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MARKET NEED

vs

TECHNOLOGY PUSH

by

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August 1991

Contents

MARKET NEEDS vs TECHNOLOGY PUSH

Market dimensions

The "Market" can be seen from several perspectives, ie

* Geography
* Customer
* Product

Below we will discuss megatrends and a few other factors which are decisive for corporate strategies in choosing markets and technologies.

1. Megatrends

Whatever perspective is chosen there are certain overriding trends - Megatrends - which determine the long range development of the Market (and Technology).

The most important Megatrend is the development of the world's population and its geographical distribution.

* Population

The world's population is now about 5.500 million. It is expected to be 6.000 million at year 2000.

Different predictions estimate that the world's population will level out (no of births = no of deaths) at about 10.000 million at around year 2075.

Each of these 10.000 million people is a potential customer of goods and services. The global need of infrastructure (roads, housing, energy, communications) is enormous.

In year 2025 Asia is predicted to have 4900 million, Africa 1580 million, North America 595 million, South America 498 million, Europe 512 million and Soviet Union 350 million. The World's total population in 2025 is predicted at 8466 million (Ref. World Resources Institute, Washington D.C. 1990). Between now and 2025 is not a long time. It is what it takes to build a railway network in a country or an energy network.

* Growth of Megacities

A consequence of the population pressure, specially in developing countries, is the growth of cities. This causes great problems in many countries with underdeveloped infrastructure. The market for construction and transportation industry is practically infinite.

World's total urban population is predicted at 5120 million in 2025 (2260 mil. 1990), of which 4050 million in less developed regions (1385 mil 1990).

* Global trade expands

During the postwar period (since 1950) the expansion of global trade has been twice as large as that of gross domestic products. Liberalisation of world trade has been pushed by consecutive rounds of GATT (General Agreement on Tariffs and Trade). Product development, like trade, must be seen in a global perspective.

* Geopolitical changes

As a result of the economic expansion - through technology and world trade - the geo-political arena has changed dramatically, specially during the last ten to twenty years.

The concept of sovereignty has been eroded. No nation can survive alone.

There is a clear shift from military strength and sovereignty to economic and technological strength (eg Japan and West Germany).

East-West conflict (cold war) is over and will be substituted by the North-South conflict, ie between rich and poor countries, both globally and regionally.

* Economic changes

A nation is an un-natural unit. A modern nation needs to be a global trader. Japan decided on such a policy after its embarrassing defeat in World War II. Japan has succeeded and now serve as model for other countries.

In June 1990 Europe (EEC) passed USA as the largest and richest market in the world.

Gradually EEC will incorporate Eastern European countries in its economic space. This means a market of about 500 million people.

In the Americas, USA and Canada has agreed to remove trade barriers by 1999, creating a North-American free trade zone. The inclusion of Mexico is under negotiations and President

Bush has proposed the integration of South and North America in a gigantic free trade region of "the Americas".

Worldwide, this kind of borderless phenomena are going to unite the wealthy nations of the North, but will create great problems with the South.

The wealth today is created in the market place, no longer by natural resources of primal qualities. Intellectual properties, technology, good education, hard work and entrepeneurship are the key factors for creating wealth. These factors are decisive in the competition between the three major actors in the world economy, ie USA - Europe - Japan, but ultimately also between the North and the South. Ideologies play a smaller and smaller role.

("The end of History" by Fukuyama).

2. Market (Needs) determines Technological Innovations
Facts and Model

* Facts

Technological Innovations are often manifested by patents, trade marks or some other form of immaterial rights protection.

Research results are usually manifested by publishable reports or dissertations.

Many investigations in the past show that the primary factor in triggering an innovation is a well manifested need rather than a technical possibility. On average a need or market demand determines the innovation in 75 percent of cases while technology per se is the origin of only 20-25 percent of successful innovations.

Measured by number of patents the origin of innovations (patents) can be summarized as follows:

	No patents individual/year
Universities	<0.02
Collective res. institutes	~0-0.01
Innovation companies	2-3
Smaller companies	1.8
Larger companies	0.2

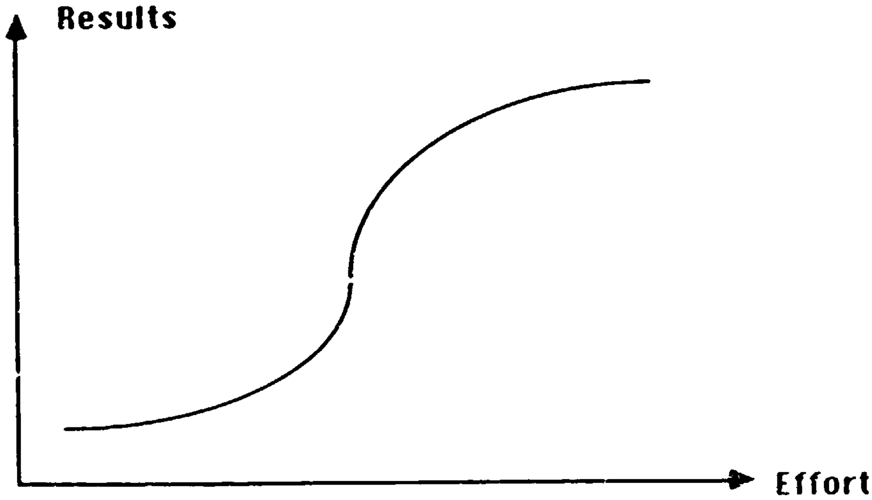
The above figures are averages for Europe and USA. They are about 10 - 15 years old. The situation has changed somewhat today with the advent of "science and industrial parks" around universities.

But the general conclusion still holds that scientists in universities are (and should be?) less sensitive to market needs while inventors are more problems- and market oriented.

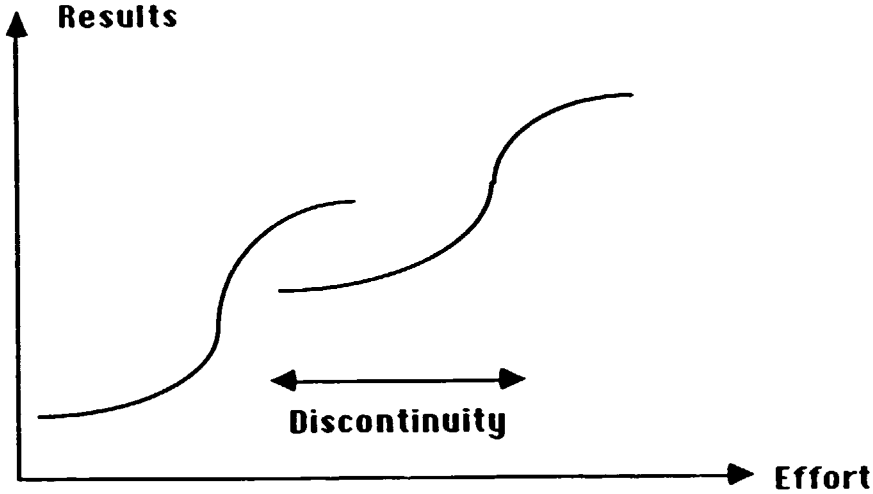
* Product life cycle

Technologies are born, grow strong, mature and finally die, overtaken by a more competetive alternative

The potential of a technology can be illustrated by the well-known logistic curve.



The challenge for any company is to manage to "jump" with technology changes. One can just imagine what IBM would have been in relation to Apple if IBM had not taken on the PC at the very last moment. Many more die in the process of discontinuity illustrated below. And IBM does have problems today.



Warning signals indicating when one is reaching the end of a product life-cycle:

1. Consensus that present R & D results are unsatisfactory
2. Increased number of missed deadlines and cost exceedings
3. R & D focus shifts from product to process orentation
4. Lowered creativity in R & D
5. Low spirit and worries among R & D staff
6. Potential business expansion based on narrow market segments
7. Large differences in R & D costs between competitors without visible results
8. Changes in R & D management without visible results
9. Narrow market niches lost to small new business.

* Market pull and Technology push

* Market pull

Many products are developed from a market need situation. Most companies today emerge in this way.

Ideally a new product is developed in close cooperation with a potential customer. If there is more than one customer with the same need, the company is in repetitive business and can grow strong and rich on that product.

However, the customer can usually not explain needs he does not perceive for the future. For example; TV would never have been developed from customer demands. The same can be said about the 'Walkman' for which SONY in Japan created the market. This is where we find the border line between Market need and Technology push.

* Technology push

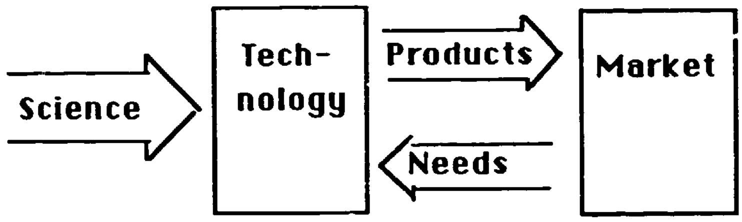
The alternative is thus to develop products from a technical opportunity. When the airplane was developed the Wright brothers had no intention of entering the tranportation business. The same can be said about Shockley, Bardeen and Brittain when they developed the transistor, for which they got the Nobel Prize. In both instances technical and scientific curiosity was the driving force.

However, the way from science to commercial success is long, costly and troublesome. Only those companies which are organized to take care of new technical opportunities better than their competitors have a chance to succeed on the market.

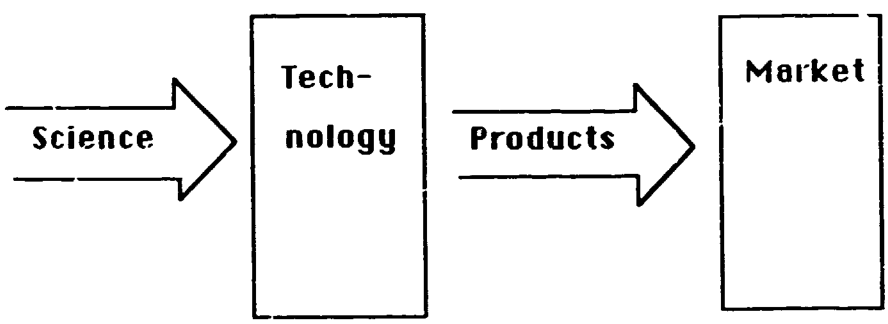
Creative skills should never be used to develop products for their own sake. If there is no customer, willing to pay enough for a new product, the chances are small for success by Technology push. The Japanese have proved to be particularly successful in introducing new products on the market.

* Models

The illustrations below are meant to show the "models" of Market pull and Technology push respectively.

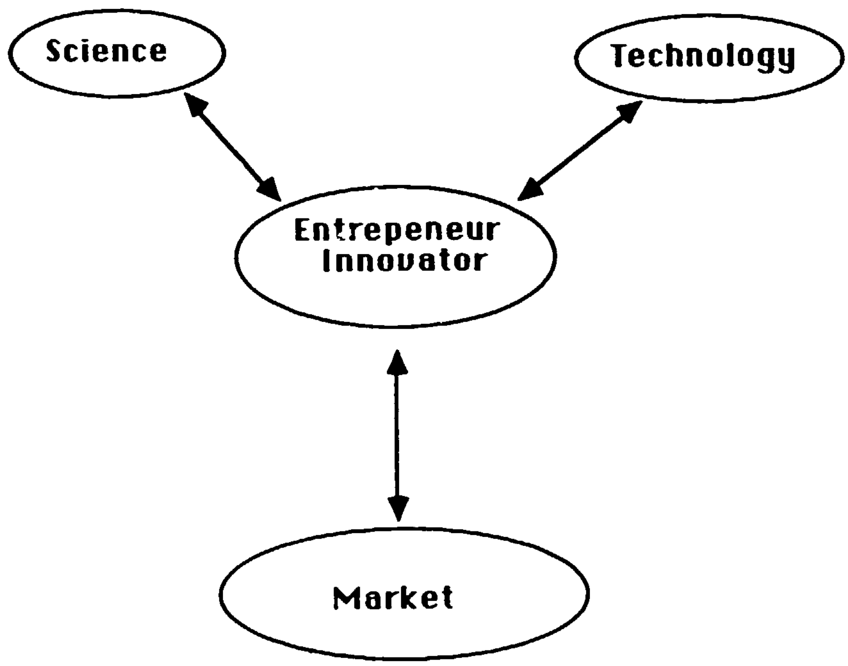


Market pull



Technology push

Another way of developing new products has been expressed by Christopher Freeman at SPRU in England in the following way;



According to Freeman the key person is the Entrepeneur/Innovator who takes in information from Science, Technology and the Market in an iterative and rather disorderly manner to reach to a new product concept.

