emergence of this industry but have each extended their products downwards and are now competing for a share of the market. Other consumer product giants such as Texas Instruments, Mattel and Atari delayed their entry until 1979.

There appears to be a general consensus that the industry structure will change significantly over the next several years with fewer overall vendors and with many of the early makers acquired by larger companies. When IBM introduced its personal computer in August 1981, the product announcement struck fear in the hearts of its competitors(16). The IBM product is likely to be a winner on many counts - technical features, functionality, price and distribution strategy. Prices start at \$1,500 (U.S.) with the average system costing in the \$3,000 - \$5,000 range. To boost the use of its personal computer, IBM has established a Personal Computer Software Publishing Department that will make available software written by IBM employees, outside authors and independent software companies. Also, for the first time, IBM has announced that product distribution and sales will not remain exclusive to IBM's sales force and that retail stores such as Sears, Computerland and others will handle volume orders.

A prognosis of large market share shifts in personal computers is shown in figure 10. Over the long run, IBM is expected to take the largest single part. Apple and Radio Shack will lose market share but will continue to grow.

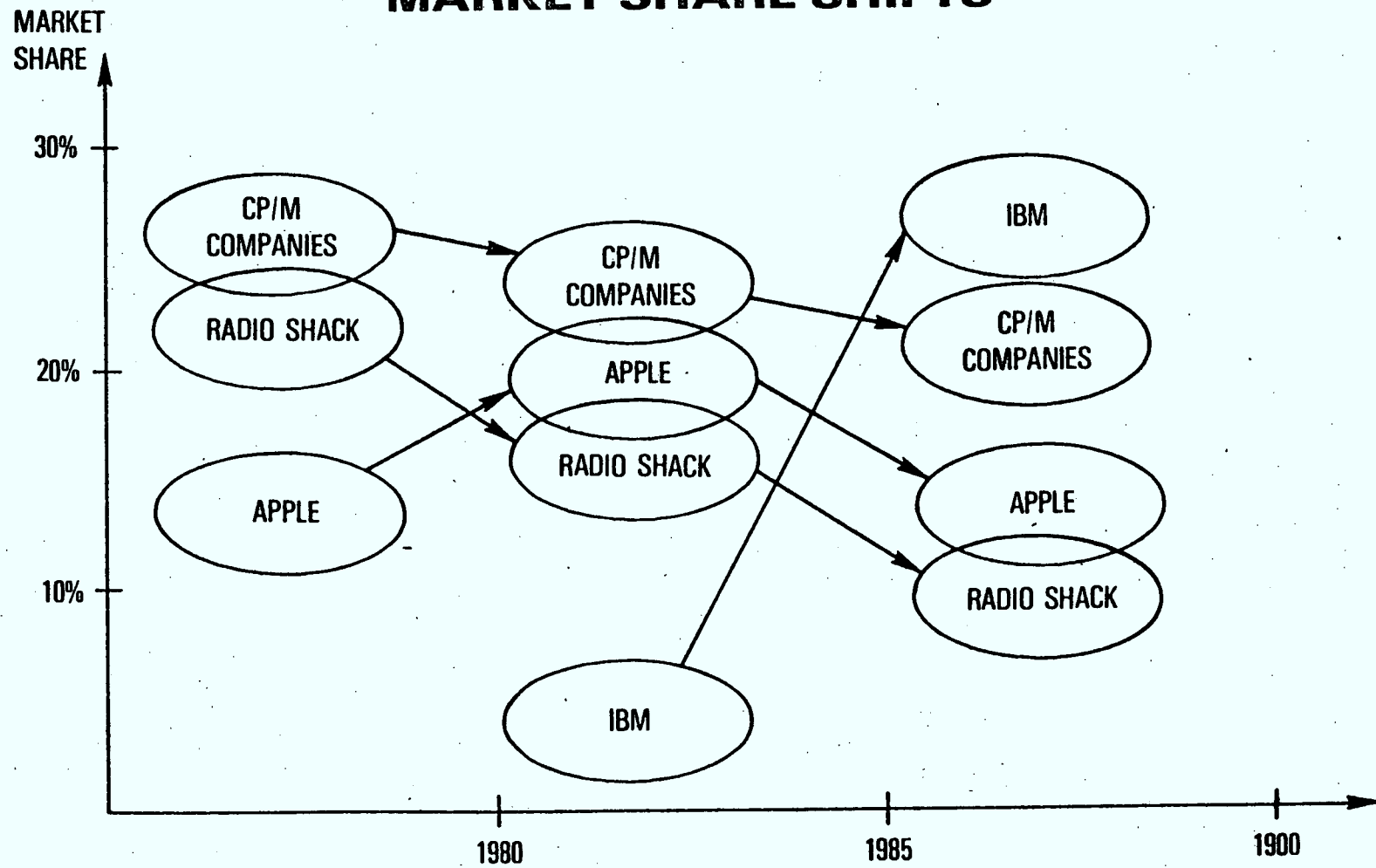
5.3 Canada's Indigenous Industry

The world personal computer industry is highly concentrated with American suppliers accounting for more than three quarters of total shipments. As with other types of computers, the Canadian market is largely served by U.S. imports and the technology is dominated by the local branches of U.S. firms.

Canada's indigenous computer manufacturers have been unable to achieve a world class position in this industry. With a domestic market left unprotected through low tariffs, the local industry has not been able to use the domestic demand as a springboard for developing inroads in foreign markets. As a result, the annual balance-of-trade deficit has reached over \$1.2 billion in 1981 in the computer sector (disaggregated figures for personal computers are not available)(17).

Despite the sub-optimal scale of Canadian manufacturers, some local companies have succeeded in uncovering loopholes in the offerings of the larger U.S. companies and are consolidating their positions in the market. In the personal computer sector, there are encouraging signs that Nabu Manufacturing Corp. of Ottawa will shortly launch a new array of personal computer products.

MARKET SHARE SHIFTS



