Forces of Change Affecting High Technology Industries

By D. Bruce Merrifield
Assistant Secretary for Productivity,
Technology and Innovation
U.S. Department of Commerce

This is one in a series of articles *National Journal* will publish on public policy issues important to high technology industries. These papers will provide the foundation for discussions at The Government Research Corporation's conference, "High Technology Industries: Public Policies for the 1980s" to be held in Washington, D.C., February 1 and 2, 1983. Mr. Merrifield is the Assistant Secretary for Productivity, Technology and Innovation at the U.S. Department of Commerce. The views expressed herein are those of the author.

INTRODUCTION

This article addresses some of the major forces in the world that are restructuring not only the U.S. economy but the world economy as well. These forces, in fact, are so powerful that management in the next decades will be the management of continuous change.

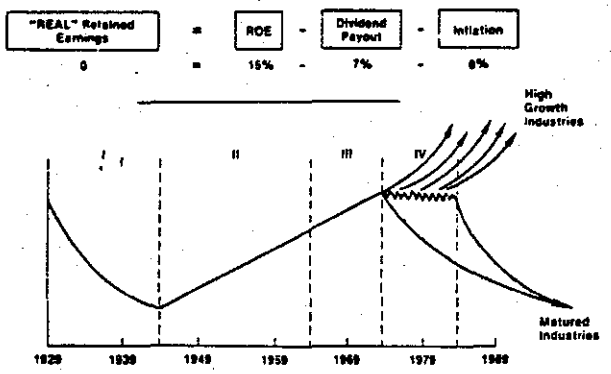
One of the great forces of change will be the targeted industry strategy that the Japanese have modeled so effectively. It is now being copied world-wide by Europe and other countries. Another force for change is the emergence of the lesser developed and the underdeveloped countries that have natural resources such as natural gas that are now wasted. These countries have realized that they can build turnkey plants and add value to their raw material products. Ultimately, these investments will have an impact on much of the $250 billion worldwide business in commodity petrochemicals. A third major force for change is the technology explosion which has generated something like 90 per cent of all of our knowledge in the sciences in the last 30 years. It will double our knowledge again in the next 10 or 15 years, and will tend to make major investments obsolete long before their useful life can be realized.

IMPACT OF INFLATION

Here in the United States we also have some special problems. These relate to an adverse synergism between our past tax laws and chronic inflation. Figure 1 illustrates the simple arithmetic that describes what really has happened to "smokestack America" over the last decade. Return on equity (ROE) is an after tax number that averages about 15 per cent for all companies in the United States, but it's not a realistic number, as we all seem to know. It first needs to be corrected for dividend pay-out which averages about 47 per cent in the United States. So if we take away 7 per cent of that 15 per cent, we have 8 per cent left. Then it is necessary to subtract inflation which operates as a direct hidden tax on equity, and over the last several years has averaged about 10 per cent. The net result is that even starting with a 15 per cent return on equity there is a negative "real" return on earnings. Moreover, this is

representative of many of the companies that make up "smokestack America."

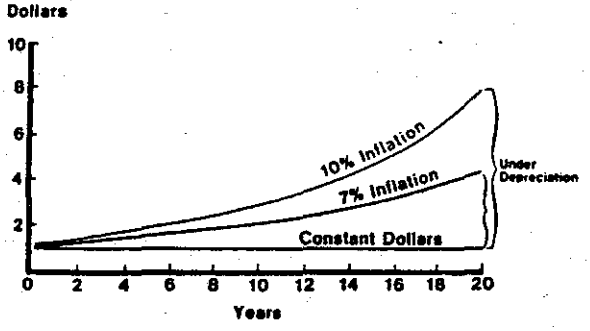
FIGURE 1



The Kidder Peabody Financial Quality Profiles that adjust earnings for inflation and identify discretionary cash flows, actually have shown that a majority of the companies that make up the Dow Jones, for example, have been liquidating themselves in seven or eight out of the last ten years. Moreover, many companies have much less than a 15 per cent return on equity, and they are eroding their assets at a very significant rate. Figure 2 is another way to illustrate this effect. If a million dollars is invested in a piece of equipment or a facility that has a useful life of 20 years, that investment could be recovered under previous tax laws over that period of time. But at 10 per cent inflation, it would cost $8 million to replace it. The other $7 million would not have been reserved and would have been falsely reported as profits on which 46 per cent taxes would have been paid and of which perhaps 40 to 50 per cent would have been spun out as dividends.

FIGURE 2

EFFECTS OF INFLATION



It is important to understand that increased innovation and productivity are required to permanently bring down inflation. General guidelines that emerge include: the necessity of managing capital intensive operations for cash flow; harvesting or divesting cash traps, and reinvesting in high growth, low equity intensive, proprietary systems that have a high asset turnover ratio; or in assets or operations that index to inflation, such as oil and gas, timber, land, financial services, and marketing distribution systems.

KONDRATIEFF LONG WAVE

It is interesting to speculate about why "smokestack America" is in such trouble. One oversimplified but useful concept involves the "Kondratieff long wave." Kondratieff, as you know, was a very bright Russian back in the 1920s who disagreed with Marx and Lenin that the capitalist countries would self-destruct. He pointed out that they seem to do that every 54 years, but then they come back again. Of course, that wasn't very popular at the time, and they exiled him to Siberia. The concept has been very controversial, but recently Dr. Jay Forrester at MIT has rationalized the long wave in terms of four phases. The last long wave started in 1929.