This view is close to the 'chaos' model of creativity and innovation, which we will discuss later.

3. <u>New Challenges</u>

As mentioned earlier the world scene is under continuous dramatic change which affects company R & D strategies and technological development in a significant way. Both the geopolitical and customer map changes continuously and concurrently new challenges will be facing companies in the future. A few of these new challenges are discussed below.

* Towards free market economies

One great challenge is the collapse of command economies in which grandiose five-year plans have been decisive for industrial development. Instead the market forces will be determining product development and the introduction of new technology both on a short- and long-term basis.

The same can be said about the South, ie developing countries, which are now demanded to introduce open free markets aimed at meeting their own needs. In both cases western investments and joint ventures will increase and technology and innovations will play an important role.

Local creativity and innovations for development will be stimulated and facilitated through education and exchange with Western industrial countries. In Sweden has been established a special organization (IDEA) for the encouragement and promotion of creativity and entrepeneurship of innovations in developing countries. Swedish official development assistance policy is under serious scrutiny.

Peoples Republic of China and Taiwan were the same country 45 years ago. Today Taiwan's per capita GNP is 8000 dollars while China's is about 350 dollars. Singapore with 2 1/2 million population has a 8.000 dollar per capita GNP which was reached in just the 20 years since she declared independence from Malaysia, which has a per capita GNP of 1800 dollars.

The same can be stated about such countries as Hong Kong, South Korea and a few countries in South America.

It is wise to remember, however that so called "high technology" is not necessarily a panacea to economic progress and prosperity. In the end, the wealth - producing forces of any economy are its immaterial resources - not oil or gas, copper or iron, but rather the intellectual and organisational skills if mobilized in a open, competitive and democratic system.

It is symptomatic that many of the most successful economies such as Japan, Switzerland, Taiwan, Hong Kong and Singapore, have practically no natural resources on which their progress could be based.

The innovative capacity of the industrial countries is facing an enormous challenge in joint development with those countries which are now determined to integrate their economies with the open world economy.

* Civilian and military technology

World War II marked a phenomenal success for scientific innovation and goal-oriented research specially in Europe and USA (eg the Manhattan project for the atomic bomb).

The military-industrial complex became an institutionalized mechanism for channeling gigantic funds to advanced research for military purposes.

These efforts eventually led to spin-offs of products for the civilian sector. USA was rather successful in this while Soviet Union failed completely in deploying military research for the needs of its people.

Japan and West Germany have demonstrated that they could build an industrial machine entirely focused on the civilian market. The American model of S & T is under serious scrutiny and the Soviet model has literally collapsed.

A new challenge for all countries with large spending on military R & D is to shift from military product development to products aimed for the civilian market. It is today increasingly difficult to distinguish military from civilian technology when it comes to quality, performance and reliability. It can no longer be claimed that the leading edge technologies come from military R & D.

Enormous resources and skills will have to be re-oriented towards the civilian market needs. In this we have a lot to learn from Japan and West Germany.

* Sustainable development

With closer international cooperation, increasing economic and ecological interdependencies can give rise to new and non-military threats to national security and survival.

The Independent Commission on North-South led by former German Chancellor Willy Brandt stated in 1980:

"Our survival depends not only on military balance, but on global cooperation to ensure a sustainable biological environment, and sustainable prosperity on equitable shared resources".

The latest independent commission led by prime Minister Ms Brundtland of Norway dealt specifically with the environmental issues of the world. The report, published in 1988, was called "Our Common Future", and stressed again, like the Brandt report, the necessity of international cooperation for ecologically sustainable development.

Massive and potentially irreversible environmental destruction is consuming the earth's resource base.

Between 1950 and 1983, 38 percent of Central America's and 24 percent of Africa's forest disappeared.

Logging, agricultural expansion, and urban growth contributed to the destruction of forests, which undermines development by destroying watersheds, reducing fuel and materials availibility, destroying species, and affecting the global climate. The so called green-house effect from rising atmospheric concentration of Carbon Dioxide (C02) is already underway. Between 1950 and 1983 the level of C02 emissions tripled. The largest portion is due to the industrial countries, but thefastest growth of emissions has been in developing countries. Environmental problems are exacerbated by the population growth of 86 million each year. Almost all of the growth in global population has been concentrated to the developing countries, where human demands often overtax the local ecosystem.

The potential of new technologies for vastly improving human well-being is great.

Microelectronics can be applied to development problems even in the poorest countries.

The new telecommunications technologies can permit education to spread widely and cheaply.

Many potential biotechnology applications are of great significance for developing countries. Biotechnology is less capital intensive, less energy demanding, and usually less sophisticated and complicated than current physical and chemical industrial methods.

Prof. Hedén of Sweden has created the BioFocus Foundation for the mobilization of experts in biotechnology through a computer network to tackle defined problems in developing countries. The great challenge before us is to integrate new technological opportunities in a harmonius and organic manner into the economic development plans of countries and business plans of companies so that local and regional eco-systems can be sustained for the long term benefit of the countries. This challenge is indeed equally demanding for industrialized and developing countries.

At a meeting in Maastrich, Holland in November 1989, IFIAS presented the following agenda for action on "Restructuring for Sustainable Development"

1. Ecological restructuring of the Economy
2. Preventive environmental policy
3. Ecological orientation of economic policy
4. Clean Technology
5. Sharing global environmental costs.

4. <u>Mobilizing Research and Innovation</u>

The demand from market and the new challenges discussed above put great pressure on the research at universities and institutes as well as on our ability to deliver solutions of the problems indicated above. The challenges are enormous and require new tools and organisational models, so that we can become more efficient in harmonizing the needs of the Market with the skills and capacity of Research and Innovation.

Let us first agree that Research - specially as it is carried out at Universities - is not the same as Innovation. Research generates new knowledge while Innovation results in new ideas or products on the market. As products and services in society contain more and more of knowledge and science inputs it is important to create mechanisms and organisational structures that facilitate the transfer of research results to practical utilization. However, instead of quarreling about definitions of what is research, invention or innovation we should focus our interest on how best to take care of new ideas for industrial and societal development.

The Swedish company Fläkt, one of the world's leading airconditioning companies, has made the following list of "How to keep informed and to find the new ideas"

* Commitment by top management necessary
* Effective R & D organisation
* Unit for business development
* Unit for information search
* Active patent group
* Goal-oriented innovation search
* Focused external search, through
    * Travel
    * Customers
    * Competitors
    * Universities
    * Science parks
    * Research institutions
    * Venture Capital
    * Technical council
    * Recruitment of qualified staff
    * Continuous education.

Several similar examples can be given. Common for them are the matching of R & D with the business goals of the company.

On the Research side we have lately been witnessing the emergance (explosion) of science and industrial parks around universities.

This is certainly an interesting step towards bringing scientific research closer to the market, but it has still not been proven how effective this mechanism is. The most important change has to do with tradition and attitudes on both the University side and the Industry side.

In an interesting article in Financial Times of June 21, 1991 called "The role of research: when less is more" is discussed how Western countries must learn to bring sophisticated products

quicker to the market. The trouble, the article states, is that more R & D does not automatically mean better.
Many heavy research spenders in industry have learned that however good a central laboratory may be, it does nothing for profits and long term survival if the rest of the company cannot exploit its output effectively in the market.
As "Third generation R & D" explains the role of industrial research has changed radically since the days when R & D departments could be left to come up with brilliant innovations simply by persuing their intellectual curiosity. Shorter product lives, fiercer competition and rapid exhaustion of new technologies have brought a need for more focused research, harnessed to corporate objectives (discontinuities).
New product development involves multiple transfers of knowledge (and trust) within the company and with external partners such as universities. The linkage with senior management is pervasive, the challenge of managing R & D for results is to develop these interfacial linkages so that, in the ideal case, linkages and transfers are automatic, hardly observed by their participants.

"Third Generation" R & D offer the following guidelines:

* Involve researchers in overall business strategy by explaining to them clearly and encouraging them to challenge it.
* Avoid excessive specialisation of research in narrow disciplines.
* Assign researchers to projects on the basis of character and personal skills, not just of formal qualifications.
* Regularly rotate staff, particurlarly new recruits, between R & D and other corporate functions - in both directions.

These are not necessarily original ideas. They are already applied by Japanese companies, and we know the results.

INDUSTRIAL COMPETITION

and

MARKETING OF SCIENTIFIC PRODUCTS AND INNOVATIONS

by

Dr Sam Nilsson
The Innovation Institute, Sweden

August 1991

Content

INDUSTRIAL COMPETITION AND MARKETING OF SCIENTIFIC PRODUCTS AND INNOVATIONS

1. Scientification of industrial production

When discussing industrial competition we are essentially dealing with productivity, ie the efficiency of industrial output in terms of costs for material and labour. The company which most effectively can use the factors of production has a competetive edge over its competitors. Today's most important factor of production is educated labour and scientific information. This is why industry is moving closer to and indeed into the environment where scientific results are being produced, ie the world of universities and research institutions. This, on the other side, confronts science and scientists with difficult dilemmas concerning the independence and autonomy of research. These are moral questions.

There is science for understanding and science for manipulation and while they merge into one another, and the former frequently now provides the basis for the latter their styles and motivation are different. Science for understanding is an expression of human curiosity, the need to devise an intellectually graspable model of the natural world which enables us to find our way around it, to think about it coherently and to realise how things we observe 'hang together'.

Emotionally the development of such intellectual models derives from the sense of wonder in the face of nature and has much in common with the creative work of artists.

This was the motivation of Einstein which eventually led the famous formula

$$E = mc^2$$

which expresses the equality of Energy (E) and matter (m). Few, if any, scientific achievements have more profoundly demonstrated the dilemma of scientists we mentioned above when it comes to science for its own sake and science for applications. It has been said that a society which demands of its practitioners that they subordinate their imagination to the priorities of the accountant, the official and the military machine will destroy their creativeness as surely as if it imprisoned them in concentration camps.

One of the greatest achievements of organized manipulation of science, the Manhattan project for the production of the first atomic bomb, was exactly such an intellectual "concentration camp".

This, however, is not to suggest that science motivated by the desire to manipulate aspects of the world in which we live has nothing in common with science for understanding or that it does not have a legitimate place among human activities, but rather that their purposes are different, the attitudes of mind of those who practise them may well conflict, and above all that science for manipulation must be justified by its results. It should be required to demonstrate that the benefits it confers on humankind outweigh their costs - material, social and spiritual.

The famous Dutch physicist, HG.B. Casimir, who was one of the pioneers in guantum physics and who eventually became the Research Director of the giant Dutch electronics corporation Phillips, once stated that we can look at the evolution of science and its industrial applications as a <u>Science - Technology Spiral</u>. Technology, says Casimir, feeds on scientific research which uses technology for new advancements in science, and so on ....

It is another question, of course whether Industrial society - the triumph of material consumption is a determinant if good and happier life.

The phenomenal success of the Industrial Revolution has led to the expectation - combined with the much advertised confidence that science and technology could provide a limitless flow of new materials, new sources of energy, new knowledge, processes and tools to keep the cornucopia of commoditites overflowing - provided the apparant justification for faith in industrial society: a vision of steadily increasing material prosperity filtering down to the poorest levels and spreading progressively into less industrially developed societies across the world. This expectation and vision drive the competition of today's industries. The scientification of industrial products is one of the <u>comparative advantages</u> of industry of today compared with industry of easterday. The moral questions discussed above are, however, now also beginning to enter the agenda of industry. In Japan industrial leaders talk about a new moral for industrial development and technoethics. We will revert to these issues later.

2. Comparative advantages

There are a number of comparative advantages which must be used systematically by industry if it is going to compete favourably with other industries. We will discuss a few of the most important comparative advantages.

* Technical development

  It is not necessary for any particular industry to master all aspects of a particular technology to be able to use it for its own competitive strength. In fact, Japanese industry has been very successful in translating science and technology to marketable products, not so much because it has entertained its own advanceed technological development but because it has been able to use available knowledge on the world's "supermarket" of technology, which mostly has been delivered and paid for by other industrial countries. Former foreign minister of Japan, Dr Saburo Okita has stated that Japan still today to about 50 percent is a "copying" society. How true this is, is difficult to tell, but it is only fairly recently that Japan began to produce new products from its own investments in (basic) research.

  The Table below shows how the expenditure for R & D in different parts of the world have changed since 1970. While USA and the EEC are pretty constant, Japan has increased R & D quite dramatically between 1970 and 1983.