Source: Future Computing Inc.

FIGURE 10

6. MARKET BEHAVIOUR

6.1 Pricing

It was noted earlier that the unit price of personal computers was an important factor in the widespread availability and usage of this technology in the 1980's, particularly in the consumer market.

Movement along the learning curve, an expanded market, decreases in hardware costs through microelectronics, continuing research and development, economies of scale in production and distribution, and active competition are all factors that can lower prices. Notwithstanding, many industry observers forecast no dramatic price declines in the foreseeable future and the low-cost consumer market will be slow to develop because it is still not possible to sell a useful product at a price - \$500 or less - that can achieve substantial sales.

The principal reason for this pessimistic forecast is the high cost of developing software. Cost reductions will be difficult to achieve in personal computer software and much of the cost savings that microelectronics have made possible will be eaten away by higher software investments.

The principal cost factor in software creation is human intelligence which does not easily lend itself to increased productivity or other means of efficiency enhancement with the result that the average cost of software development is therefore unlikely to decline. However, the availability of software improves the saleability of personal computers as was noted earlier. To the extent that increasing sales result from higher quality software, vendors are being encouraged to invest more heavily in software development and to spread software costs over a larger number of units.

From an economics standpoint, software is an ambiguous commodity. Software is clearly a valuable good and its development entails considerable cost. Its production cost is, however, negligible. Once the software is created, the production of an additional copy costs almost nothing. The primary conditions for a viable software market are present but a market presumes that property rights exist. Moreover, the enforcement of such rights must be relatively simple - theft must be both illegal and costly relative to the value of the good stolen. An important question thus concerns the status of proprietary rights in respect to software(18). Patent authorities throughout the world have, so far, refused to grant patentability of software on the grounds that it is difficult to fit software into the classification of "inventions" and to prove its inventiveness. The legal situation concerning property rights in software is thus confused and there is an abundance of inconsistent articles on this matter in professional periodicals.

