Economics and New Technologies

Technology transfer will play major role in innovations of 1980s, but new measures will gauge successes in changing world

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The most important years of our lives are beginning right now as we move into the decade of the 1980s. We are in a period of economic change and restructuring that calls for new technology and innovation. There will be new demands; new opportunities. The pace of innovation will accelerate to make the new decade the greatest period of technological change any of us have experienced in our business careers. And the licensing executive will play a key role in making this innovation happen.

Looking at economics as an instrument in forecasting technological needs we see a strong, mutually causative relationship. For technology creates economics as much as economics creates technology. When we study our technology as we study our economy, we'll find we are studying different aspects of the same system. So, a forecast of one will forecast also the other. Let's begin with a look at economics.

Economics is a social science in love with numbers. With economics, the most complex thought can often be reduced to a single number. In the United States we are 223 million people driving 103 million cars and living in 75 million households. Some 97 million of us are working on 2.7 million farms, 14.6 million business establishments, and 80,000 governments; and we are raising 64 million children under the age of 16. Our economy supports 1 federal, 50 state, and 80,000 local governments spending over $1 trillion and employing 16.2 million workers. And with economics we can express this huge, complex economy in a single number as a Gross National Product of $2.6 trillion, (or in 1972 dollars, $1.4 trillion). A tremendous richness and variety reduced to a single, very inadequate number! What do economists see, looking ahead into the 1980s? Here are a few recent headlines:

NARROWED OPPORTUNITIES, FIXED LIMITS SEEN FOR 80s

BANK OF AMERICA OFFICIAL SEES U.S. AT AN ECONOMIC CROSSROADS

ECONOMISTS SPLIT ON COMING DECADE

PROSPECTS SEEM BLEAK FOR COMING DECADE

IRAN CRISIS WORSENS INFLATION OUTLOOK

SIMILARITIES ARE DRAWN BETWEEN NEW DECADE AND THE 1930S

LIQUIDITY CRUNCH THREATENS LDCs

INNOVATIONS KEY TO MARKETING SUCCESS IN 80s

PRICE OF CRUDE OIL MAY HIT $45

We went into the 1970s with crude oil at $1.80 per barrel. At the end of the decade it was $24. 1979 imports were some 3 billion barrels, 2% more than in 1978, but 44% greater in dollar cost with a total import bill for crude oil in 1979 of $56.7 billion. 1978's average price of $13.30 increased to $18.72 in 1979. In 1980, prices surged to an average above $30. Even with a 5 to 6% decline in imports, the import bill was up some $30 billion over 1979.

Inflation

Energy prices have become an important cause of inflation, but not the only cause. Mexico and Argentina, self-sufficient in oil, have inflation rates of 25% and 90%. West Germany and Switzerland, importing virtually all their oil, have inflation rates less than 5%. In most countries of the world, inflation has become institutionalized at rates that tell us economic change must occur. How inflation will be controlled is a major issue for the 80s and will be dealt with. Technology will be an important part of the answer.

While prices are going up, productivity is going down. In 1979, productivity of U.S. nonfarm businesses was down 1.2%. In the second quarter of 1980 it was down 2.9%. If we are to control inflation; if we are to have a bigger pie to share, we will need improved productivity. We will have to produce more from the man-hours of labor, the materials, the energy, and the capital used. Companies throughout the country are beginning to understand what productivity is, and what it means in their operations. Productivity objectives and measures are more and more appearing in company plans, programs, and control systems. As this trend develops it will spur the innovation of new technology to improve productivity. The economics of productivity will demand new technology to create greater value from the inputs of man-hours, materials, energy, and capital.

Through the 1980s we can expect a continuation of

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business cycles. Early in 1980 we experienced, in most industries, a very sharp economic decline. In the last half of the year recovery began for many industries, although this recovery was soon threatened by continuing high interest rates. But whatever the reported production rates, an economic squeeze confronts all companies, and especially those whose sales remain depressed. Even in the expansion phase of the business cycle, companies will continue to confront difficult economics.