The first phase is a 15-year collapse in which many obsolescent facilities in overcapacity are written down, taken over, or go into Chapter 11. Then at the end of that period (in 1945) a tremendous excess demand over supply has developed in the capital sector, and it fuels the second stage, a massive 20-year capital reinvestment. Forrester points out that the best technology existing at that time tends to fuel the entire cycle. In steel that was the open hearth furnace. Hundreds of millions of dollars were being invested in new steel facilities, with significant economies of scale. Prices were going up faster than costs, so cash flows were great, and profit margins were large. Forrester further points out that this process rejects new technology on the basis that it is risky to try something new when everything is going so well with the present systems. So, when the basic oxygen furnace came on the scene, it was rejected in the U.S., but under Marshall Plan money it was put into Japan and Germany. By about 1965, a world balance in demand and supply for steel had developed, but the steel business did not see itself in the "materials" business, and consequently continued to invest in steel. The third phase, then, is a period in which steel capacity is overbuilt perhaps by 25 per cent worldwide. Competition holds down prices as costs continue to rise and the business begins to erode its assets in real terms. In addition, engineering plastics also are beginning to niche away markets from steel; also at the present time graphite fiber reinforced epoxies that are stronger than steel and lighter than aluminum—that don't stress fatigue, or corrode—will begin to replace steel in many applications as the price of graphite fibers continues to decrease. Steel will never disappear, but with enormous worldwide overcapacity much of the older U.S. capacity will inevitably be shut down. So what we see then in the fourth phase of the Kondratieff/Forrester cycle is a period of economic turbulence in which the recession cycles deepen and then the next collapse occurs. And of course, we're now in the 53rd year of the 54-year cycle. But actually, the decline of the capital intensive commodity businesses started about 10 years ago, and many obsolescent overcapacity facilities have already been written down. If it weren't for the emergence of new technologies, the economy would be in far worse trouble than it is. But fortunately, as Forrester points out, the 54-year cycle that rejects new technology has also seen a spectacular explosion of new products and systems.

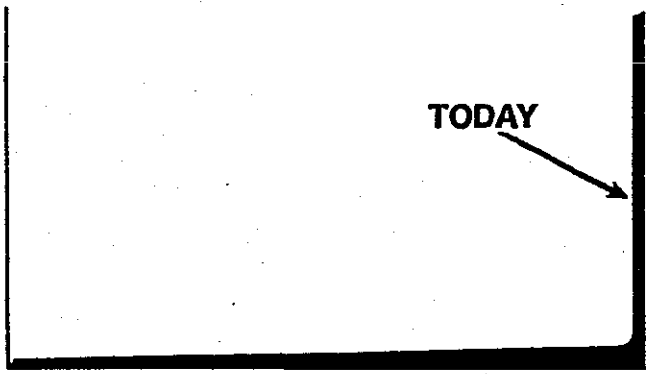
TECHNOLOGY EXPLOSION

In fact, in just this last 30-year period, something like 90 per cent of all scientific knowledge has been generated. This pool will double again in the next 10 or 15 years. Of course, 90 per cent of all the scientists who have ever lived are now living and working, and they will double again in that period. As a result, a tremendous build-up of underutilized technology is already fueling the next cycle—in electronics, communications, engineering, plastics, biogenetics, specialty chemicals, pharmaceuticals, and so forth. Also, fortunately, these new technologies are now offsetting the decline of the capital intensive commodities and the net GNP is even inching up a little bit.

The new systems will take on increased significance in the next few years, and we are looking into one of the most interesting periods the world has ever seen. Basically we have two economies: one is in trouble, and the other is exploding. Thousands of new companies have formed in the last several years. The explosion of new technologies is illustrated in Exhibit I. It shows the explosion of technology plotted from the beginning of civilization 10,000 years ago up to 2000 A.D.

EXHIBIT I

TECHNOLOGY EXPLOSION



Moreover, the United States a decade ago, with only 5 per cent of the world's population, was generating something like 75 per cent of the world's technology. Now the U.S. share is about 50 per cent. In another decade, it may be 30 per cent, not because we're generating less—we'll be generating a great deal more—but because the other 95 per cent of the world will also be contributing. All countries in the world now see technology as essential to quality of life and are getting into this business. There are a billion people in China, for example, one out of four in the world, and they intend to be at the leading edge of every technology by the end of the century. Perhaps half the new scientists and engineers will be emerging in underdeveloped countries.

This explosion of technology, therefore, is much more significant than is easily realized and it will change our lives continuously. Some of the areas in which major new developments will occur will be in materials science, agriculture and in hundreds of derivative areas. For example, in the materials area, ceramic engines (now being tested in Japan) may make current internal combustion engines obsolete. Graphite fiber reinforced plastics will progressively niche away markets in construction, aircraft, automobiles, and appliances, as will engineering plastics, alloys, and laminants. The biochemical area is a fascinating one with major developments occurring in understanding the learning process, and in realizing the total conquest of viral diseases including cancer. The ability to correct genetic defects will develop, as will the ability to produce plants that grow in cold and arid climates. The cloning of superior livestock and of genetically assembled hybrid organisms are reasonable possibilities.

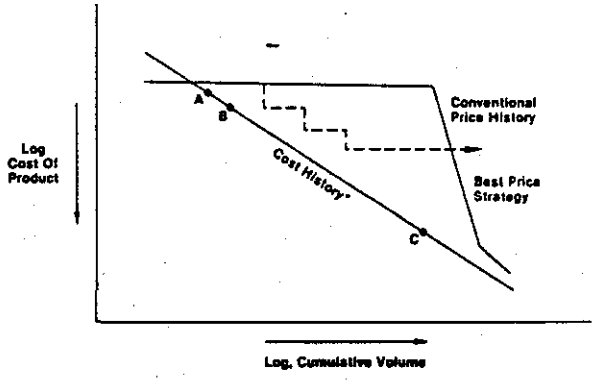
Electronic systems will pervasively restructure our lives, with electronic mail providing access in our living rooms to the Library of Congress, to most of the important university courses, and to continuous news updates. The frontier of education will be adult education as the pace of change requires a continual learning process. This period will, at the least, be an interesting one.

TARGETED INDUSTRY STRATEGY

Another great force that is restructuring the U.S. economy is the "targeted industry strategy." It is based on the "learning curve" first articulated as a strategic planning concept by the Boston Consulting Group back in the late 1960s. Japan adopted this concept as a basic strategy at that time and targeted steel, automobiles, consumer electronics, and microchips as priority areas. They have used this concept very astutely.

EXHIBIT II

LEARNING CURVE STRATEGY



* Costs Decrease "About" 20% For Each Doubling Of The Volume

The concept is simple. If, in Exhibit II, the log of the cost of a product over its lifetime is plotted against the log of its cumulative volume, a straight line results. Every time the volume doubles, the cost goes down about 20 per cent. The traditional price history is illustrated by the top line where a new product is marketed in small volume, but as volume increases economies of scale result and costs decrease. Typically, a general manager will leave the price where it is allowing competitors to come in under that price umbrella, and trading market share for short-term profits. Traditionally, after half the market is given up, the price collapses and a commodity

situation results. However, if the price had been decreased as shown by the dotted line to a point below anyone's entry point, the resulting profits might be ten times as much. Moreover, even a late entry can forward price below anyone else's cost and take all the new market growth. All that is required is to carry the negative cash flow in the interim.