Distribution of R & D Expenditures (percent)

	1970	1975	1980	1983
World total	100	100	100	100
Industrial c:s	72.5	70.2	72.7	72.7
EEC	20.3	21.6	21.5	20.9
Japan	6.7	9.5	11.7	12.6
USA	39.9	33.3	33.7	33.4
CMEA c:s	25.2	27.1	24.4	24.2
Developing c:s	2.3	2.7	2.9	3.1

(Trade and Dev. Report 1987 (New York, UN. p.78)

* Intrapeneurship

Another comparative advantage is the degree to which a company is able and willing to put into practice the ideas proposed by its own employees. We call this intrapeneurship. The company 3M in USA has been one of the pioneers in this and many European companies have adopted this method of product renewal with great success. We will look at a few examples later. In Japan the structure of industry and the tradition is different. Here we have gigantic corporations like Matsushita Electric and Sony, which however, in spite of their size have been able to maintain the spirit of internal inventiveness. One of the reasons is that these companies were once created by such entrepeneurs and inventors as Matsushita and Ibuka and Morita of Sony. Another reason is the unlimited interest of Japanese people in new products. And the Japanese market consists of 120 million people. Proposals for changes of production or product improvements from the employees are 10 - 100 times more frequent in Japanese companies than the averages of European companies. Japanese companies respond immediately to new proposals and the awards to the employees are usually not economic but practical. Here the employees will be able to see their proposals put into practice directly while the formal procedures in European and US companies often delay the practical applications, which of course has a discouraging effect on the proponants. In Japan the top management gives its full and direct support to changes while in Europe and USA the opposite is not uncommon. Below is shown a list of argument called 'Idea Killers' which many people will recognize.

IDEA KILLERS

"It's against company policy".

"Top management would never go for it".

"That's beyond our responsibility".

"Has anyone else ever tried it?"

"That has already been tried in . . . ".

"It won't work in our industry".

"No-one would ever accept that".

"It's not feasible".

"It would be too expensive".

"Let's hold it in abeyance".

"It would be too impractical".

"We're not quite ready for that".

"It was tried years ago and . . .".

"It's not new, it reminds me of . . . .".

"That would never work because . . . .".

"I remember reading about something like that".

"But what would you do about . . . .".

"I considered that myself once, but . . . .".

"It's great but ahead of its time".

"We've never done it that way before".

"But it may make our other products obsolete".

In Finland: Have they tried it yet in Sweden?

In England: Has ICI tried it yet?

In Japan: Where are the case studies?

In the USA: Put it down on one sheet of paper

THE UNIVERSAL IDEA KILLER: .... SILENCE.

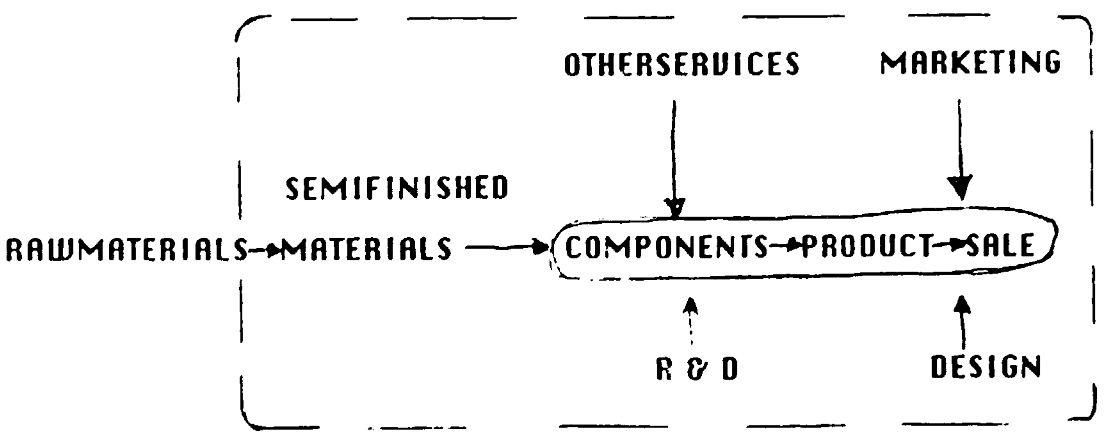
The "Idea Killing Phrase" used most in your company: ______________________

* Technical development moves closer to the Market

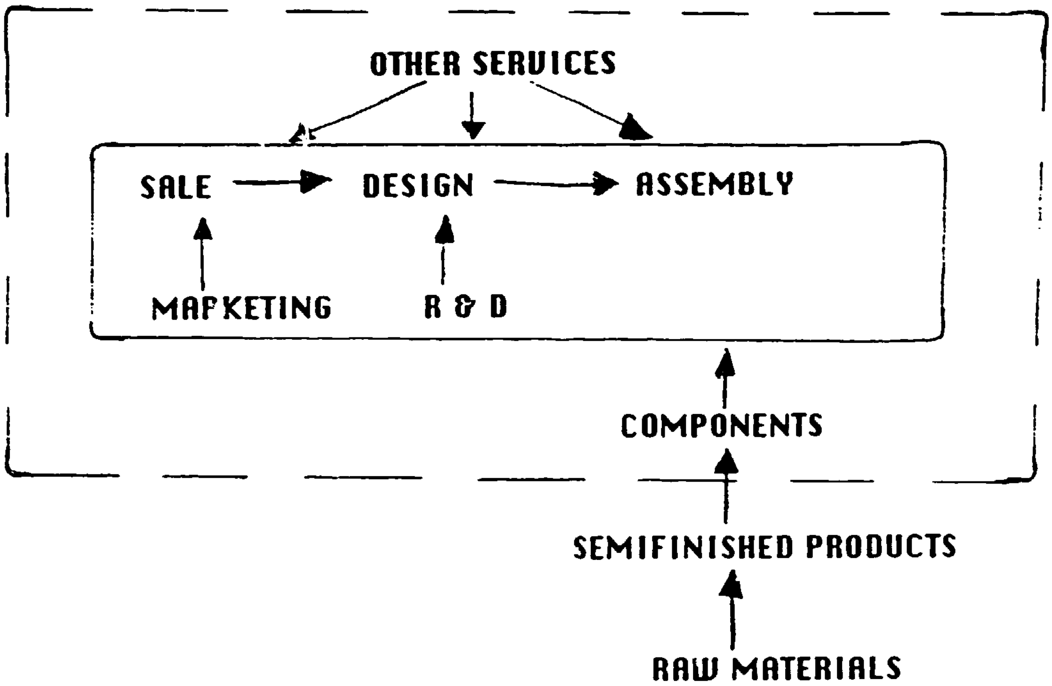
We discussed earlier that scientists in a company must be made more aware of the business idea of the Company if the in-house research will affect more directly the profits of the company. But the technical development of the company must also be made open to impulses from the market.

Present development in information technology (IT), of which Prof Ian Angell and his team from London School of Economica will tell you more, has had a profound influence of company structures. In the figures below are shown the structures of the Traditional company and the Modern Company. As is seen the core activities of Marketing, R & D and Design can be more closely integrated in the Modern company while subcontractors will be responsible for systems and components which are assembled into the finished product to be sold on the market. The activities requiring the most sophisticated knowledge content are kept inside the company while the standard components are bought from subcontractors outside. This increases the flexibility of the product development and will allow more custom-adapted products. At the same time this development of the Company Structures puts higher requirements of technical development and services of the subcontractors. This also leads us directly to the problems of management of technology and complexity.

TRADITIONAL FIRM



HOW THE NEW TECHNOLOGIES CHANGE THE F I R M



* Management of rapid turn around

A few years ago some 700 companys executives in Europe where interviewed about the future of their business. Their answer to the question "Which is the most difficult challenge during the 1990's" was "Management of Technology".

This challenge can be met by improving the ability of assemblying and understand the flow of information available to practically everyone in todays society. Many people think that this ability is still on a 17th century level.

The technical development should be able to help us to liberate the creative forces for the use of information.

Our ability to create understandable messages from the abundant flow of information has not, however progressed nearly as fast as our ability to transfer, store and multiply information.

This will be one of the most important comparative advantages in the future.

The Japanese are considered to be best in "generative learning" or "creative knowledge" in contrast to the Western "reactive instinct".

There is a need to change education in a direction that leads us away from fragmentation of knowledge towards a more holistic perception.

The hierarchical structures must be broken down and information must be disseminated in wider circles so that people get more time to think and reflect on the information they get. A democratization of information.

The structure of the organisations of information society will be flat and based on networks.

To summarize:

* The Individual and his creative capacity will be the focus
* The award for the individual will be personal development
* Permanent and fixed work instructions will be avoided as much as possible
* Information will be disseminated in all directions which are relevant for the work in the company.

The technical development department of the Swedish company Fläkt (air conditioning company within the ABB group) has presented the following list of measures to meet the discontinuity in product concepts we spoke of earlier;

* Introduce hybrid products quickly
* Optimize costs and prolong life of 'old' products
* Create a vision of the future
* Communicate the vision at all levels of the company
* Create a preparedness and will for changes
* Be humble

3. <u>Time - to - Market</u>

A very important new concept introduced by Japanese industry is Time-to-Market. This is the time between deci sion to develop a new product and the time when the product is introduced on the market.

Time-to-Market can be minimized by a number of measures·

* Recognition that the target moves with time and ususally quite rapidly
* Organization must be mentally prepared for the new product
* The Sales organization must adapt the clients to the new product because they will loose interest in the 'old' product
* The shorter Time-to Market the longer will the new product exist on the market.

Examples from car industry show that Japanese Honda has a Time-to-Market of 2 to 3 years for a new car concept while it is 5 to 6 years for car manufactures in USA and Europe.

The Japanese motorcycle manufacturer Kawasaki is trying to bring down the Time-to-Market to one (!) year. For its competitors in the West it is about 5 years. This means that Kawasaki can wait 4 years during which it can follow and learn from technological and social trends on the market, before they start development of the new motorcycle concept.

4. <u>Just - in - Time R & D</u>

Another concept related to the concept Time-to-Market is Just-in-Time R & D. This has also been introduced by Japan. There is an anectdotal story about the car name Datsun which epothomizes the meaning of Just-in-Time in a nice way. The story tells that the British, astonished about the quick delivery of the car, asked the Japanese deliverer "that soon" which caused the equally astonished Japanese to name the car 'Datsun'.

In the following three tables are presented some of the reasons why Japanese companies are so much better than their European and American competitors in bringing new products quickly to the market and Just-in-Time.

The content of these tables illustrates in an interesting way the difference between the Western scientific <u>fragmented</u> way of attacking product development and the Japanese <u>holistic</u> way to tackle all problems simultanously.

* Pops up just in time
* Is an improvement rather than revolutionary
* Reduces costs
* Fits into product family and sales channels
* Fits into manufacturing strategy

Characteristics of a good and profitable invention

PRODUCT DEVELOPMENT	
Conceptual	**Physical**
- system	- cosmetic
- structure	- mechanical
- features	- processes
- circuits	- components
- software	- manufacturing
- quality	- quality

The basic principle of just-in-time R & D is to consider ALL the aspects of the product in parallel, and NOT in serial fashion as is usual.

CURIOSITY-ORIENTED R & D Success ratio 0 - 1 %

* **radically new features**
* **new products**
* **new processes**
* **unknown markets or technology**

MISSION-ORIENTED R & D Success ratio 30 - 90 %

* **improved products**
* **better methods**
* **lower costs**
* **known markets and technology**

Classical Western research policy is centered towards curiosity-oriented creativity in order to generate "breakthrough innovations". The Japanese research and innovation policy is focused on mission-oriented creativity, which has proved to be very successful for improving products. In a normal situation, a good mix could be 20 % curiosity-oriented and 80 % mission-oriented research.

Summary of the most important comparative advantages:

How to introduce scientific products on the market

* Business sector within the company responsible for new opportunities
* Engaged person (project leader = intrapenueur) as driving force
* Sponsor in top management
* Cooperation with client
* "Timing" very important (Time-to-market)
* Encourage and award the "doers"

5. USA - Europe - Japan

* Trading zones

Against the GATT efforts to establish a global free trade market goes the efforts to establish regional free trade zones. The most prominent example is EEC in Europe, which, with gradual integration of the Eastern European countries, might become the strongest market in the world. The American politicians talk about the "European Fortress". Pushed by USA a free trade zone consisting of USA, Canada and Mexico is emerging. It is called NAFTA and eventually it may incorporate South America as President Bush has suggested. In this case it would have the acronym AFTA, Association of Free Trade of the Americas.

In Asia does already exist the ASEAN trade cooperation. It stands for Association of South East Asian Nations (Malaysia, Thailand, Phillipines, Singapore, Brunei and Indonesia).