As we move into the 1980s much attention is being given to the Kondratieff Wave, or long wave of economic performance. Small wonder . . . for the long wave says that we have recently passed the high point of the wave and are now looking ahead to a period of decline with a trough about the year 2000. The last trough was in the 1930s; the previous one in the 1890s. Whether or not the long wave exists has been a subject for debate among economists for many years. Recent work has added an important dimension to an evaluation of the phenomenon. And that dimension is technology.

Gerhard Mensch, publishing in Germany in 1975, described the long wave as a series of unconnected S-shaped curves arising from interconnected basic innovations which "took off" more or less together.[1] Dr. Jay W. Forrester and the System Dynamics Group at MIT have come to a similar conclusion:[2]

> "The 50-year long wave again may have reached a critical peak. If this is so, a period of stagnation threatens; a technological era is ending. At the same time, the life cycle of growth is reaching a point where important aspects of economic activity will have to change, where environmental limits will force a compromise between population and standard of living. Now is the time to examine the fundamental interactions between economic behavior, technology, inflation, and attitudes. Now is the time to plan for the second half of the life cycle of growth. Now is the time to look across a potential next valley in the 50-year wave to examine the technologies and energy sources most likely to replace those now in use."

While the long-wave theory has been developed by economists, it now appears that it is as much the province of technology as it is the province of economics. The long wave viewed by the economist sees ahead two decades of decline. The view of the technologist sees new technologies now emerging to succeed those now driving our economy. I share this second perspective. We are in a time of transition. Whether or not we will see a period of stagnation and decline will depend on how productively we manage the old, and how successfully we innovate the new. For both, technology is the key, and the work of the licensing executive in transferring technology will be essential.

Created Threat

The greatest threat to our economy, our technology, our culture, our existence in the new decade is the awesome threat of nuclear weapons. In military arsenals today there are 40,000 such weapons, the equivalent of 1.3 million Hiroshima bombs. Ten thousand are large, strategic weapons. One 20-megaton weapon dropped on a large city would create in a blinding, explosive flash a crater one mile across and 200 feet deep. Over an area of eight miles nothing would be left standing. Over an area of 40 miles flammable material would instantly ignite, and winds of hundreds of miles per hour would fan awesome firestorms. From this terrible destruction, millions would die. Radiation sickness and deaths from radiation and burns would kill additional millions. All from just one bomb, and thousands stand poised, keyed to their targets! The whole scenario of nuclear war is unthinkable . . . it is simply impossible to think rationally about such a holocaust. Yet today it stands at our doorstep.

Victor Weisskopf, MIT Professor Physics Emeritus, wrote recently, "Today the situation looks bleak, and the danger of nuclear war increases daily. A miracle may be needed to avoid the holocaust, but this miracle must happen."[3] Let us not be comfortable in assuming such a miracle. Over the months and years immediately ahead we must find a way to eliminate the threat of nuclear destruction. All else depends on this.

Overall, the economic outlook for the 1980s can be summarized as follows:

1980s Economic Outlook

GNP growth ex-inflation of 2-3% per year.
No extended boom periods
Perhaps two or more recessions.
Redistribtuion of wealth to OPEC and others controlling basic resources.
Continuing inflation.
Some (great?) disruption of energy and raw material supply.
Debt service burden (crisis?) — especially for developing countries.
Economic nationalism contending with open trading relationships.
Increased international rationalization of production.
Limited capital formation.
Directive intervention by governments.
Increasing social and environmental costs.
Burden of armaments and threat from nuclear weapons.
Increasing rate of innovation.
More with less — greater productivity in the creation of value from inputs of labor, materials, energy, and capital.