Of course, that's obviously not quite feasible for most American companies. However, a nation such as Japan can do this. The procedure is first to target the industry, then bring tpgether all of the players in that industry such as in steel; next, the small companies are eliminated to concentrate the business and imports are closed off to further base-load economies of scale in the home market. Then R&D objectives based on manufacturing engineering improvements are parceled out to avoid redundant effort and the new systems are leveraged 80-90 per cent with low cost capital. Incremental pricing then puts all the costs into the first eight-hour shift for the home market, and the next two shifts are for export at substantially less, and finally the product is forward priced below the existing costs of American companies. Market share is gained very rapidly until economies of scale catch up with the prices.

This is a very astute strategy, and as we all know, has been very successful. However, it must be understood that it's limited to those areas where there are large volume markets, and where there is a long enough time period to recapture that negative cash flow and pay out those major investments. Economies of scale then become the dominant factor, even over the best technology.

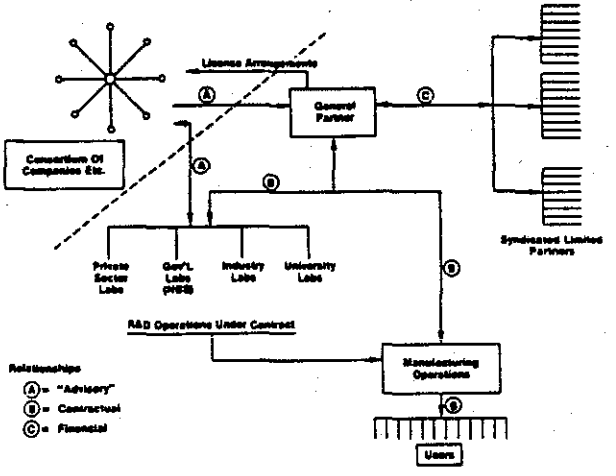
COLLABORATIVE R&D IN THE U.S.

This strategy is so effective that it is now being adopted by other countries as well. Therefore, it's important that we begin to collaborate in the U.S. on an equivalent scale of effort. United States antitrust laws, however, have prevented such collaboration, and it's important to think about modifications to those laws. Also, there is a need to find ways within the antitrust laws to collaborate on a scale equivalent to those that are now used by the Japanese and other consortia around the world. One such way involves the use of the R&D limited partnership concept. This concept allows large companies to collaborate without antitrust implications.

In Exhibit III let's assume that the consortium shown in the upper left-hand corner is perhaps an electronics group, that might include IBM, Bell Labs, Motorola, Digital Equipment, Control Data, Intel, and others. They would not normally be allowed to collaborate. The antitrust guidelines say that no more than 25 per cent of any market is allowed to collaborate in a given consortium. This concept, therefore, sets up a separate legal entity called a general partner. The general partner then identifies what the user group (the consortium) would like to have. In this case, it might be a megabit chip, a million bit dynamic random access memory chip. The first thing the general partner does is contract with the "users" to take or pay for a certain number of these chips contingent only on meeting pre-agreed upon cost performance specifications. The second thing he does is to contract with appropriate laboratories to do the work that is necessary. These are arms-length contractual arrangements that avoid any antitrust implications. The third thing he does is to syndicate venture capital money from the private sector. This is a relatively low risk situation since commercial success is guaranteed in advance and since the best laboratories in the world are doing the work. The general partner now can either license the megabit chip technology back to the individual companies, or better still, can manufacture it for them on a scale far down the cost experience curve in excess of anything the Japanese or anyone else could put together. Alternatively, he can license it to an individual company for manufacture on a large scale. The consortium gains proprietary rights to the megabit chip without putting any money into it, because of their original take or pay orders, and their laboratories are doing work that they would like to do, but are being paid to do it.

EXHIBIT III

R&D LIMITED PARTNERSHIP



This basic structure is now being developed for all sorts of consortia in flexible manufacturing, biogenetics, and so forth. The general partner can be a university, an industry association, or a group of individuals. One of the key factors is that once the limited partners are paid off, then the cash flow continues to come back to the general partner. If the general partnership is set up as a nonprofit operation, then the continuing cash flow is available to fund second and third generation projects. It then becomes a cash machine for continuing developments, funded out of the private sector which is the important thing. The role of the government here is strictly limited to a catalytic one, that develops guidelines and advises groups when desirable. This is a major thrust of the Department of Commerce.

CONCLUSION

It is important to remember that the United States has by far the world's most advanced technology in almost every area of interest; it has an incomparable industrial infrastructure with which to translate new developments into products and processes; it has a unique entrepreneurial culture; and finally, it has the world's most effective capital formation capability. All that is needed are the initiatives required to mobilize these capabilities, remove the barriers that impede collaboration and further enhance the incentives for doing so. The United States, with all its remarkable resources and capabilities, can then be the major beneficiary of this period of change.