A recurring theme in trade publications concerns the desirability of separate pricing of software and hardware. Should personal computer makers be required to price software as a separate commodity? Should manufacturers be required to make their software equally available to all users, those who purchased the manufacturers' hardware as well as those who did not? There are no definite answers to these questions at present. In the past, makers of personal computers who invested

substantially in software development did so by the promise or expectation of monopoly control in the market over the hardware produced and were thus reluctant to price software separately.

It was noted before that the marginal cost of reproducing software is nearly zero. Large fixed costs (software development) and low marginal costs (software production) often give rise to a natural monopoly. There are substantial economies of scale in the production of any specific item of software. In such a case considerable advantage may be achieved via discriminatory pricing. Consider figures 11(a) & (b). In each figure, curve D shows the demand for software and curve MR the marginal revenue if a single price is chosen. In the absence of price discrimination, the quantity sold would be q^* , and total revenue would equal the area under the marginal revenue curve up to q^* .

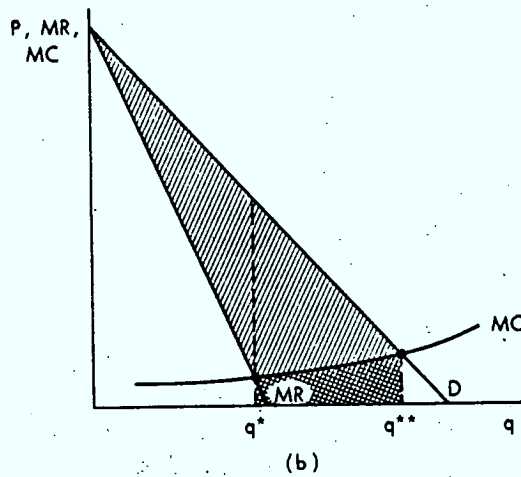
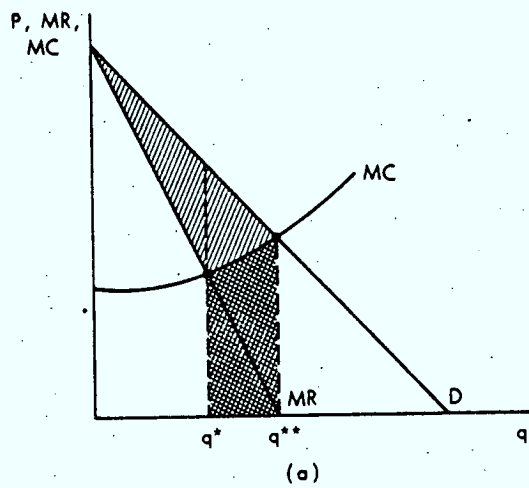
Now consider the impact of a change to a perfectly discriminatory pricing policy. The demand curve becomes the marginal revenue curve. Quantity will be increased, to q^{**} , and total revenue will equal the area under the demand (marginal revenue) curve up to q^{**} . In each diagram, total revenue increases by an amount equal to the total shaded area, total cost increases by an amount equal to the cross-hatched area, and net profit increases by an amount equal to the difference. Clearly, the lower the marginal cost curve, the greater is the potential gain from price discrimination. (19)

Any developer has substantial incentive to price software discriminatorily, charging customers primarily on the basis of value. But how can the value of a specific item to a given customer be determined?

One possible surrogate is the cost of the personal computer on which the software is to be used. A reasonable working hypothesis would be: the greater the cost of the personal computer, the more valuable the software. A less obvious alternative (not widely used) would be simply to raise the cost of the hardware appropriately and "give away" the software.

Most personal computer makers price their software separately because the expectation of monopoly control of their hardware has not materialized due to the complementary nature of the products in the marketplace and the industry's gravitation towards emerging de-facto standards in software portability from one machine to another.

One advantage of separate software pricing is to boost the creation of software by independent authors and to reward them with royalties on the value of sales. This approach is increasingly being favoured by leading vendors.