There are, however discussions going on in Asia about creating an extended trade zone, EAEG (East Asia Economic Group) which would comprise the ASEAN countries plus Japan, South Korea, China, Taiwan, Hong Kong, Vietnam, Kambodia and Laos. EAEG would become a market of more than 1.700 million people with very young average age, which is to be compared with EEC:s 325 million and USA:s 250 million. In GNP the EAEG countries would pass that of EEC in year 2000 and is predicted to be 4 to 5 times larger than EEC in year 2050.

However, Japan has shown some resistance to EAEG because it fears that it would cause trade problems with the rest of the world. In addition there are several uncertainties in Asia which must be resolved before EAEG can be created, such as the liberalization of China and its relations to Hong Kong and Taiwan, the conflicts between the two Koreas and the tensions in Indochina.

Whatever will happen with the regional markets in the world the present industrial competition is dominated by USA, Europe and Japan.

We will look at the scientific and industrial competitiveness of these countries below.

* USA

As was mentioned earlier the high-tech development in USA has been largely based on the military-industrial complex. The well-known success of science parks around the US universities has also been largely dependent on research contracts from Department of Defense (DOD). American industry and researchers are traditionally very good at producing novel concepts and sophisticated products but generally not interested in the high quality production aimed at the civilian market. Aerospace research and industry may be an exception but this is also much dependent on contracts from DOD. The battle over "industrial policy" in Washington DC seems over. The winners are those who believe that government should not directly support high-tech industries. As a consolation prize, the Bush administration is promising to back "generic, precompetitive, enabling" technologies. This attitude of the US government not to give directives to industry or to develop an industrial policy for USA contrasts sharply to the role of MITI in Japan or to the multitude of R & D programs sponsored by EEC. In 1989 Thomas Murrin, deputy secretary of the Department of Commerce and other proponents of a strong government role in technology began to lose ground when the administration squashed a Commerce Department plan for supporting high-definition television (HDTV) technologies. We now know who are the winners of HDTV.

Mr Michael Boskin, Chairman of Council of Economic Advisors says that the government should not be picking 'winners and losers' among industries.

However, government could identify technologies worthy of nurture if these technologies are in the precompetitive phase and therefore can affect a great many industries.

One mechanism for supporting precompetitive consortiums is the Advanced Technology Program (ATP). The money will be in the form of matching funds for small companies or consortiums.

Still, even the ATP is rediculously modestly funded: $ 10 million in fiscal 1991.

Another mechanism the government might employ is procurement of civilian technology, by buying a fixed number of products at a set price. Governmental precurement is a technique that has been used extensively in the military and space sectors with great success

But USA is still struggling with the problems of developing a long-term policy for R & D and industry, and it will probably take a long time before USA will be able to find an alternative to the traditions and methods of the military-industrial complex.

An even more serious drawback for the US industry is its poor quality of production, specially in comparison with Japanese and European industry.

Since US industry and the US society as a whole is totally committed to short-term profits, there is very little interest in investing in education of labour. This is probably the most serious handicap for US industry, especially since it has a long term impact. The educational level of Japanese and European workers is much higher which is of crucial importance both for quality and productivity.

This situation is reflected in the two diagrams below. The first shows the trade surpluses (1990) of Japan and USA in relation to each other. The American trade profile with Japan is beginning to look like that of a developing country.

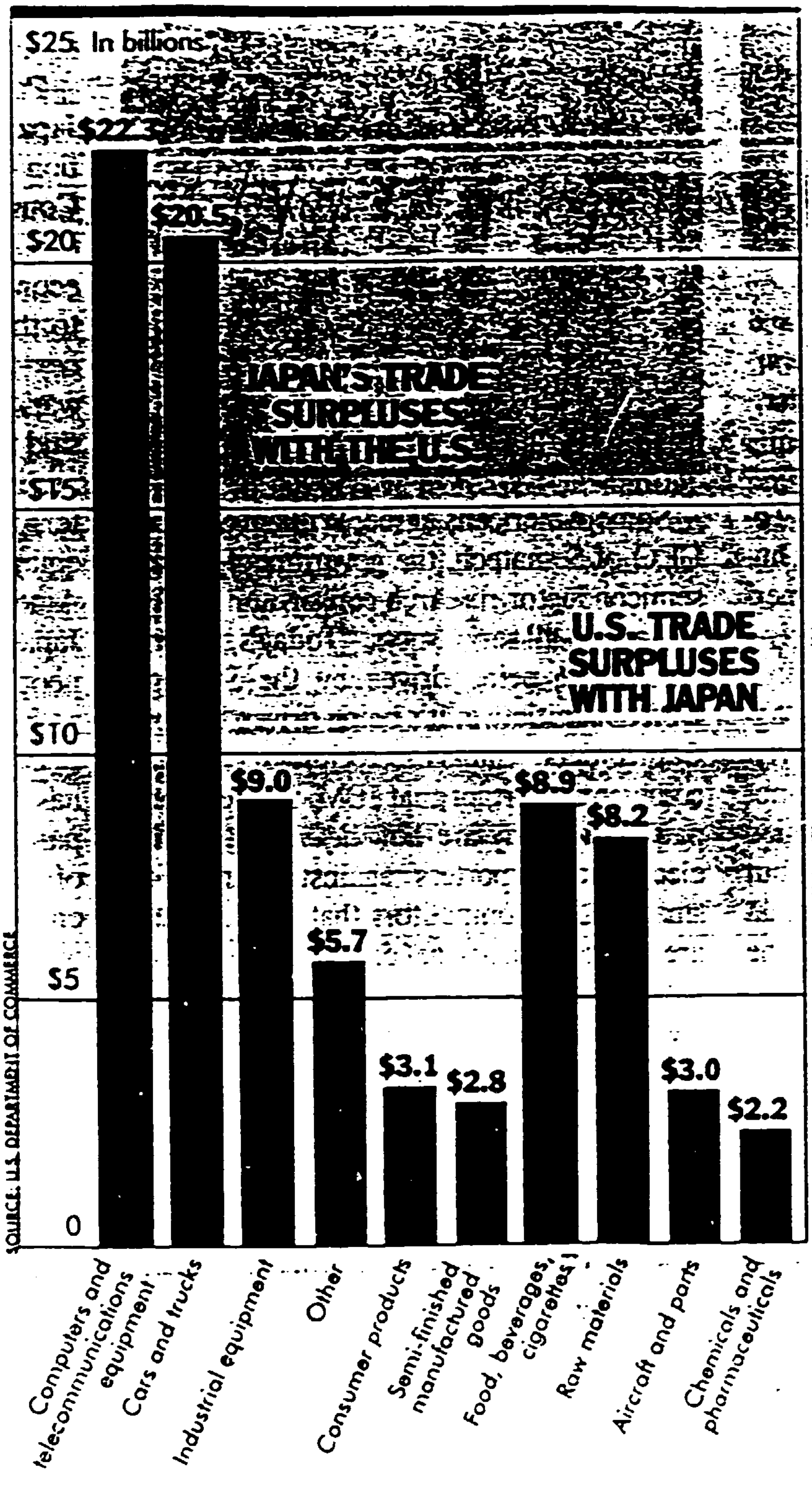
The other diagram shows that the trend is that Japan will surpass USA for many high-tech products on the world market.

While the US trade deficit has declined after the reevaluation of the Japanese yen in 1985, its proportion of Japan's total surplus went up - from 62 % in 1986 to 75 % in 1990. America's electronic industry is still the largest in the world. Yet the US electronics deficit with Japan rose from $ 17.5 billion in 1985 to $ 18.2 billion in 1990.

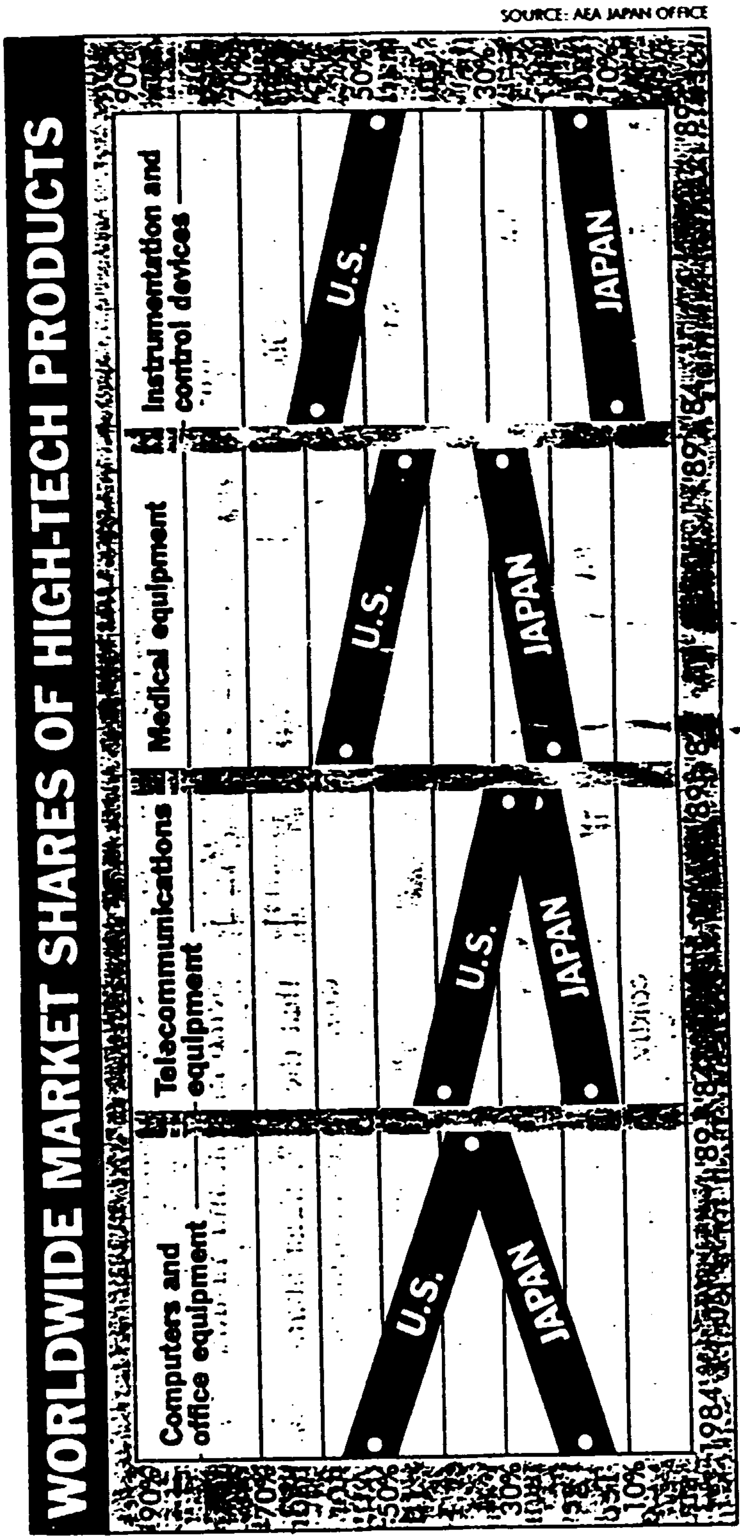
Many more examples can be given of the problems of US industrial competitiveness. They all depend on a few key factors of which

* short-term profit motives
* neglected education
* dependence on milatary sector

are the most serious.



* Figures for 1990.



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* Europe

The European Community (EEC) is the largest and richest market in the world. To the 325 million inhabitants in EEC will gradually be added 150 million in Eastern Europe. By tradition Europe has relied on Science and Technology (S & T) for its economic development for a very long time but it was mainly after the World War 2 that the European countries began to institutionalize S & T as part of the government structure. The EEC has a special Directorate for S & T (DG12) in Brussels. A very large number of programmes have emerged during the past few years to stimulate and implement cooperation in S & T among the EEC-members. Some of the programmes do, however allow non-EEC-members such as Sweden, Norway, Finland, Yugoslavia and Turkey, to participate. This arrangement will probably be extended to selected East European countries in the near future. Below will be presented a few of the EEC-programmes within S & T. In 1984 the EEC decided to coordinate its support activities for S & T. So called "Frame programmes" were introduced on a time limited basis. The first was for the period 1984-87 and the second "Frame programme" is for 1987-91.

The EEC-Support to the second "frame programme" is about USD 6 billion and it comprises the following main areas of activity.

* Life Quality
* Information and Telecommunication technology
* Modernizing industrial sector
* Biological resources
* Energy
* Cooperation with developing countries
* Marine resources
* Science and Technology cooperation in Europe

Besides supporting specific programme areas like these, the EEC can support selected projects in which the EEC pays 50% of the R & D expenses by special contracts. Common EEC research centres exist in a few places, ie Italy, Germany, Holland and Belgium.