Is this characterization of the economy of the 1980s optimistic or pessimistic? By conventional measures it is somewhat pessimistic. But the measures are part of the problem. We use GNP measures and National Account measures thinking they describe reality. Within our businesses we use income statements and balance sheets in a similar way. But over time, reality has changed while our measures have not. GNP is not an adequate measure of our economy today, and will be less so tomorrow. For a company, income statements and balance sheets are inadequate measures of income, assets, and obligations. An important task for the 1980s will be to find better measures. By the old measures the decade of the 1980s may not look very good. By the new measures it may be one of our greatest periods of progress and growth. And in our companies we will find that numbers which state matters so clearly often conceal more than they reveal. Our

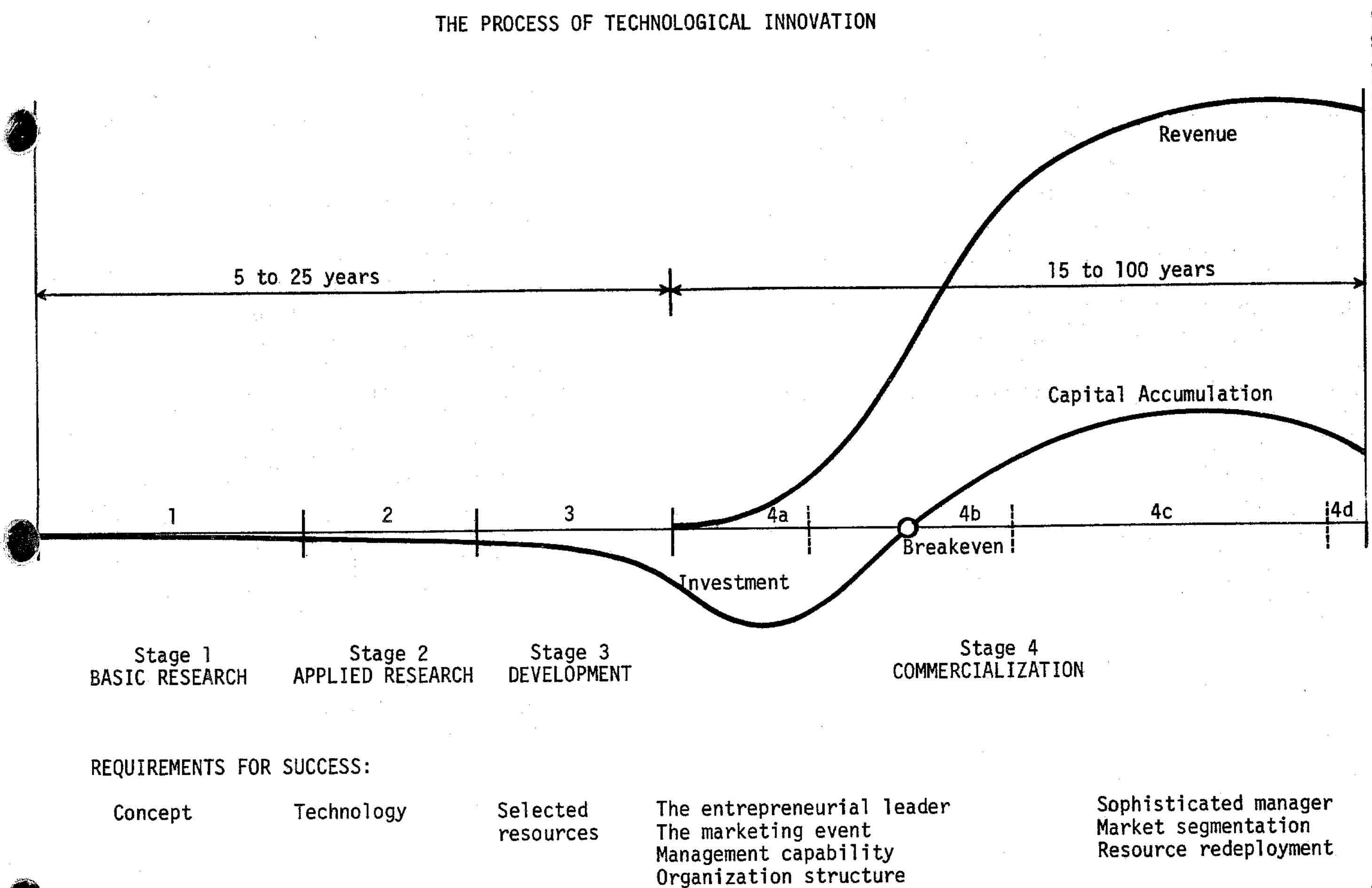

FIGURE 1

financial statements and our ROIs have become fiction before our eyes and we're only just beginning to notice. New measures are needed to improve our vision.