Major World Forces of Change

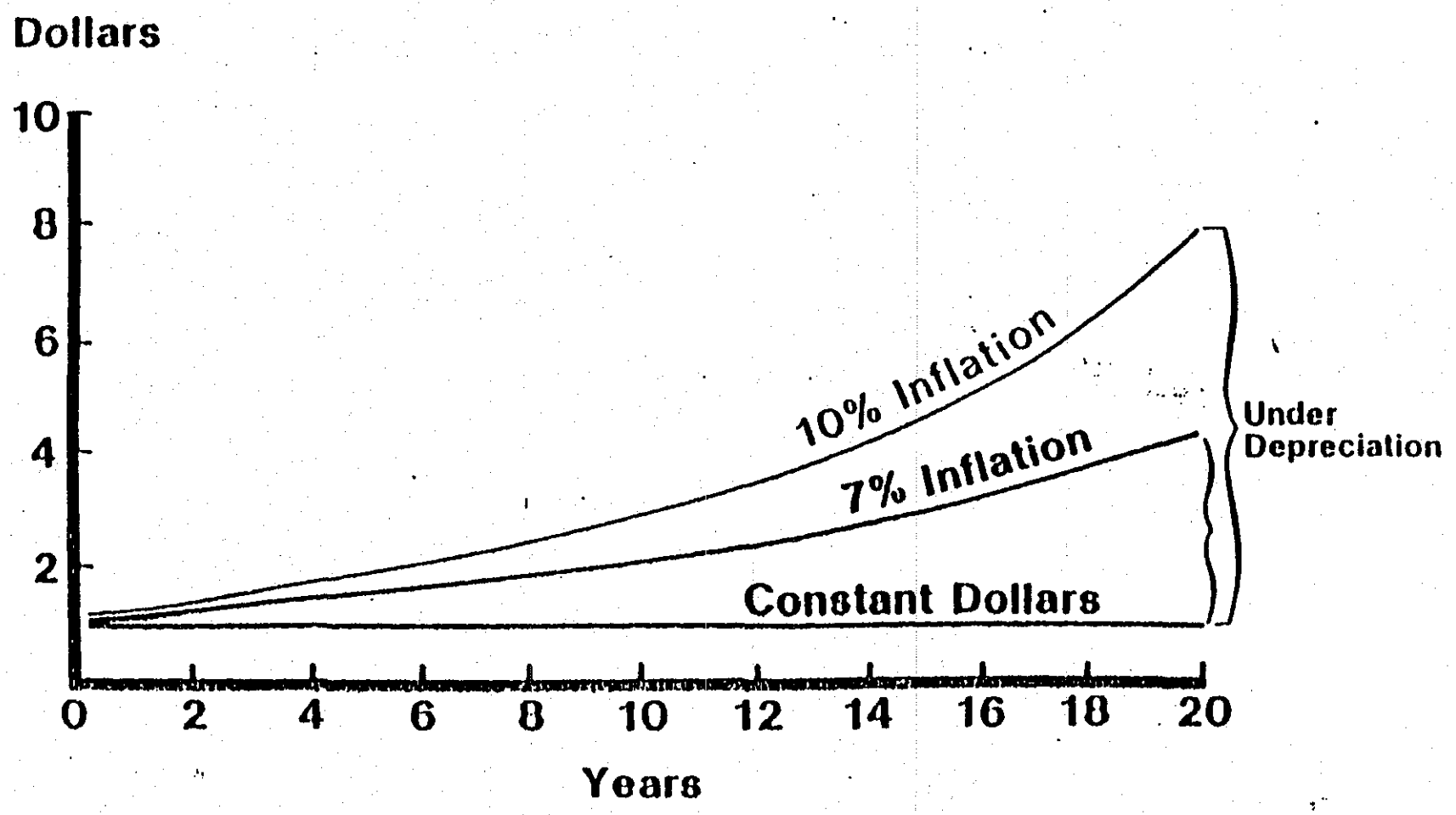
- In the U.S. — Taxes and Inflation
- The Technology Explosion
- The "Targeted Industry" Strategy
- The Petrochemical Shift