The "Life Quality" programme area covers such activities as radiation protection, analysis of the human genome, and environmental protection.

The Human Genome Analysis, HUGO is a two-year programme with USD 20 mill support. It is essentially focused on development of methods to understand and cure serious diseases. Research laboratories in several EEC-countries will participate and the European Molecular Biology Laboratory in Heidelberg, Germany will play a key role.

The Environmental protection programme is called STEP (Science and Technology for Environmental Protection). The total budget is USD 100 million during the period 1989-1992. STEP covers such special areas as "Environment and health", "atmospheric processes and air quality", "water quality", "research on ecosystems", "protection of the European cultural heritage", and "technologies for environmental protection".
Within STEP there is a special integrative programme called REWARD (Resources and Waste Recovery).

One of the largest programmes ever launched by EEC is ESPRIT (European Scientific Program on Research in Information Technology). Its budget is in the order of billions of dollars for a four-year period:
An ESPRIT-II programme has recently been initiated which will focus on Information Processing Systems, Office and Business Systems, and Industrial Production Systems. The budget for ESPRIT-II is USD 400 million.

Within telecommunication alone there is a special programme called RACE. It covers the period 1989-1991 and the total EEC-budget is about USD 700 mill. RACE has a considerable industrial participation.
Within the Frame programme Modernizing the Industrial Sectors it is worth emphasizing the BRITE/EURAM programme with special focus on production technology and advanced materials. Its total budget is in the order of USD 150 million.
Two additional programmes within this frame programme should be mentioned, FOREST is focused on renewable raw materials and REWARD is focused on waste recycling as

was mentioned above. The budget for REWARD is USD 8 million.

Within the Biological Resources frame programme the Agricultural restructuring programme is worth special mentioning. Its main purpose is to assist farmers in Europe to cooperate and introduce methods for the preservation of natural resources and the landscape when the agricultural production system is undergoing dramatic structural changes.
The total budget for the period 1989-1993 is USD 70 million mainly for research on such topics as changes of production and distribution systems, product quality, plant- and animal health, new applications of traditional agricultural methods and socio-economic aspects of the agricultural transformation.

Science and Technology for Development (STD) comprises two sub-programmes, ie tropical and sub-tropical agriculture, and medicine, health and nutrition in tropical and subtropical regions. A budget figure was not available at the time of writing.

In order to improve cooperation in Science and Technology within the EEC several programmes have been initiated. The SCIENCE-programme is specially designed to support cooperation between research groups in two or more EEC-countries within natural sciences and technology. In this programme are also Sweden, Norway, Finland, Austria and Switzerland invited to participate.

COST is another programme for cooperation in Science and Technology which is more focused on industrial cooperation than to support individual research groups.

The COST-program comprises 12 EEC-countries and 7 non-EEC countries, ie Finland, Norway, Sweden, Yugoslavia, Switzerland, Turkey, Austria.
COST:s main activities are:
* Initiation and Co-ordination of project cooperation among the countries.

* R & D projects lying between basic research and development.

* Participation by universities, agencies and industries (min 4 countries are required)

In the spring 1989 there were 46 COST-projects for a 3 to 5 year period.

Network management is being applied by COST.

A rather new and very interesting programme is SPRINT which stands for Strategic Programme for Innovation and Technology Transfer. It is a pure EEC-programme and should be seen as a natural extension of such R & D programmes as ESPRIT, RACE and BRITE. The main purpose of SPRINT is to stimulate innovation in the EEC-countries and to improve dissemination of new technologies.

The SPRINT programme has been decided for the period 1989-1993 with a budget of about USD 100 million.

Special emphasis is put on the strengthening of the infrastructure for innovations by shaping intra-EEC-networks of actors for technology transfer and innovation support.

I will finish this survey of the S & T Cooperation within the EEC by presenting EUREKA which was created in 1985 by 19 European countries and the commission of the European Communities.

The EUREKA framework aims to further Europe-wide cooperation in advanced technology projects with civilian ends.

To obtain EUREKA status projects must meet the following criteria:

* cooperation between participants (enterprises, research institutes) in more than one European country
* the use of advanced technology
* the aim of securing a significant technological advance in the product, process and service involved to which a viable international outlet exists.

The history of EUREKA is interesting. When Japan launched its 5th Generation Computer Programme in the early 80's, USA responded by SDI, the Strategic Defense

Initiative. President Mitterand felt that Europe should have its own technological challenge programme. He was tired of the bureaucracy in Brussels which prevented quick initiatives in S & T and moreover he felt that several non-EEC countries should be given the possibility to contribute to the technological future of Europe. This is how EUREKA was formed.

EUREKA was founded in 1985 and in June 1989 nearly 300 EUREKA projects had been launched. These comprise over 1500 participants and the total costs are estimated to USD 7 billion.

Some selected EUREKA projects will be presented below.

Prometheus is the project which aims at creating the "intelligent car and auto traffic". Prometheus stands for "Programme for a European Traffic with Highest Efficiency and Unprecedented Safety".

At the end of the 20th century Europe is facing very serious transportation problems. Prometheus will tackle three challenges

* Safety
* Environmental pollution
* Traffic saturation

It will do so by developing 'intelligent' innovations which take account of the full complexity of the factors at stake in a systems fashion.

Modern data transmission and communication will play a significant role and even satellite communication will be used. Most remarkable perhaps with the Prometheus project is that it has made possible cooperation among eighteen car manufacturers which are normally fierce competitors.

Another important EUREKA project is EUROENVIRON. It is a British initiative and will be an "umbrella project" for cooperation in the area of "clean" technologies. More than 900 industrialists - both in technology and customers - applied for participation when EUROENVIRON was launched in the middle of 1989.

EUREKA totally involves 930 major industrial companies, 350 small and medium size enterprises, 270 research centres and 230 university teams from 19 European countries.

Besides the two specific examples given above there exist EUREKA projects in energy ($ 600 mill), communications ($ 850 mill), information technology ($ 850 mill), new materials ($ 150 mil), robotics and automation ($ 900 mill) and biotechnology ($ 450 mill).

I have gone into some more detail of the EUREKA programme because it demonstrates how much a flexible network for S & T cooperation can achieve in the very short time of four years. EUREKA may serve as a model for regional cooperation in other parts of the world. It demonstrates in a practical way how governmental institutions, industrial competitors and customers can and must work together to arrive quicker and with less financial risk at solutions which the entire European community can benefit from.

On the whole the model of regional cooperation in S & T which is emerging in Europe and within the EEC is probably the most powerful that exists today. The multitude of programmes and projects in S & T may seem confusing but it gives a diversity which, at least in the beginning, is much more fertile than a monolithic superstructure.

Below is shown the financial dimensions of the EEC Frame Programmes in R & D.

<u>R & D Frame Programmes</u>

1987 - 1991	3125	Mill ECU	(approx $ 4bn)
1990 - 1994	7700	Mill ECU	(approx $ 10bn)

It should finally be mentioned that there exists since many years a European Science Foundation ESF. It supports mainly basic research activities in such areas as high energy physics, molecular biology and astronomy.

From the presentation above one might conclude that EEC has taken upon itself the same role as MITI in Japan as a stimulus and cathalyzer for R & D and industrial development. It is also interesting to note that the 'frame' programes of EEC represent several of the 'new' challenges for R & D and industry which were discussed earlier.

European industry on the whole is very dynamic and modern in its outlook, even if the European tradition is still heavily dominated by the "curiosity-oriented" R & D tradition (Nobel Prize Syndrome). We have still a long way to go toward the market and goal-oriented R & D approach which is so typical for Japan.

Reference: EC Research Funding, 2nd Edition
A guide for applications, Commision
of the European Commities, May 1990

* Japan

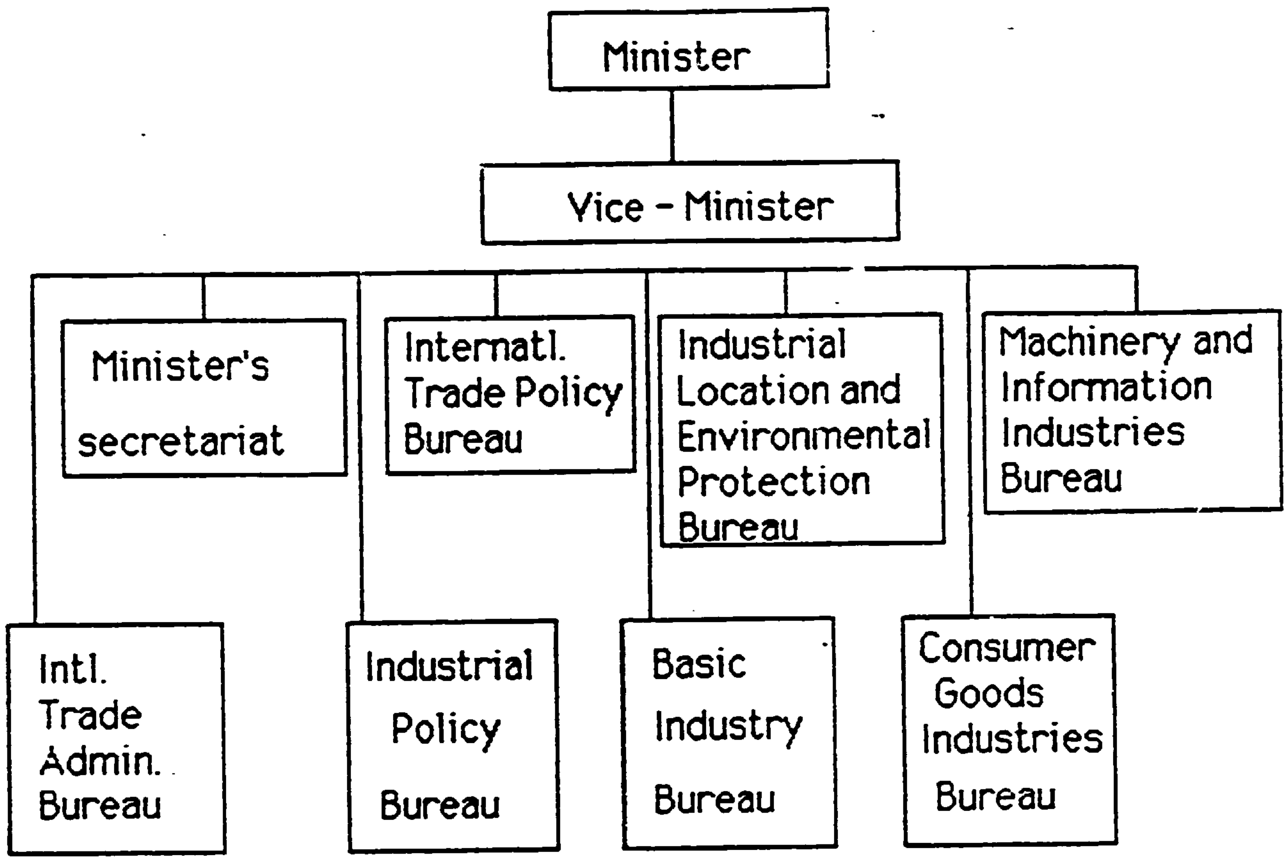
Since the end of World War II the military security of Japan has been guaranteed by USA. Moreover, the new constitution of Japan after World War II does not permit Japan to spend more than 1 percent of its budget on armament.

As a consequence Japanese leaders decided to launch a major programme on education and R & D and to develop products for the civilian market.

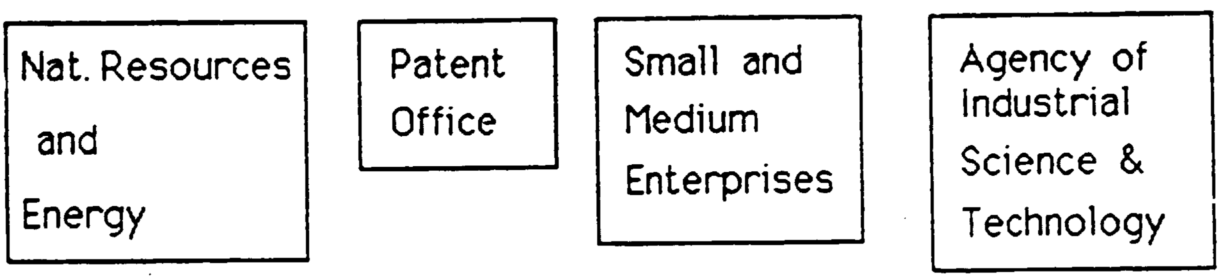
For Japanese companies market comes first, profit second. Japan is definitely playing by different rules than both USA and Europe in its industrial development. It is difficult to know where government ends and the private sector begins.