Performance Areas

The new measures will include more than profit measures. They will include all of the key performance areas important for business success:

Profitability
Market position
Productivity
Innovation
Physical and financial resourses
Motivation and organization development
Public and environmental responsibility

The new measures — both of the economy and of company performance — will not be measures of *no* growth, but rather will be measures of a *different* growth. By about age 18 or 20 all of us stopped growing as we define growth in a physical sense. But our growth as individuals has continued. In all the things that matter most our growth can go on through a lifetime.

Jonas Salk in his book, *The Survival of the Wisest*,[4] describes the transition from physical growth to quality growth as the transition point of a sigmoid curve, commonly found in the biological sciences. In the early stages all is growth, expand. As growth continues, feedback gradually changes and growth slows to level off at some optimum. Applied to our economy the transition is to a different kind of growth requiring quality measures along with the quantity.

Extrapolation of past trends ignores this transition. These trends, as reported in the Global 2000 Report to the President, "Will lead to a world that, at the turn of the century, will be more crowded, more polluted, less stable economically, and vulnerable to disruptions than the world we live in now."[5] Projections of the old measures do not "see" the reshaping now going on in today's period of transition. The outcome is by no means certain. Nor have we found the appropriate measures. All that appears certain to virtually all students of the comtemporary change is that we are now undergoing some kind of major, historic transition unlike anything in the past. For the timid, change is frightening. For the satisfied, change is threatening. For the confident, change is opportunity. In fact, without change there is no opportunity. Growth is one kind of change. In the transition we are now going through there is new kind of change; new kind of opportunity.

New technology supplants old technology to provide increased value to users. Yet the new, emerging technology is typically "unseen" by the practitioners of the old. More than a century ago sailing captains could not see a steam engine in an iron hull. Half a century ago the chairman of Baldwin Locomotive advised his shareholders that "steam has powered America's railroads for a hundred years and will continue to do so." What are the technologies of the coming long wave? What are the innovations that will drive our economy over the coming decades? And who are the entrepreneurs and the entrepreneurial companies that will make it happen?

The new innovations in some form, at some stage, are discernable now, for the process of technological innovation extends over many years, as shown in Figure 1. The great new innovations of the 1980s are today in stages 3 and 4a of development and commercialization; some perhaps in 4b, rapid growth. For each successful innovation the essential elements are seven:

The concept.

The technology.

Selected resources.

The entrepreneurial leader.

The marketing situation, matching need with technology.

Management capability.

Organizational structure encouraging change.

In many companies, especially large companies, these elements — or some of these elements — are lacking. When this is so, the result is too much development effort with too little entrepreneurial result. Most often the explanation for failure or limited results is some combination of inadequate management capability, organizational structure, and perhaps lack of an entrepreneurial leader. Successful innovation changes the company as well as the product. In the early development stages free form or task force structure is needed, with controls informal and qualitative . . . all motivated and made to get results by the entrepreneurial leader. All this is more than some old-line organizations can handle. The result is that innovation happens somewhere else. Small companies are the major "somewhere else." But in the decade of the 1980s large companies, too, will have to be small where innovation is the game. "The company way" will vary, depending on the task at hand. The large companies of today, where this is not the case, will not be the large companies of the year 2000. In this age of transition, in this period of great innovation, the great companies of 20 years hence will be created.