INFLATION

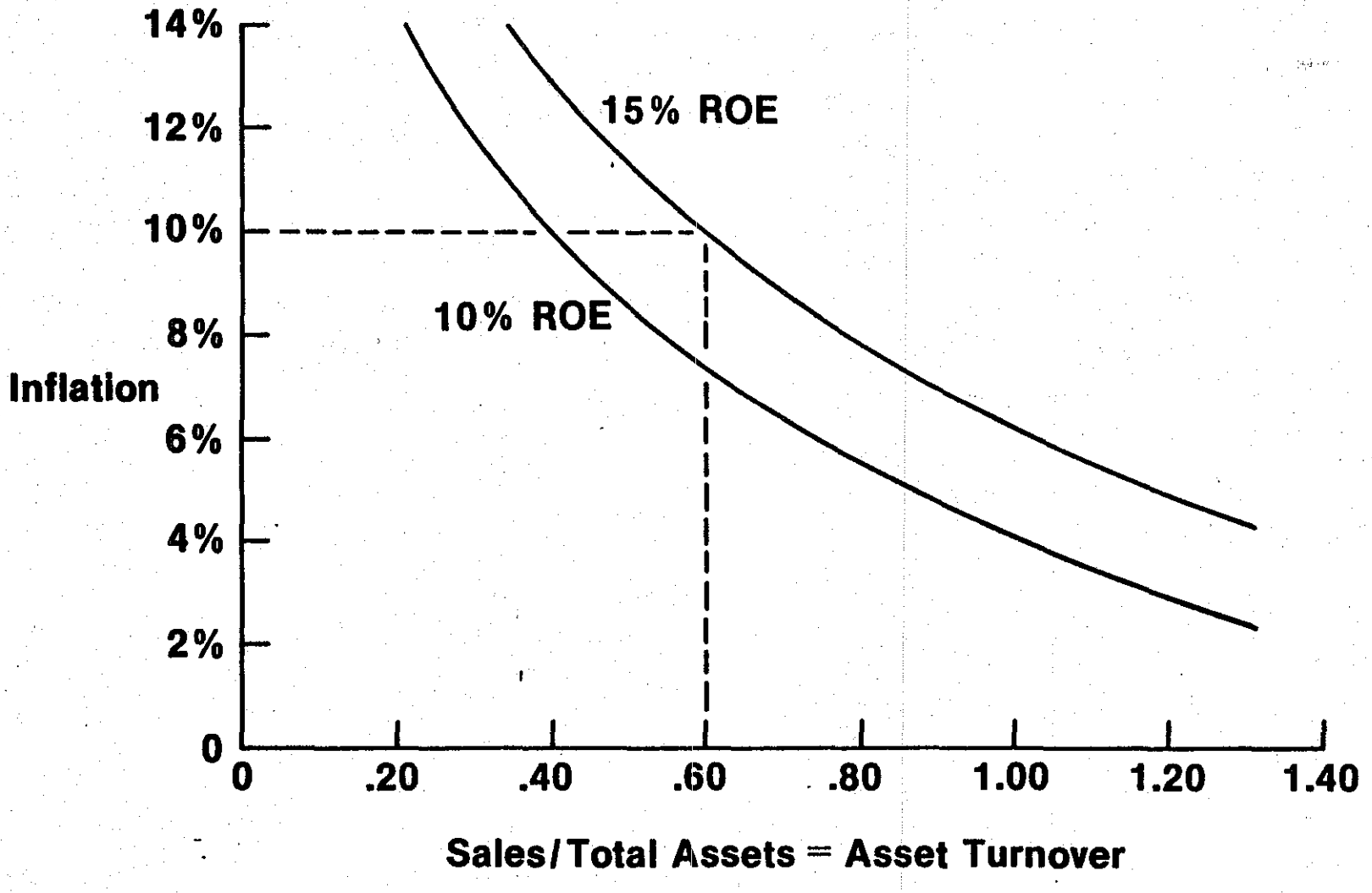
A DIRECT TAX ON EQUITY

[RETURN ON EQUITY]	—	[DIVIDENDS PAID OUT]	—	[INFLATION RATE]	=	[REAL RETAINED EARNINGS]
15%	—	7%	—	10%	=	−2%

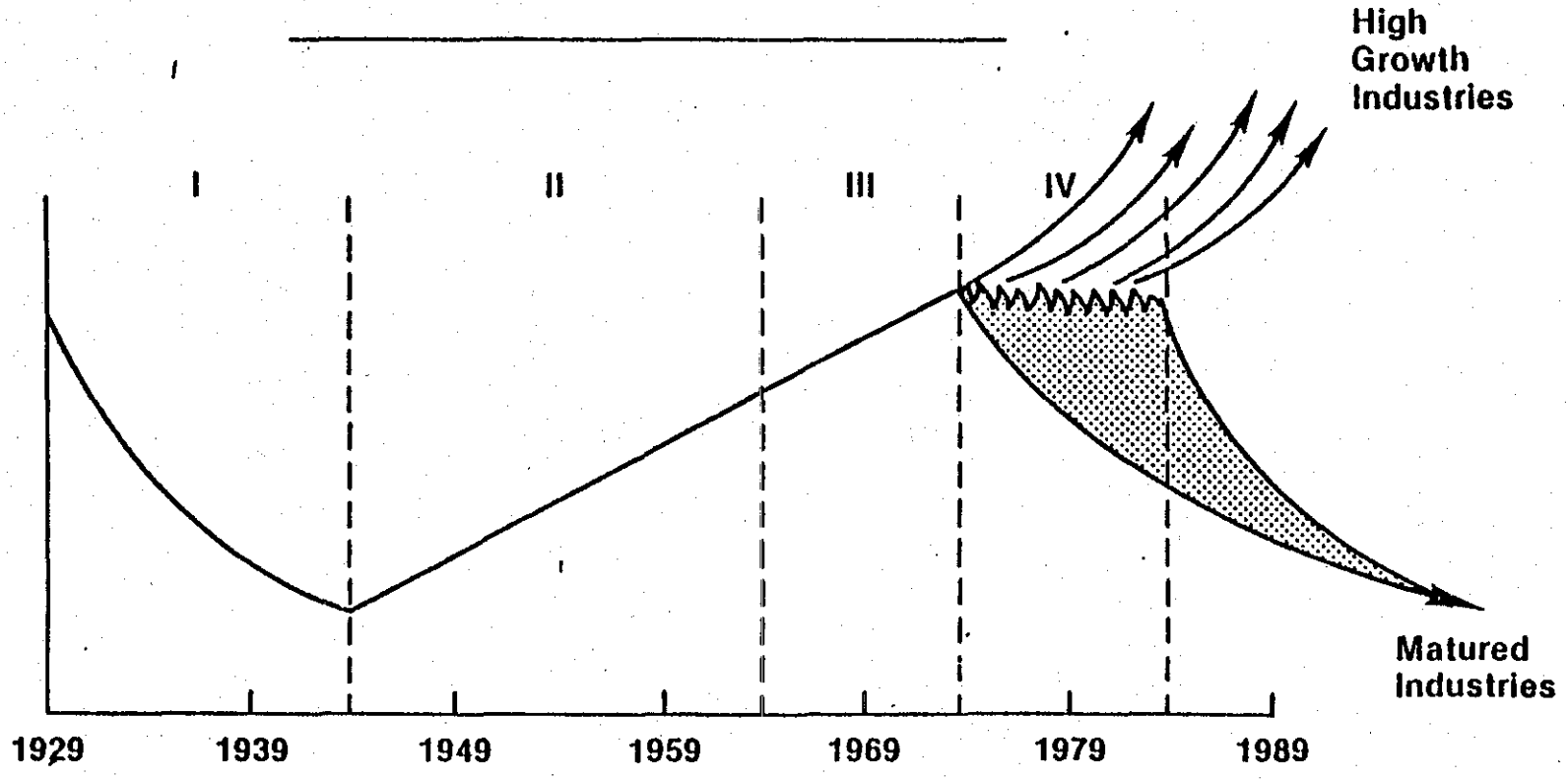
EFFECTS OF INFLATION



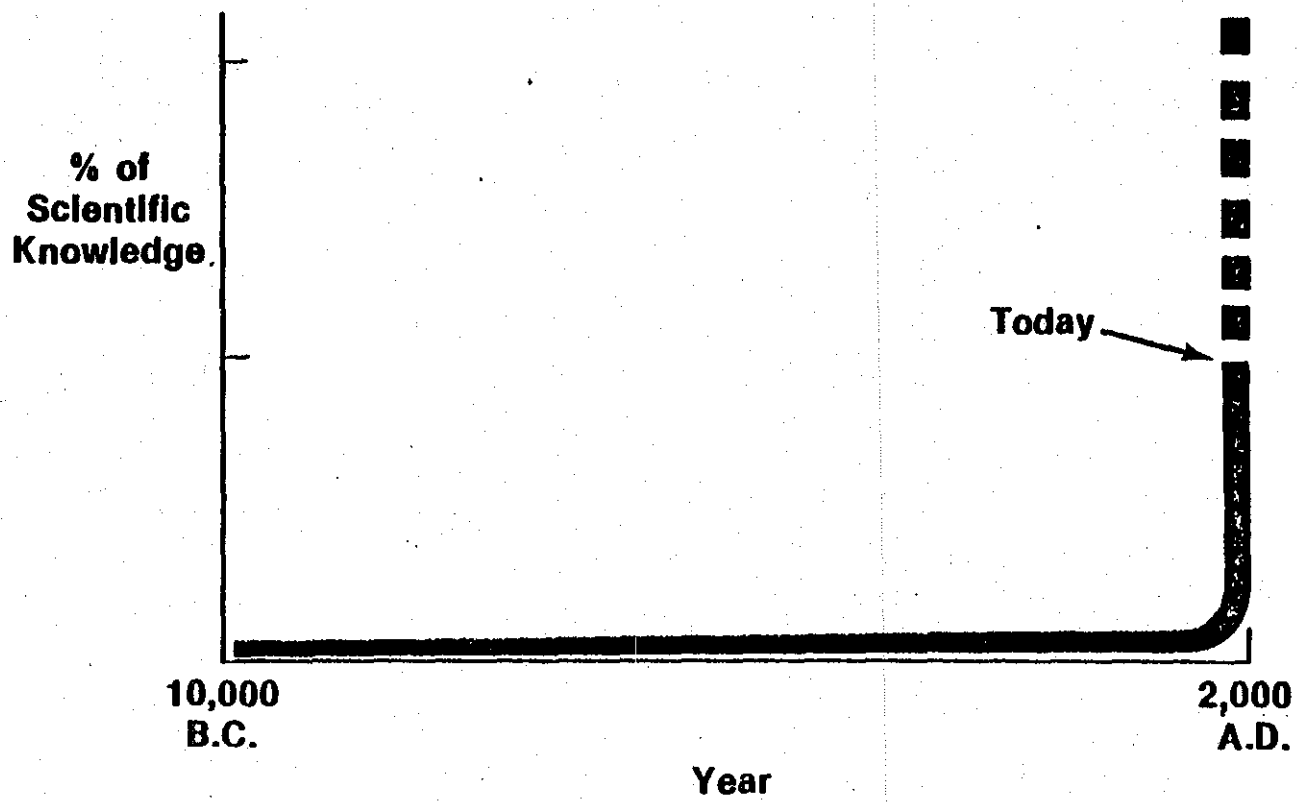
Breakeven Points at High Inflation



"REAL" Retained Earnings	=	ROE	-	Dividend Payout	-	Inflation
0	=	15%	-	7%	-	8%



The Technology Explosion



Growth Areas

Materials Science

- Engineering, Plastics
- Composites, Alloys
- Graphite Fiber Epoxies
- Ceramics, Laminants