MITI, the Ministry for International Trade and Industry is probable the strongest ministry in the world and certainly very decisive for the industrial and R & D policy of Japan. The structure of MITI is shown in the diagram below.

MITI (Japan)



Agencies under MITI



The MITI bureaucrats are extremely powerful and well educated.

MITI draws up plans for the long-term technological development. Japanese companies are invited to submit proposals for the technological programme in question in fierce competition with other Japanese companies. MITI decides how the R & D programme should be distributed among the competing industries and research institutions. This is how "goal-or mission-oriented" research was developed and, as we know, it has been very successful as a contrast to the "curiosity-oriented" R & D approach of Europe and USA.

It should also be pointed out that the universities in Japan are usually not directly involved in the industrial R & D programes. The science park concept as we know it in Europe and USA does not exist in Japan. Instead, practically all goal-oriented research, including the necessary basic research, is done by industry. Japanese industry has a very high mobility and flexibility regarding the picking up new ideas and technologies.

The models of technical development are constantly being improved, and there is an enormous multitude of governmental, non-governmental and mixed variety of institutions in Japan.

When the news about the ceramic superconductors, which allow higher temperatures to be used, were published, Japanese companies Hitachi and Toshiba mobilized in a very short time a few hundred scientists and technologists to work on practical applications, while IBM were proud of its Nobel prize and most Western companies were taken by surprise. Within a year Japanese companies had filed 1800 patent applications on super-conductivity.

Another example which shows that the Japanese approach to added value product development is very different from the European and the American is that of carbon fibres. While the French companies introduce directly carbon fibres in air plane design to make them lighter, the Japanese companies are much more cautious. They begin with simple products such as fishing rods, tennis rackets and golf clubs which the ordinary mass consumer can use. If they fail there will be no serious accident or no-one would loose a lot of invested money. In this way Japanese companies could make some profit immediately and step by step become more and more advanced in the applications of carbon fibres, and eventually also use them in air planes.

It was the same philosophy which reduced the price of Large scale integrated circuits (LIC). The Americans developed LIC:s for missiles while the Japanese started with pocket calculators. In 1975 one LIC costed about 50.000 yen, but if it could be miniaturized to be used in a pocket calculator it should be possible to sell 100.000. If so, the prize would drop to 10.000 yen. This is what happened and today millions of pocket calculators have been sold and the price for one LIC is 200 yen (about $ 1). This is a beautiful example of the fundamental difference between the civilian product oriented Japanese development policy and the military-industrial complex policy we spoke about before.

Another distinct characteristic of Japanese R & D policy and industrial development is its long-term perspective (10-20 years).

Industry has already invested some 50 billion yen ($350 ,mill.) to make flat 40 inches TV-screens based on liquid crystals which can be put on a wall.

The strong competition among Japanese companies is still another characteristic. This favours pluralism, In 1989 115 new telefax machines were introduced in Japan, ie one every third day, and 96 new copying machines.

Another example of goal-oriented research" in Japan is the 5th generation computer program initiated by MITI some 15 years ago. Even if this program did not reach its goal of world supremacy in the computer field it elevated the level of many related technological areas of great importance for Japan's competitive power.

A 6th generation computer program has recently been launched by MITI. It involves some 100 scientists from industry, universities and government agencies. It comprises the following components.

* Basic research
* Computers should be able to interpret information of all types (digits, letters, pictures)
* Parallel processing, optics, neuron networks.

International cooperation has been recommended by MITI for this programe. It will be interesting to see the outcome of this goal-oriented research program.

The 'ad-hoc' approach to new product development in Japan has proved very efficient and it has a great deal of "chaos" management in its character.

6. Marketing of Scientific Results and Innovations

* Differences in management style

Above we have discussed comparative advantages in the competition between corporations and the R & D policies of governments.

We have also discussed the differences in style and tradition of corporations in USA, Europe and Japan, between which the battle of the world market takes place. As the world becomes less militarized the corporations which quickest can bring scientific results and innovations to the civilian market will prove to be the winners.

Professor Henry Minzberg at MIT is considered to be the guru of the bottom-up management. He believes that the huge and rigid management structure of America's Fortune 500 corporations is loosing ground to Japan, where a more flexible management style exists. He thinks that if workers and middle managers will participate more actively in the corporate decision-making the industrial renewal will be vitalized instead of leaving it to top executives whose "only" qualification appears to be the possession of a MBA from a well-known US university.

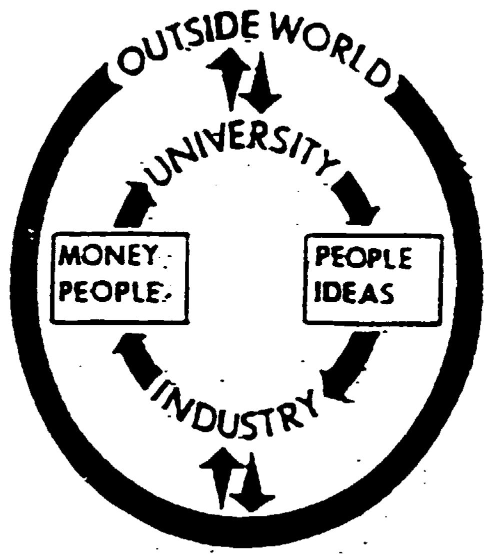
We cannot afford to have a society of elitist managers, preselected at a young age on the basis of academic criteria and then promoted on a "fast track" outside of the difficult work of making products for and serving ordinary customers.

In most big corporations, particurlarly in USA, says Minzberg, employees are treated as "mindless" even though they often have intuitive insights into how their companies should perform, based on their experience on the shop floor or with clients.

This attitude is particulaarly destructive when it comes to introduction of new products. Equally, scientists in universities belong to an elite which has very little training and understanding of how to translate a scientific result into a new product for the market. It takes a special breed of people and mix of skills to introduce an innovation on the market.

* Spin-offs from University research

The figure below, produced by the Dutch Contract Research Organisation TNO, shows the University-industry cycle. Its essential message is that ideas are produced by university while the money is in industry. There is, of course a certain truth in this statement but the greatest problem is that of attitude rather than money.



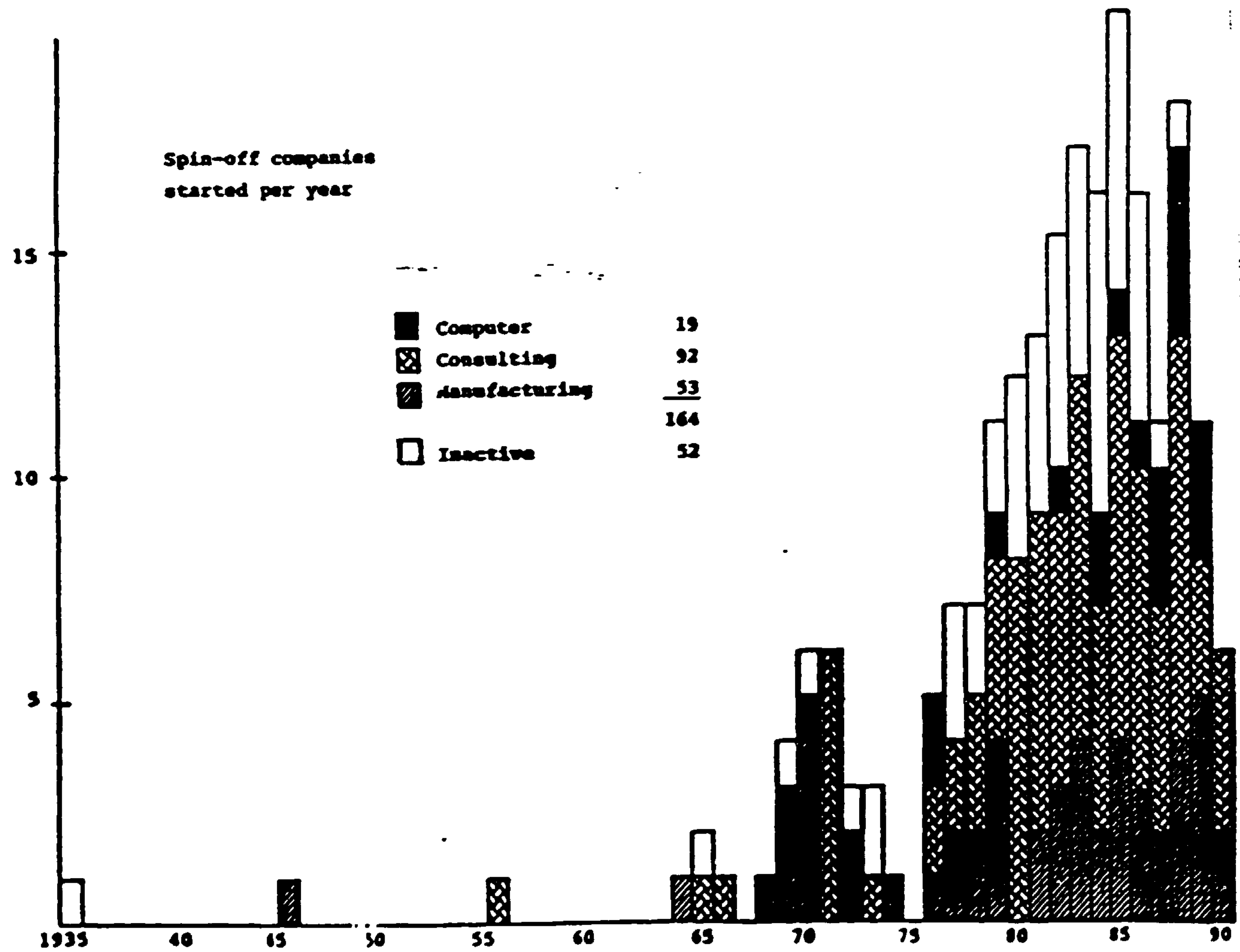
The university-industry cycle

Industrialists in general - and specially in USA and Europe - are much too short-sighted to take their time to discuss with university researchers the potential value of an idea, and the university researcher do not understand the working criteria of industry. Recognizing this fact, the idea of 'science parks' near universities was born. They would serve as incubators for new ideas and product concepts before being brought to the market and as an environment where people from university and industry could meet and build bridges. Science parks started in USA, where they have been quite successful. The most well-known are 'Route 128' around Boston (MIT) and Silicon Valley at Palo Alto in California. Today we can see Science parks at most of the prominent universities in Europe and some of them are quite successful (eg Cambridge University in UK). In Sweden there is a Science park at every University.

Below are given a few examples.

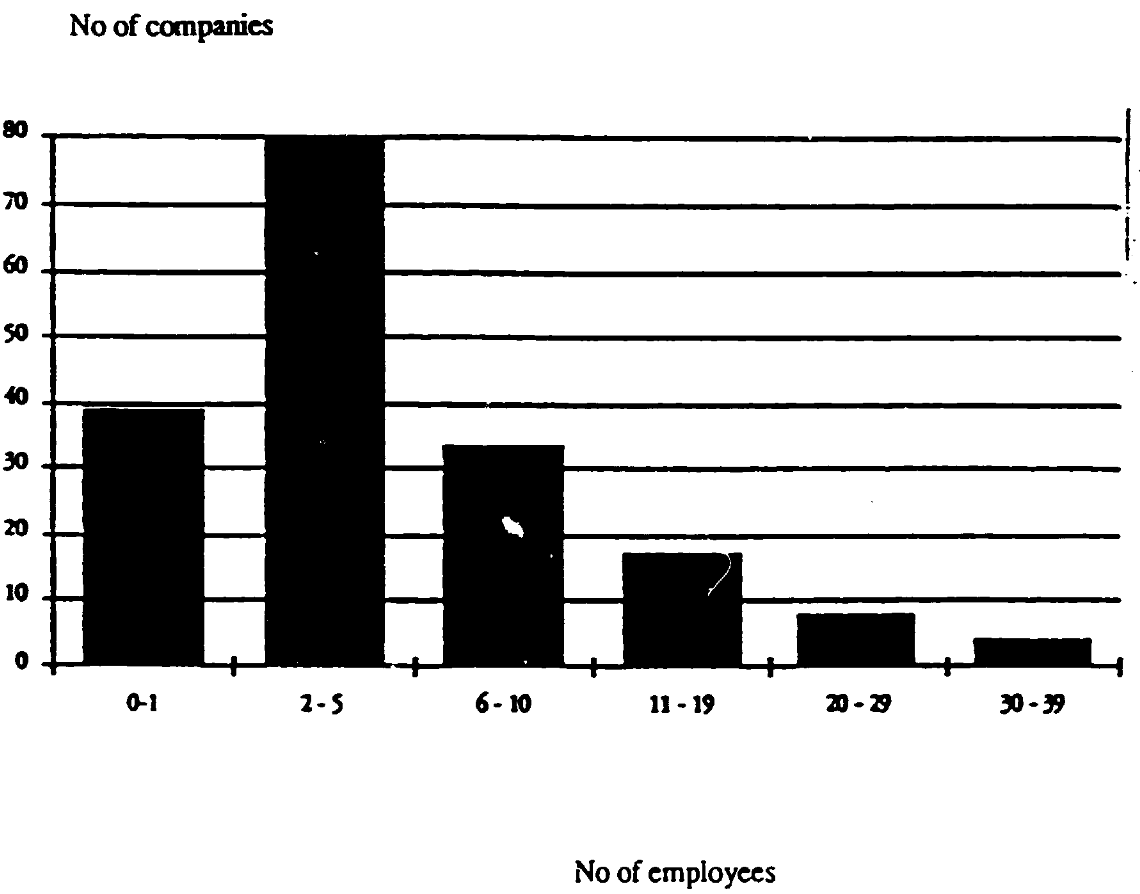
Chalmers Institute of Technology at Göteborg, Sweden has been very successful in generating spin-off companies and technology transfer to industry. By spin-off company we mean a company started from research by university faculty, students and staff without intervention by employment at another company.