Source: Author

FIGURE 11

From a hardware standpoint, all the studies reported in this paper use the price of personal computers set by a manufacturer as a measure of cost. Obviously, the price represents cost to the user but it is not necessarily the cost of production. If all personal computers were sold in a perfectly competitive market, price would equal both marginal and average cost of production. But the market for personal computers, although competitive, hardly corresponds to the model of perfect competition because of the complex structure of the industry, the treatment accorded to software production and pricing, and the high degree of product differentiation. As discussed earlier, the demand for personal computers is highly price elastic with a demand curve downward sloping. Under these conditions, a profit maximizing seller will plan on a price-quantity combination for which price exceeds marginal cost, the extent of the disparity depending on the difference between marginal and average revenue, i.e. on the elasticity of demand. The elasticity of demand is, however, not the same for the entire market as we noted earlier. Elasticities differ substantially from one market segment to another, e.g. from the hobbyists to the professional/business users and consumers.

What, then, does the price of the personal computer represent? It may be regarded as an imperfect measure of cost of production, subject to an expectation of considerable error. On the other hand, it may be regarded a measure of value to the user.

One might conclude that price measures user value relatively well and cost of manufacturer rather poorly. More properly, personal computer pricing results from the interaction of producers' technological possibilities and buyers' values; in other words, it reflects both supply and demand.

6.2 Selling Policy & Strategies

Several selling strategies are available to suppliers wishing to compete in the personal computer market. Companies able and willing to make large up-front investments can consider providing total systems (hardware and software) solutions to business users and to the budding mass consumer market and to reach buyers through existing distribution channels. This strategy carries with it both high risk and high potential rewards. It also requires sizeable investments of the order of \$50 to \$100 million and is therefore only appropriate for large, financially capable organizations, like IBM, DEC, HP, Xerox, Hitachi of Japan and Siemens of Germany(20).

A second strategy is to develop integrated packages of hardware and software tailored to the needs of one or more vertical markets. Such packages might be designed for business analysts, stockbrokers, civil engineers or actuaries. The keys to this strategy are the identification of viable market segments, the development of uniquely useful and economically justifiable products, and successful marketing. This strategy is appropriate for medium-size personal computer manufacturers such as Apple and Radio Shack. The shortcomings of this strategy may be insufficient market potential within a given market segment, vulnerability to changing buyers' preferences, and intense competition from other vendors seeking opportunities in a vertical market.

Finally, some vendors may still be successful as primary hardware suppliers while leaving others to carry out software development. This alternative is viable for small firms with unique technology and hardware design skills and the ability to manufacture cheaply. This strategy might prove particularly attractive to Japanese and other Asian-based electronic manufacturers who are soon expected to encroach on the North American personal computer market(21).

Independent software suppliers and the software publishing industry (see figure 12) are also facing changing market conditions and, as was noted before, software entrepreneurs are playing a critical role in the evolution of the industry by working cooperatively with hardware suppliers in the development, distribution, user application assistance and after sale maintenance of high quality software.

It is interesting to note that the personal computer is opening the way for a booming new industry: computer software stores.(22) A new type of retailer has emerged over the last two years and it is predicted that over 1,600 software stores will open in North America by 1986. Computer Land Corporation is the leading retailer and currently operates a franchise chain of 220 stores in the U.S.A. The company sells more than 5,000 software packages for personal computers ranging from inventory control to games such as Space Invaders. In Canada, Computer Innovations, a division of Nabu manufacturing, operates six stores and plans to increase its coverage to 30 within the next few years.