Successful Methods

Because innovation is so important, companies have studied the process and tried to rationalize it and specify it in algorithms. In my experience I have seen such efforts more successful in producing work than in producing innovation. Analysis can not produce the answers, for innovation is about the future which can not yet be known and is yet to be created. Heuristic methods work better than algorithms. I have lead, or participated in, a number of important new ventures. From this experience I would characterize some commonly used methods as rather less productive, while other methods only beginning to be recognized, produce far more in results:

LESS PRODUCTIVE METHODS
Criteria
Check lists; rating scales
Centralized review groups
Market studies
Financial analysis
System of procedures

MORE PRODUCTIVE METHODS
Concept development
Decentralized responsibility
Finding market opportunity which can be expressed as a superior customer value
Relating to company strategy
The entrepreneurial leader
The organizational structure

In what I have described emphasis is on the key role of the entrepreneurial leader, the individual who makes something new happen. He changes the technology. He changes the market. He changes his company. What kind of person is this? The following are important traits:

Good physical health

Superior conceptual abilities

The broad thinking of a generalist

High self-confidence

Strong drive

Basic need to control and direct

Moderate risk taking

Very realistic

Moderate interpersonal skills

Sufficient emotional stability

Low need for status

Such people will be the entrepreneurs of the new technologies of the 1980s. They will form and build their own companies. And they will work successfully in large company organizations, conditions permitting. And what will they be innovating? What will be the important "new wave" technologies responding to the economics of the 1980s? Four broad, general areas can be discerned:

1. *There is a need to shift from the intensive energy economy we have built up to one which is less energy intensive.*

Many significant innovations will respond to this need, such as:

(a) Membrane separation techniques.

(b) Photo-optics.

(c) Biotechnology—alcohol fuels, single cell proteins from cellulose, beneficiation processes, nitrogen-fixing crops, alternates to chemical fertilizers and pesticides, pollution abatement.

(d) Enzyme chemistry to produce products of great purity, using less energy, and reducing waste.

(e) Replicated photosynthetic fixation of carbon. Natural photosynthesis produces a thousand billion tons per year. We can harvest, but with microbial photosynthesis combined with anaerobic digestion we may also produce.

2. *There is a need to restructure industrial processes in terms of the emerging structure of costs and*

constraints: cost and availability of fossil fuels, less pollution, reduction of health and safety hazards to workers and customers, recycling of wastes.

Innovations responding to this need may include:

(a) Inorganic-base polymers.

(b) Recycling technology.

(c) Recovery of materials from pollution abatement processes — sulphur, ammonia, mercury, metals, cellulose, aromatics.

(d) Production of aluminum, iron, titanium, cement from fly ash.

(e) Robotics.

(f) On-site generation of energy, including co-generation, solar collectors, wind turbines, low-head hydro.

(g) Efficient, non-polluting transport systems, including improved rail and inland waterway transport, fuel-efficient vehicles, power stations at the mine or energy source, and in some instances information-exchange systems to make transport unnecessary.

(h) A changing economics of scale as the new costs and constraints make smaller scale and flexibility and nearness to markets more cost-effective than large-scale centralization plus distribution.

3. *There is a need to develop the opportunities in the use of the one free source of energy — the sun.*

Innovations satisfying this need may include:

(a) Extending forest products increasingly into fuels and chemical raw materials such as by pelletizing of waste products; acid or other hydrolysis of cellulose to glucose with anaerobic fermentation of the glucose.

(b) Use of farmed crops as a cource of hydrocarbons. The many candidate crops that are being studied and developed include: sugar cane, sugar beets, castor beans, jojoba, copaiba, guayule, algae, cassava, gopherweed, leucaena, wood chips, kelp, and agricultural residues.

(c) Solar cells.

(d) Hydroponics.

(e) Use of ocean thermal gradients and other low delta-T sources for power generation.

(f) Solar heating and cooling.

(g) Solar separation of hydrogen from sea water.

4. *There is a need for improved ways of sensing and transducing data, determining the appropriate information, and applying the information to productive purposes.*

Along with labor, capital, and raw materials, "information" is emerging as a major input requirement in the creation of value. Innovations in this rapidly growing area include:

(a) The great increase in computer memory capacity, from the 8K random access memory chip to 16K to 32K to 64K making available almost simultaneously microprocessors, microminis, micromidis, micromaxis, and micromainframe computers.