The figure below shows the number of spin-off companies per year from Chalmers. Most significant is the dramatic increase from the mid 70's. One reason for this is that it was about this time that Sweden began to create science and technology parks and to stimulate university-industry cooperation. However, the most important reason for the increase has been the establishment of a special chair in innovation at Chalmers and that the first person to get this position was Professor Wallmark with long experience from RCA in USA. Wallmark has been an indifatigable entrepeneur of university based innovation companies.



As the next figure shows the university based companies tend to remain small (less than

20 persons) and consultative and hesitate to invest in growth of production. This is a reflection of both the attitude of university research not to take risks on the market and the lack of risk capital for new starters.

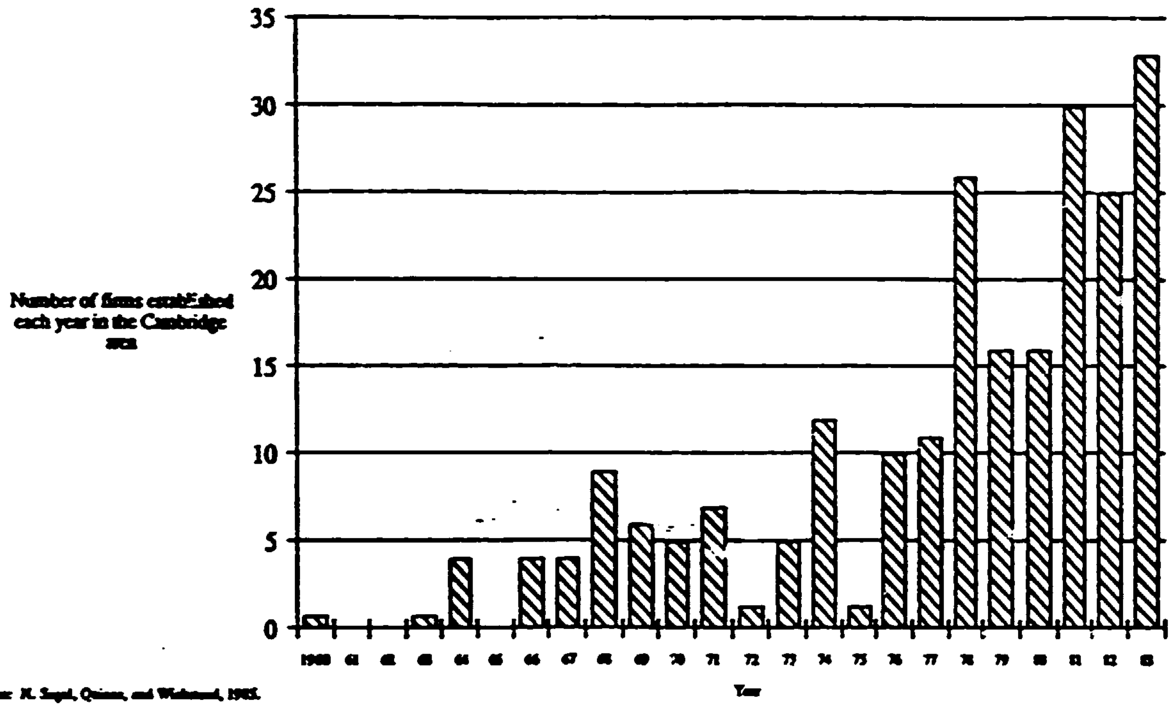


In the case of Chalmers, however the employment effect has been quite considerable. Since the end of 1987, spin-off companies from Chalmers have had a combined direct impact on employment in excess of 4000 persons not counting persons involved in subcontracted production, marketing and secondary spin-offs. About 30 percent of these companies manufacture a product, 30 percent do consulting, and 30 percent develop and sell computers and/or computer software.

A somewhat more liberal definition of 'spin-off' company has been used at Cambridge

University. Here there are many high-tech companies of which some are quite large. If we keep to definition of 'spin-off' company used by Chalmers, only about 17 percent of the numbers shown in the figure below from Cambridge can be considered spin-off companies.

. The Number of Technology-Based New Companies Established Per Year in Cambridge, England, from 1960 to 1983



Source: R. Segal, Quince, and Wicksteed, 1985.

At Oxford University has been created an international club of science-based companies to keep industry abreast of innovation at the University.

The Oxford Innovation Society was formed by ISIS Innovation, the university's own technology transfer company. The society includes such names as BOC, Cookson, IBM, ICI, Monsanto, Oxford Instruments and Sharp.

Top research managers from the member companies are being briefed regularly by professors on the latest news from the university, which estimates that it is spending £ 21 m a year in governement funded research.

The society offers member companies a window into Oxford's innovation, as well as a chance to talk informally to professors about their ideas and industry's needs.

ISIS, less than three years old, was spawned by the Government's decision to free Universities in UK from the British Technology Group's monopoly on government funded invention. It has applied for about 30 university patents and has been granted four so far (June 1990).

The inventor/researcher receives the firs £ 26.000 of any revenuce, and further earnings are shared with ISIS under a program which offers "a better deal than anyone's got from BTG".

If a company is formed, the inventors are offered equity.

Oxford Molecular is ISIS' proudest achievement. Not only is the company up and running but it has broken new ground in as much as it is set up on the Science Campus adjoining the Department of Organic Chemistry - something never previously permitted at Oxford University.

Oxford Molecular compiles computer programmes that can generate vivid 3-dimensional images of molecular structure.

The founders of Oxford Molecular first introduced ICI to molecular graphics a decade ago, but at that time there was no organisation such as ISIS to help them.

David Edwards of the Department of Engineering Sciences at Oxford developed from existing techniques, the optically scanned imaging radar.

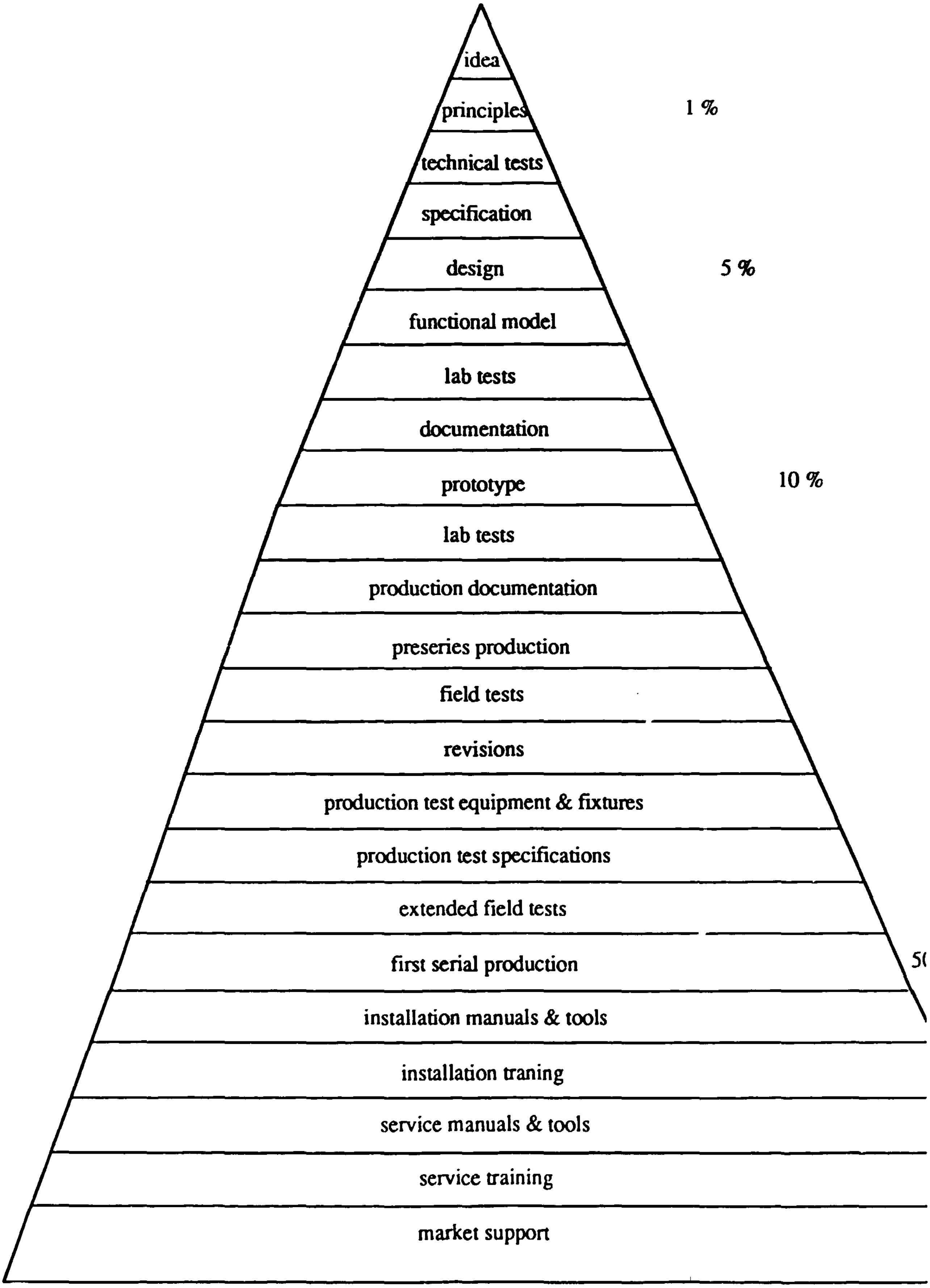
Edwards has assigned his radar to ISIS. For his invention ISIS is planning an industrial "auction". The aim is to negotiate three things for Edwards: a licence agreement, a short-term development contract to back up his research grant from Science and Engineering Council, and a consultancy with the sponsoring company.

* Conclusions

From the above we may conclude the following.

* Management traditions and styles are very different in different countries. No universal procedure can be identified. However, a few key factors are decisive for success.
* The probability of market success of science products and innovations is statistically very low (1 - 5 percent). Therefore pluralism should be used for the filtering of ideas. There is no straight line to success. 'Chaos' management.
* The entrepeneur (a generalist) is the most important factor in bringing the idea or product concept through the great number of obstacles (technical, psychological, financial) to the market introduction.
* Three main alternatives for the marketing of science products and innovation exist.
  (1) Start a new company (the toughest alternative)
  (2) Agreement with a large company with strong, patient financial capacity, (good solution if the company has the right attitude).
  (3) Agreement with small entrepeneurial company (usually the best solution if sufficiant risk capital is available).

  Often each of these alternatives can be mixed with government funding, which becomes more and more important.
* When discussing costs and investments for a new product, the calculation often deals only with the first 5 - 10 percent of the total cost. We call this the iceberg syndrome (see fig below) and is often not appeciated by the inventor or researcher.


idea
principles
technical tests
specification
design
functional model
lab tests
documentation
prototype
lab tests
production documentation
preseries production
field tests
revisions
production test equipment & fixtures
production test specifications
extended field tests
first serial production
installation manuals & tools
installation traning
service manuals & tools
service training
market support
1 %
5 %
10 %

CREATIVITY AND THE INNOVATION PROCESS-
FINANCING OF RESEARCH AND INNOVATION

by

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Content

CREATIVITY AND THE INNOVATION PROCESS - FINANCING OF RESEARCH AND INNOVATION

1. Creativity and knowledge-based industries.

It has been stated many times above that "Capital" today means Creative Brains and not just money.