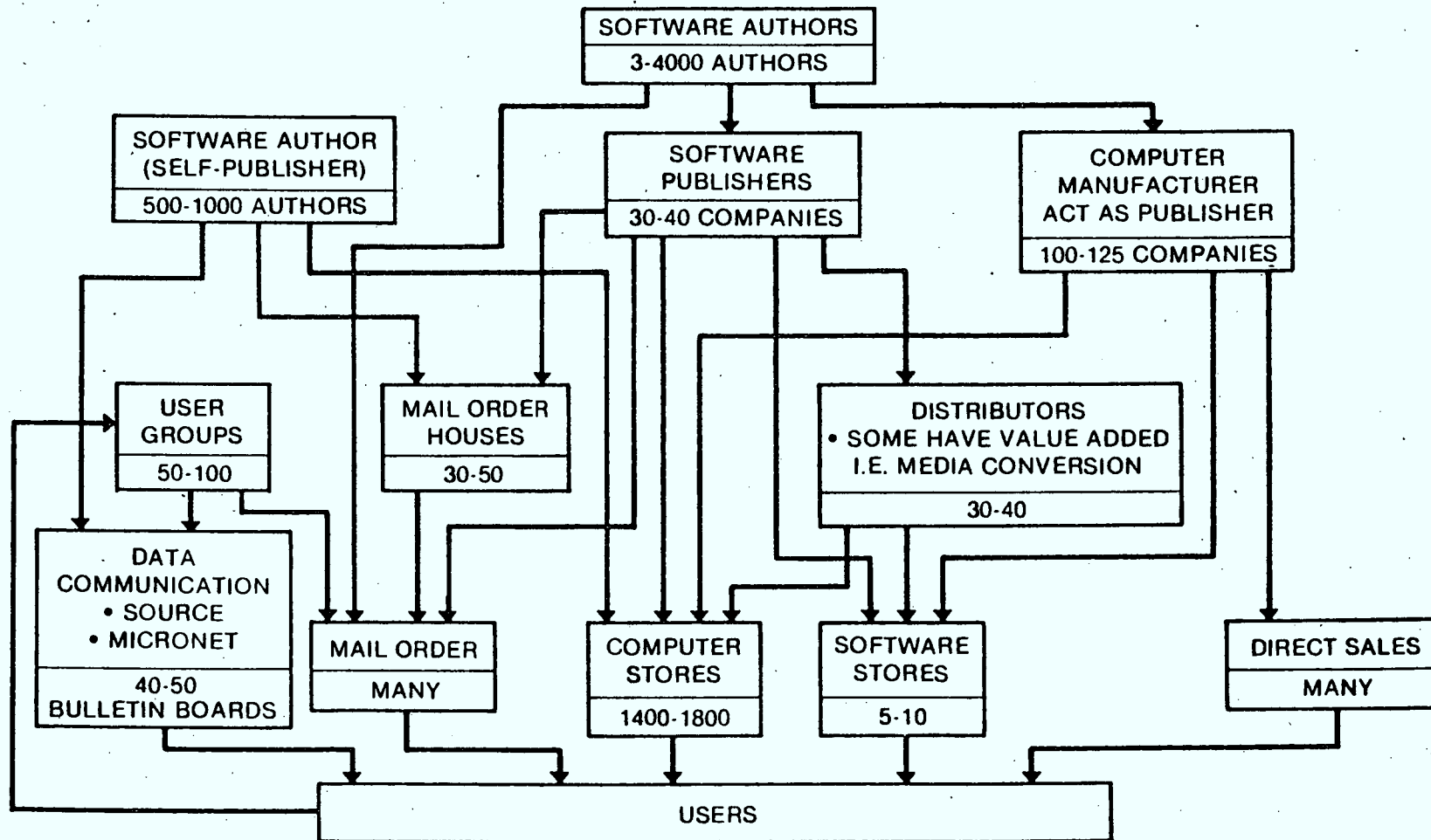
Many uncertainties still surround the creation of software and the distribution of canned packages. The stores could be plagued by unauthorized copying of software. Customer support remains a dilemma. Some retailers believe that software stores must sell software on an "as is" basis and offer minimum support, as do bookstores and record stores, if they are to become profitable. Others insist that substantial support is required to sell software, particularly in business applications. It can be safely said, however, that the quality and breadth of software has become the most important factor in personal computer selection (besides price) and that software evolution has become the throttling factor in the development of the personal computer industry.

The acid test of the personal computer industry with regard to selling strategy is yet to come, however, as manufacturers aggressively seek new distribution channels to penetrate the general consumer market. Independent and chain department stores will undoubtedly become major sales outlets for personal computers. By the mid-1980's departmental and general merchandise stores may account for up to 50% of personal computer sales to the consumer market.