(b) CAD/CAM programs and equipment to automate design and manufacturing, greatly expanding the capacity of professional talent to improve productivity and to innovate.

(c) Specialized computer systems for each of the professions.

(d) The application of electronic controllers in virtually all kinds of machinery and equipment, from machine tools to automobiles and consumer products.

(e) Low-cost color and graphic outputs.

(f) Menu systems enabling man-machine interaction to develop a desired result.

Two balloonists were floating over the countryside and became lost. Passing over a small town, they saw a young man with a briefcase walking briskly down the street. One of the balloonists called down, "Where are we?"

Looking up, the young man called back, "In a balloon!"

The balloonist looked at his companion and remarked, "That man is an MIS computer programmer."

"How do you know?"

"As usual . . . right data; wrong information."

For too long we have thought of our computers as data processing machines, processing the enormous numbers of counts and measures entered by the various input sensors and systems. Now we are beginning to use computers as information machines, helping us to obtain the information from the data that will help us to achieve a desired result. Data are the raw material for information. Information is what changes us toward the achievement of objectives. In the 1980s we will see the computer emerge as an information machine to increase greatly our capability in the two key areas of business performance in this time of transition — (1) improving productivity, and (2) innovating the new.

Measures Inadequate

By presently used GNP and financial statement measures the economic situation in our country and in our companies is troubled; the outlook gloomy. But much of the pessimism lies in the measures we are using. Right for a past time, they are inadequate for today. They do not "see" the reality of the change in this time of transition. They do not sense the opportunities of the new technologies now emerging. They do not recognize the new growth, more qualitative than quantitative.

During the 1980s we will find new measures for the changing world we are living in — new measures for our economy, and new measures also in our businesses and for our technologies. Economics — the old we know and the new we will learn — largely determines the technologies that will matter. The new economics is now spawning the new technologies that will drive our economy in the years ahead. Productivity will be one important dimension; innovation the other.

As I see it, licensing executives must be more than technicians in the transfer and dissemination of the emerging new technologies. The opportunity and the need is for you to become entrepreneurs of the technology of the new economics of the 1980s.

A licensing executive died recently and went to

Heaven where he met St. Peter, who informed him that he would reside forever in Heaven. But first he would like to show him souls in both Hell and Heaven. St. Peter then escorted the licensing executive into a hall where there was a large table with a steaming bowl of stew. Around the table sat poor, emaciated souls with hollow, staring eyes. Each firmly grasped a long-handled spoon, but all were starving. "The handle is too long to get the food to their mouths," explained St. Peter.

Then he escorted the licensing executive into another hall just like the first. Again the large table with the steaming bowl of stew. But around this table, also with long-handled spoons, sat well fed, joyful souls. "I don't understand," exclaimed the licensing executive. "All is exactly the same, yet here the souls are happy and well fed!"

St. Peter answered, "It is very simple. Here, in Heaven, the people have learned to feed each other."

For the emerging technologies of the 1980s that is the kind of role that can be played by the licensing executive. Technology transfer will be an important part of the development and proliferation of the new technologies. The opportunities and the challenges are clear. You professional licensing executive can be entrepreneurs of the great new technologies emerging in the 1980s.

NOTES

1. Gerhard Mensch, *Stalemate in Technology,* first published in Germany, 1975, translation, Ballinger Publishing Co., Cambridge, Mass., 1979.

2. J. W. Forrester, G. W. Low and N. J. Mass, *Capital Formation and the Long Wave in Activity*, System Dynamics Group, Sloan School of Management, MIT, July 7, 1977, pp 34-35.

3. Dr. Victor A. Weisskopf, "Avoiding Nuclear Holocaust," *Technology Review*, October, 1980, pp 28-32.

4. Jonas Salk, *The Survival of the Wisest*, Harper & Row, 1973.

5. Dr. Gerald O. Barney, *The Global 2000 Report to the President*, The White House, 1980.