Energy

- Natural Gas
- Electrical Storage
- Fusion

Biochemistry

- Rapid Learning
- Somatic Modification
- Cloning
- Viral Disease Aging

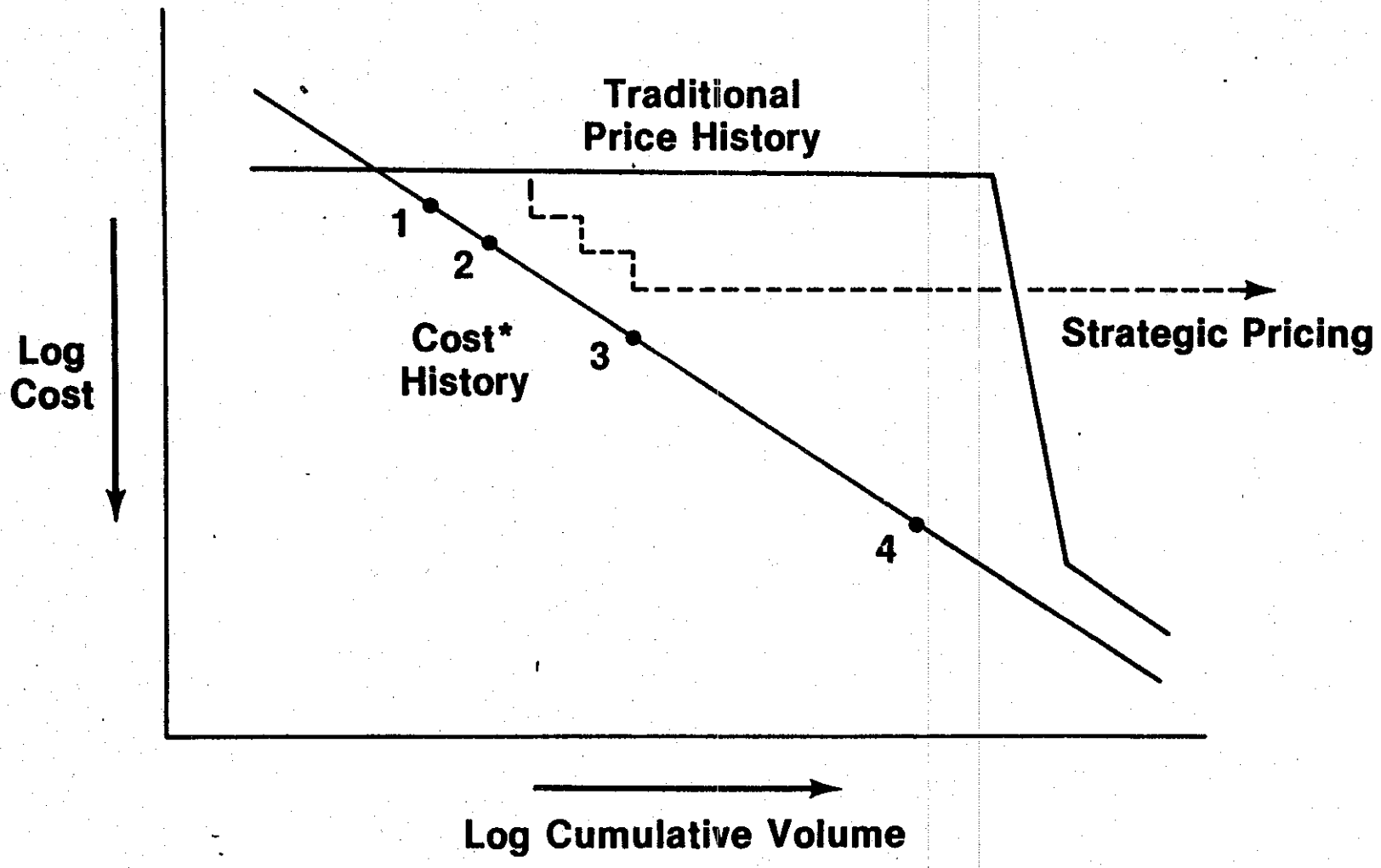
Electronics

- Electronic Mail
- Robotics
- Adult Education

The Japanese Model of the Learning Curve

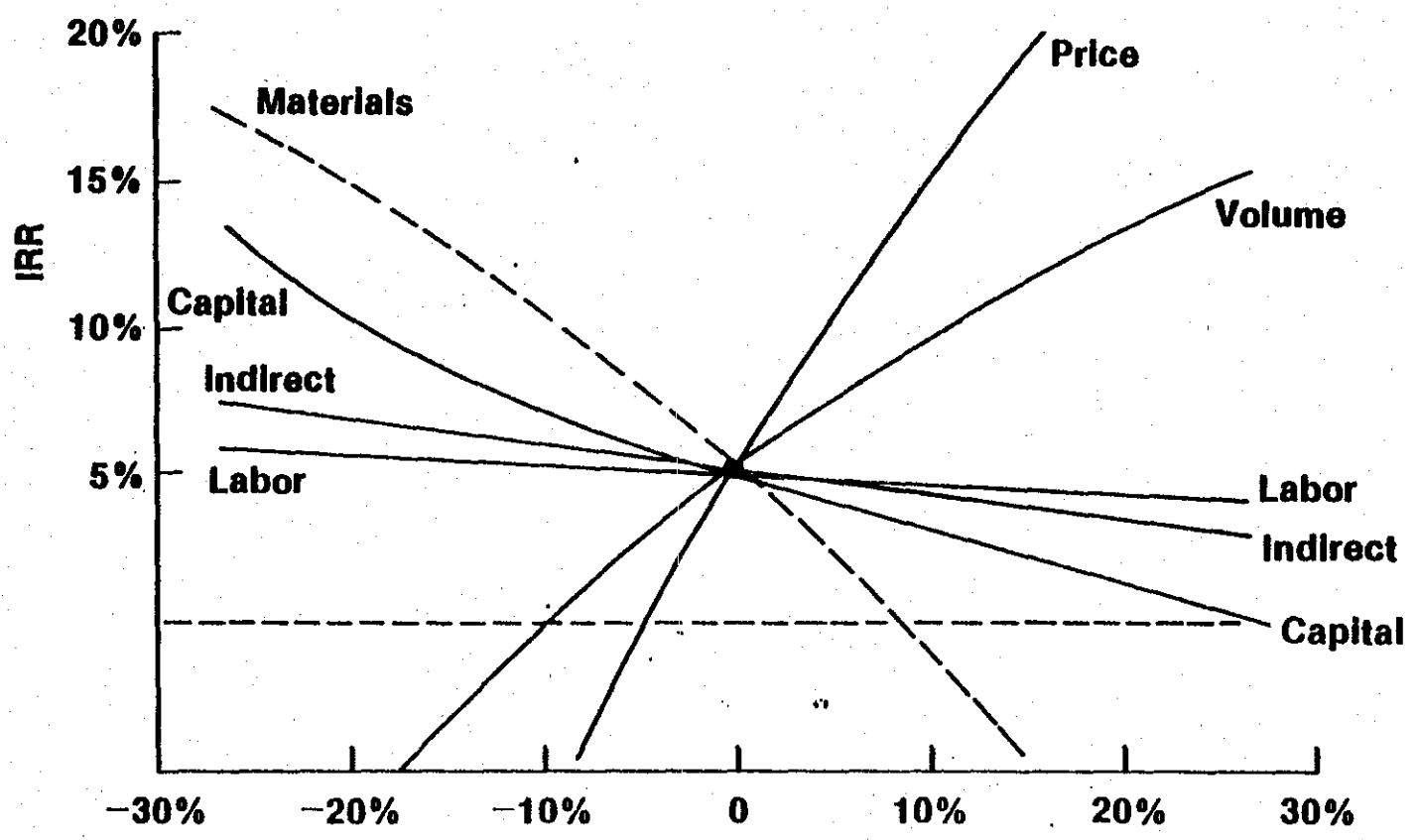
- Targeted-Industry Strategies Work Best for Large Volume Commodity Businesses Where Economies of Scale Can Dominate
- Concentration of Technical Efforts on Manufacturing — Engineering Are Essential for This Strategy
- U.S. Antitrust Laws Have Prevented Collaboration of U.S. Companies on an Equipment Scale, and Are Now Anti-Competitive

Japanese National Strategy
The "Learning Curve"



*Costs Decrease About 20% for Every Doubling of Total Industry Volume

Commodity Petrochemicals Sensitivity Analysis
(100% Capacity)