6.3 Investment Policies

Because of rapidly increasing demand, short supply and its early orientation to hobbyists, the personal computer market has tolerated long lead times, inadequate software and poor instructional documentation. As a result, a number of marginal operations with obsolescent products have been able to remain in business. In the future, however, inadequate

SMALL COMPUTER SOFTWARE INDUSTRY STRUCTURE



Source: Future Computing Inc.

FIGURE 12

investments in research and development, large-scale manufacturing, and distribution channels will drive most of the small companies out of the personal computer business.

To survive and prosper in this intensely competitive industry, the manufacturers will need to invest heavily in the following:

- o high volume and efficient manufacturing capabilities;
- o improved quality control during manufacturing process;
- o provide geographically distributed service networks;
- o maintain an on-going new product development effort;
- o establish ample application software with sufficient instructions and documentation;
- o establish a national marketing network and world-wide representation.

To avoid injury from very high new product introduction rates and to remain competitive with respect to the above-mentioned factors, manufacturers will be under considerable pressure to commit themselves to considerable investments in fixed assets and working capital at the expense of short-range profits.

A dangerous shortage of capital, a lack of attention to new product development and inefficient manufacturing are the three main factors that will eventually cause structural shakeouts in the industry, forcing inefficient and undercapitalized companies out of the business and others to accept takeovers to avoid the same fate.

7. MARKET PERFORMANCE

7.1 Market Efficiency and Public Intervention

As an oversimplified postulation, let one assume that personal computer technology were somehow suddenly and spontaneously developed entirely within the Canadian private sector, made readily available at an affordable price to each person who could use it, made unavailable to those who would misuse it, and made to attract sufficient capital investment to sustain its inventiveness and mass production. In this case, we could say that the market processes are performing efficiently. In practice, this state of bliss does not occur and various market imperfections hinder the efficient production and diffusion of personal computing. In the Canadian context, the most ominous imperfection is the complete absence of any local producer and a complete dependence on U.S. imports.

It is not the purpose of this paper to examine the many issues and reasons why Canada is not getting its fair share of economic contribution from the manufacture of personal computers other than to say that some form of government intervention will probably be required to influence the disappearance of these imperfections in accordance with the best interests of the public. There are many options of intervention available to government such as directed procurement of locally built products, risk absorption or sharing speculative investments, support of research and development, training, technical assistance and licensing, international agreements, investment tax credits, accelerated depreciation allowances - and the like. These interventions are means of positive support for developing a personal computer industry in Canada. The implementation of other interventions such as higher tariffs, quotas, and other forms of market protection are not appropriate for Canada owing to the limited size of the domestic market.

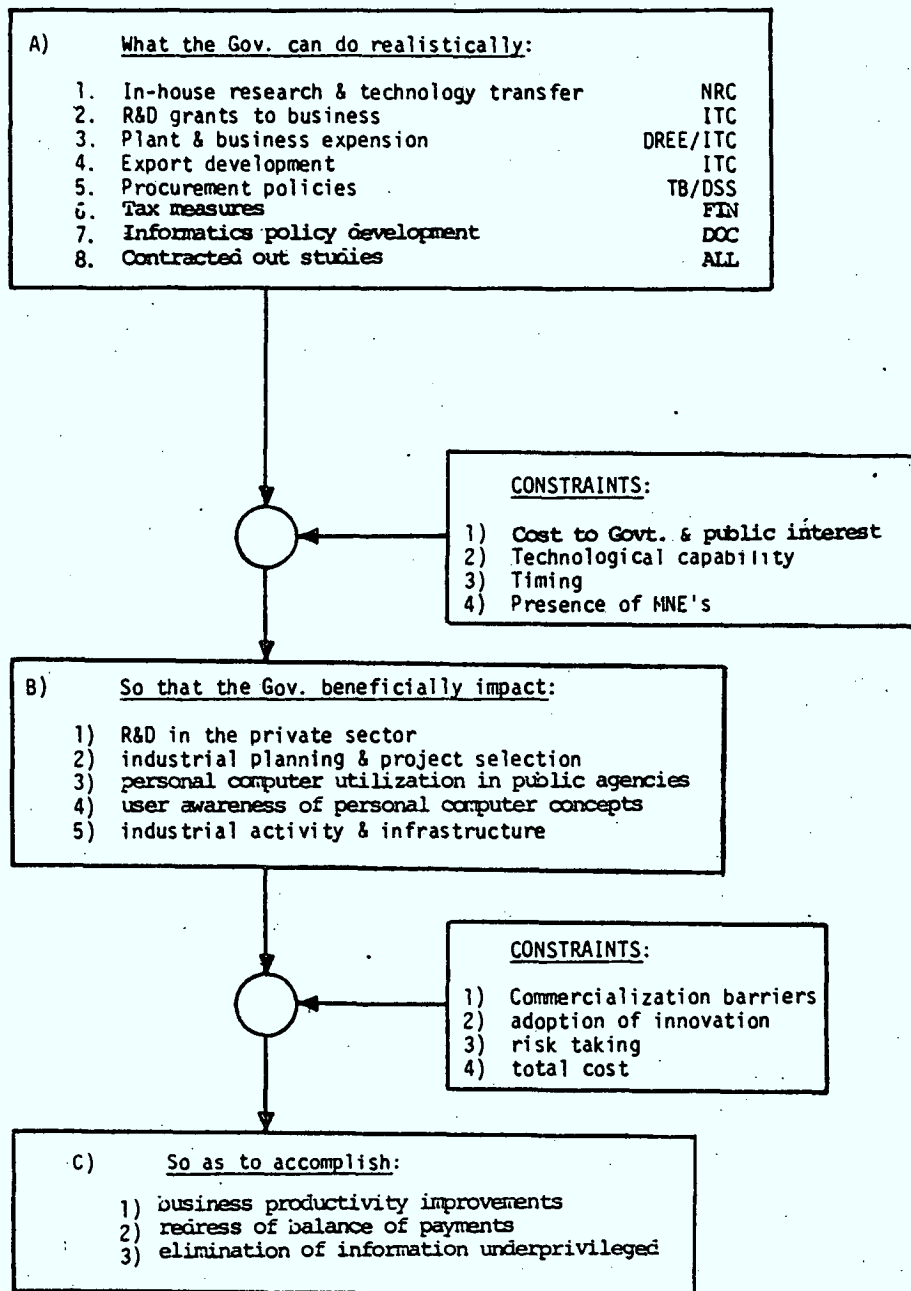
Such support mechanisms as patents and copyrights can serve as positive forces for accelerating the growth of an industry. Unfortunately, there are serious deficiencies in property rights protection under existing mechanisms as they apply to the underlying technologies of personal computers particularly in software, as was noted earlier.

In the area of patents, the rate of technological development is so high that by the time the patent is granted, the technology is invariably obsolete. Consequently, many personal computer producers no longer go to the trouble of patenting their products.

The interrelationships between some of the major supportive Canadian government mechanisms and the market process is shown in figure 13.

7.2 Investment Aspects

The personal computer sector is a capital-intensive industry requiring major investments in plant facilities, R&D and marketing in order for products to compete successfully, as given for the following example: (23).



Source: Author)

FIGURE 13

Activity:

Expenditure ratio
relative to hardware:

- Hardware development	1
- Software development	9
- Production facilities & plant	5 - 10
- Marketing & service development	10 - 15

The total investment required for start-up operations relative to hardware development costs is typically of the order of 25 to 35. With hardware development costs in the range of \$ $\frac{1}{4}$ to 1 $\frac{1}{4}$ million dollars, this would mean start up investments anywhere between \$12 and \$52 millions. The difficulties in finding the financial resources needed to spur this kind of speculative investment under present economic circumstances in Canada would undoubtedly be formidable. In addition to the conventional commercial risks, efforts to mobilize the capital are further diluted by the fact that Canada does not enjoy any kind of comparative advantage in this industry.