Ethylene Plant
11.7 ¢/lb. Ethane

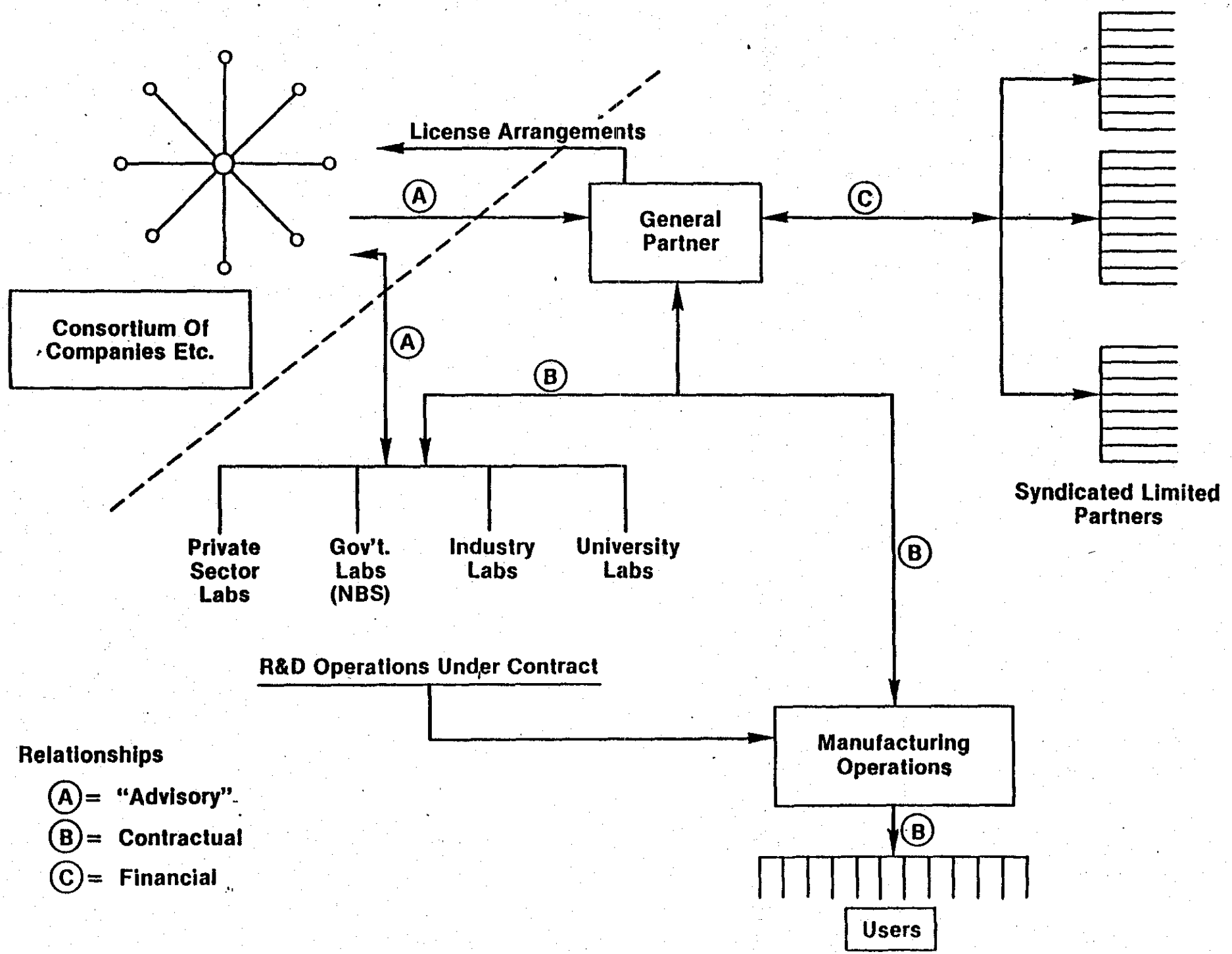
The U.S. Response

- Remove Regulatory Barriers to Innovation, and to Increased Productivity
- Modify Antitrust Laws to Allow Collaboration Among U.S. Companies
- Provide Increased Incentives for R&D and Manufacturing Investments
- Clarify the Limits for Operation of R&D Limited Partnerships

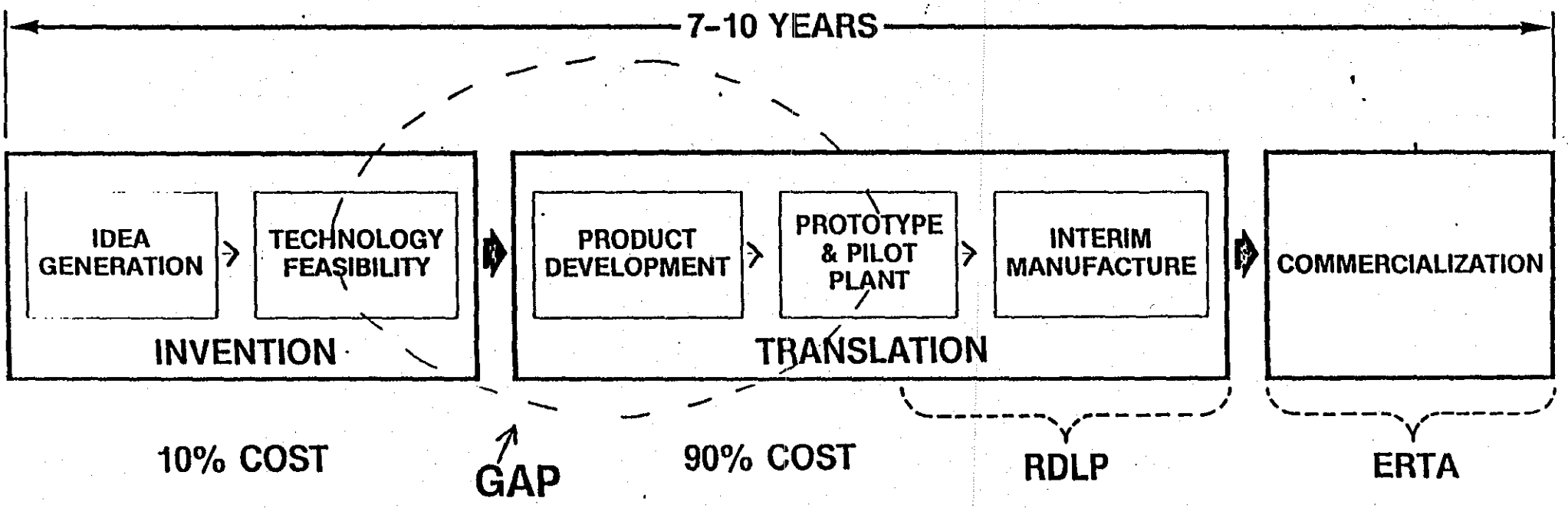
Benefits of
R&D Limited Partnerships

- Legally Ok; Limited Antitrust Concerns, Limited Liability
- Funded Off Balance Sheet Through Venture Capital
- Allows Pooling of Best Technology and Other Resources (Eliminates Redundant R&D)
- Permits Large Scale Manufacturing if Needed for Economies of Scale

R&D LIMITED PARTNERSHIP



INNOVATION



$6.6 BILLION FY 1984
U.S. GOVERNMENT
BASIC RESEARCH

Summary

1. The U.S. Now Competes in World Markets
2. Major World Forces Will Continually Restructure the U.S. and World Economies
3. The Challenge: Managing Continuous Change
4. The U.S. Has Major Advantages:
   - The World's Most Advanced Technology
   - An Incomparable Industrial Infra Structure
   - A Remarkable Enterpreneurial Culture
   - The Most Available Development Capital
5. We Must Continue to Remove the Barriers and Provide the Incentives to Take Advantage of These Incomparable Assets