7.3 Resale Price Maintenance

As noted earlier, producers of personal computers market their products through independent dealers or specialized third party retail stores either to supplement internal channel sales or to circumvent any form of direct marketing altogether. Most independent dealers of personal computers in North America provide a range of customer support services particularly in business application software and education. It is typical for dealer margins to be in the range of 30 to 40 percent of retail price, depending on volume, and dealer agreements with producers require the retailer to provide point-of-sale support to a minimum standard and maintain direct in-person contact with the customer.

The structure of marketing channels has lately broken down as rampant discounting and mail ordering is rapidly eroding into the sales of full service dealers. Mail order dealers and discount stores market at near cost retail prices, typically at margins of 10 percent or less, and offer no customer service. Some suppliers are taking a hard line against unauthorized discounted personal computers and are enforcing a ban on this type of distribution because they fear that inadequate customer support will jeopardize a positive brand recognition and slow down sales in the long term. For instance, Apple terminated scores of dealership agreements in 1981 to eliminate discounters from the market-place but, in doing so, triggered a series of court actions in the USA in which the plaintiffs alleged violation of anti-trust laws and price-fixing schemes by Apple conjoining with some of its dealers to raise prices (24). The outcome of these legal challenges is pending.

It is expected, however, that the courts will rule in favour of mail-order houses and this is likely to break marketing channels into a discount route for the consumer market and into a full-service route for the business professional market. This dealer policy is now used by some suppliers such as Commodore.

8. CONCLUSIONS

The preceding sections have outlined the characteristics of the personal computer industry within a framework of industrial organization theory. This section will serve to recapitulate some of the salient points of this industry.

We have seen that personal computing is governed by economics as much as by technology. Indeed, the directions taken by technology are governed by economics. In regard to technological progress in the computer industry, one basic fact is undisputed: improvements in the cost performance have been major and frequent. Each new generation of semiconductor technology has contributed to dramatic decreases in the price of hardware. This implies a sharply declining long-run average cost production curve every time that a new generation of technology is introduced.

From the previous sections, one can divide those affected by personal computers into three overlapping groups, as follows:

- a) The supply side of the industry which consists of the producers of goods and services such as hardware manufacturers, software developers, distributors, research and development firms, producers of components, maintenance and repair services, etc.
- b) The demand side of the industry consisting of users of personal computers, including hobbyists, small businesses, office workers, householders, students, investors, artists and, unfortunately, criminals.
- c) Other miscellaneous stakeholders such as consumer advocates, other public interest groups, trade associations, legislators, government regulators and law enforcement, agencies.

The development and diffusion of a new technology, such as personal computing, can be affected by all of the above to the extent that each of the above groups has an impact on the flow of technology, pricing considerations, applications and utilization.

Earlier sections of the paper have noted that the personal computer industry is concentrated internationally in the hands of a few multinational corporations and a larger number of independent producers, all primarily based in the USA. The Canadian market is almost completely satisfied by imports and there is no significant impediment to international trade in this sector. The economic impact to Canada reflects the basic circumstances. The trade deficit in electronics reached close to \$3 billion in 1981 of which computers and office products accounted for \$1.2 billion. It is estimated that over 35,000 personal computers were imported in Canada since 1975 in the absence of any domestic sources of supply.

Unquestionably, Canada does not get its fair share of economic contribution from this industry but the build-up of a domestic personal computer industry is a formidable challenge as the barriers to entry are very high and include substantial research and development costs, investments in the distribution channels to international markets, economies of scale and vertical integration. Left to operate in a free market environment, Canadian industry has not been able to reap the benefits to be gained from this rapidly growing market. It seems clear that the Canadian Government bears some responsibility to devise appropriate policy measures designed to mitigate the undesirable economic effects of the personal computer revolution. Section 7.1 briefly examined the public mechanisms that exist for the government to influence the direction and performance of this industry. What remains to be done is to decide the extent of policy intervention and whether the cost can be afforded from a public interest standpoint.

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