A most dramatic example of this statement is a comparison of R & D versus incremental costs to illustrate the difference between old typ industry (automobiles) and knowledge based industry (computers and software).

	Microsoft windows	Ford Escort
cost of first unit	$ 50 mill	$ 2 bil!
cost of additional unit	$ 10	$ 10.000

Apple's John Sculley says that intellectual capital will ultimately lead to "a dramatic shift in the wealth of the world" from natural resource owners to those who control ideas and knowledge. Brainpower is dangerously short - at a time when business advances are being made by creative people who outthink others, not by people who buy twice as many machines.

Most important, the return on intellectual capital can be nearly infinite. Competition in knowledge-based products is often winner-take-most.

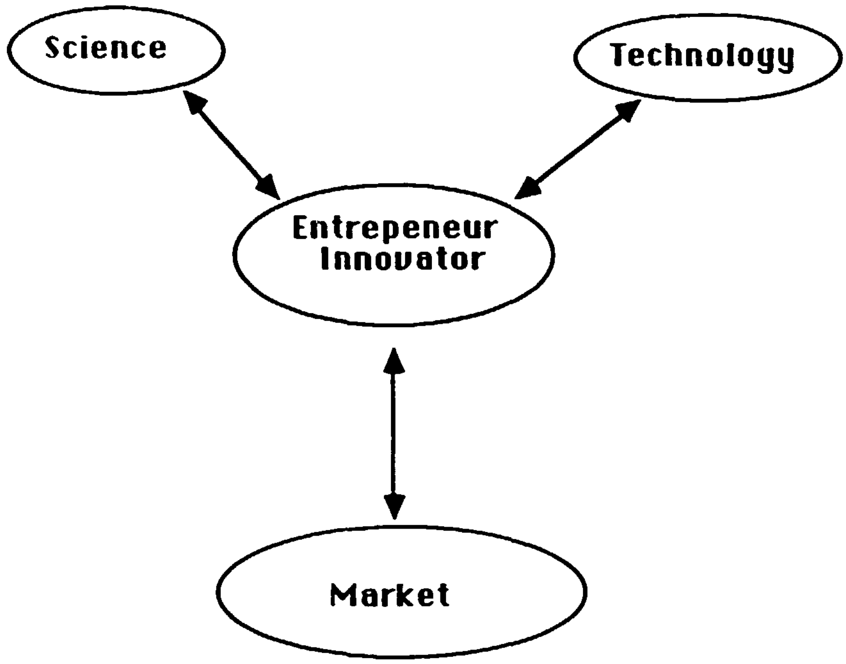
VHS videocassette recorders largely drove SONY's Betamax off the market, just as a high-tech process of the 19th century - alternating current-short-circuited Thomas Edison's direct current.

Creativity and intellectual capital is virtually impossible to measure - an off-the balance sheet asset.

Your investment in a new plant shows up as an asset. But all the money you spend training your work force to double the output of the old plant doesn't.

* What do we mean by creative knowledge ?

You remember the illustration of product development that Christopher Freeman of SPRU had proposed.



By this Freeman wanted to stress that the successful entrepeneur/innovator must be open to signals from the Market, Technological development and Scientific progress simultanously in an iterative, often disorderly manner. From this "chaotic" pattern of behavior the creative mind may find new and radical solutions to the problems. This requires a person who thinks "holistically" and not "fragmentally".

The Western school education, however, has so far awarded the receptive mind rather than the creative mind and this is now proven to be a handicap for Western product development.

From the Western 'fragmented' approach to knowledge has also followed the hierarchical corporate structures which is a further hindrance against creativity from the bottom of the organisation (Minzberg and bottom-up management).

The famous British actor John Cleese (Monthy Python) started already in 1972 the Video Art Company. Through this he is now a popular lecturer at companies about creative management. His thesis is that as the Market demands higher quality of the products and constantly better service, the organisation must be made more flexible and adaptable to the new demands.

This in turn leads to delegation of responsibility to smaller and smaller units of people. The company must have a network organisation so as to mobilize its creative potential as quickly and informally as possible.

Periferal jobs can be sub-contracted to companies outside the central business. See above about change of company structure.

Cleese's conclusion is that the 'winner' in the 1990s will be those companies which place knowledge and creative learning at the highest priority, which is contrary to what Western schools normally do. In these the personal 'development' is a mixture of control and punishment.

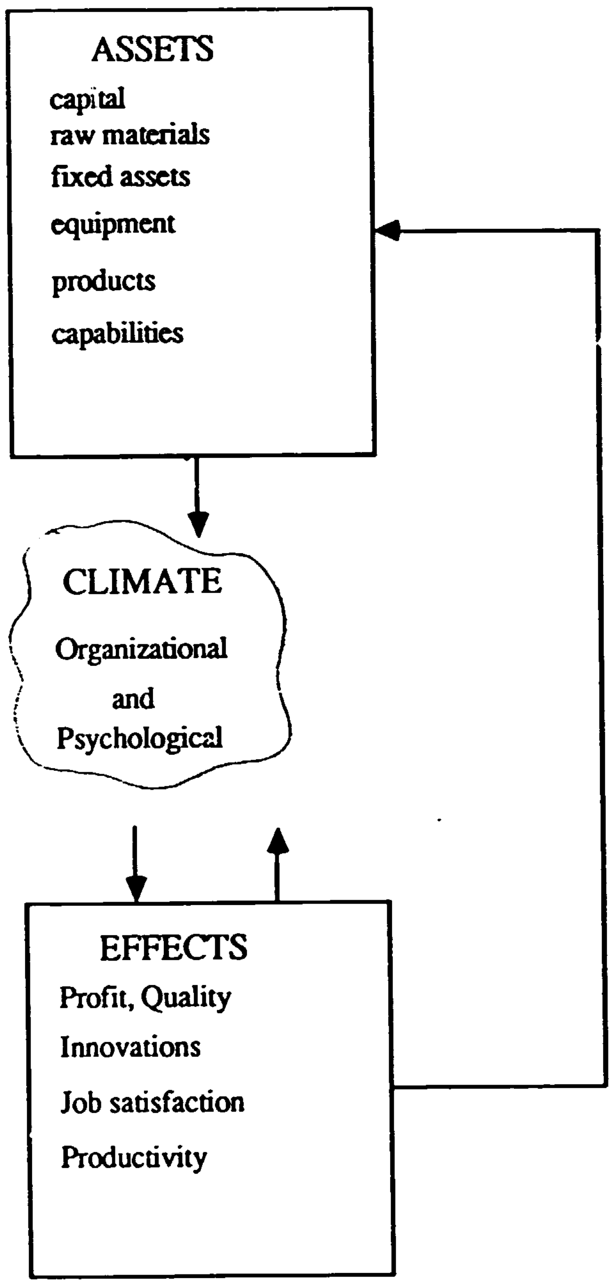
Morita of SONY has said that the secret with the Japanese industrial success is concentration on the individual, who is born curios and creative. This potential can later in life be destroyed as we have been able to do very effectively in the Western schools and industry.

We must learn to award the eccentric and divergent individuals. More 'chaos and crazyness' must be tolerated in our organisations if we are going to see more creativity. The art of modern management of innovation in research and industrial development is to find the ideal marriage between chaos and disciplined, goal-orientation. Generalists have a greater chance to succeed with this than fragmented specialists.

A model which attempts to capture this view is shown below.

The 'Climate of the organisation must be such that the "Effects" improve and cultivates the "Assets".

Losers get immured in market niches, like a player struggling in the final stages of the Japanese game GO. Winners keep winning because "congealed knowledge" often has high up-front costs but negligable marginal costs - resulting in staggering profits". It may take millions to write a piece of software, for instance, but copying it costs only just a few dollars - dramatically less in relation to R & D than, say, a second Ford Escort. And the sophisticated manufacturing processes that produce the high-tech products are susceptible to cost - saving improvements, which dwarf the usual economies of scale.



2. The Innovation Process

There exist in literature several different descriptions of the innovation process.

In general, however one can divide the innovation process in three main steps

(1) Idea stage

(2) Incubation stage

(3) Introduction to production and market

The Innovation process followed by the Innovation Institute in its work with new concepts and products has the following structure:

(1) Needs definition (market, production techniques, environment, economy, etc.)

(2) Idea generation (multidisciplinary brainstorming, client capability, technology, etc.)

(3) Development of Selected innovative ideas (adaptation of ideas to defined needs, costs, profits, etc.)

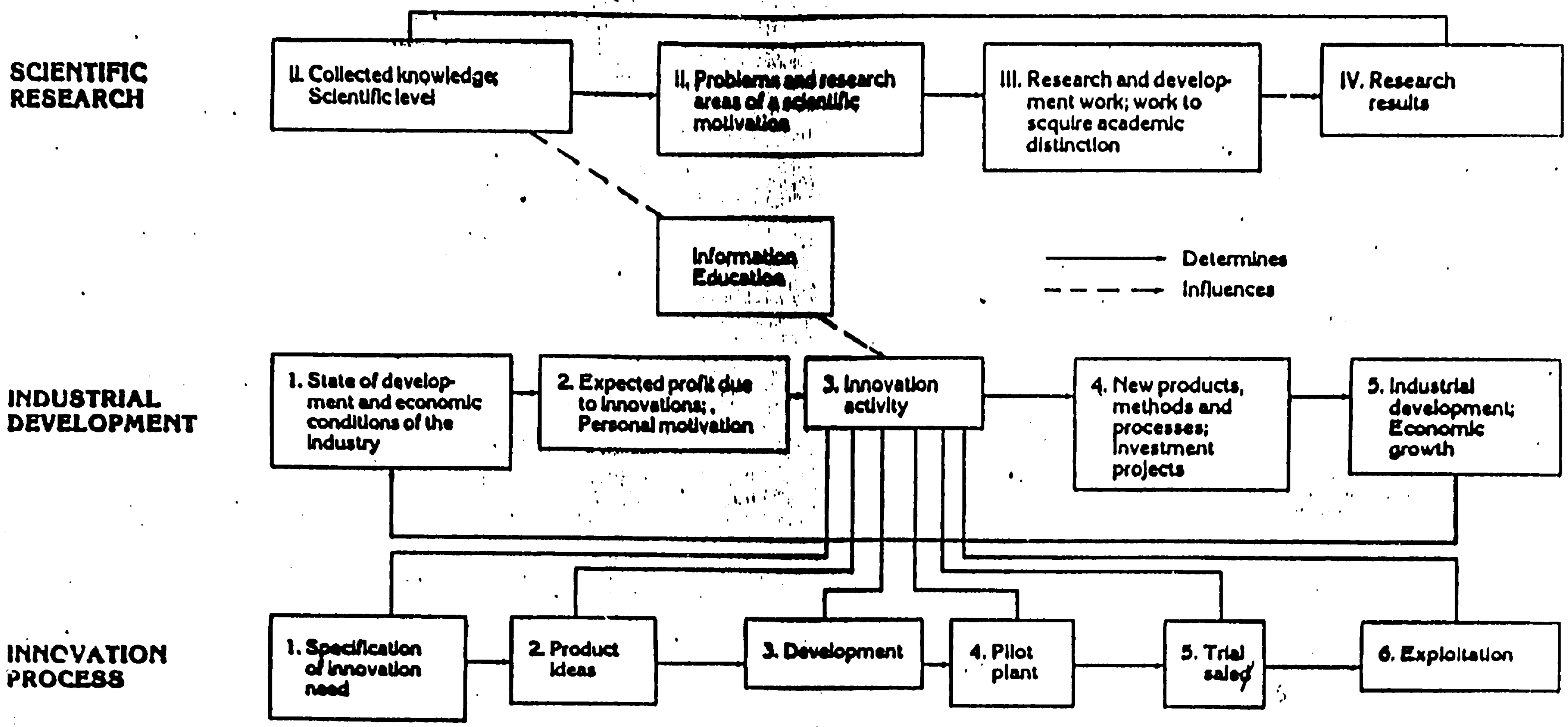
(4) Pilot production (prototypes, function, design, tests, etc.)

(5) Trial production and trial sales

(6) Commercial introduction (partners, risk capital, joint ventures, etc.)

Of some 20 innovations developed by the Innovation Institute according to this procedure during the past fifteen years, about 40 % have been introduced on the market.
The founder of the Innovation Institutet Dr. E. Haeffner has proposed a phenomenological model for innovations in relation to industry and universities. See illustration below.

A MODEL FOR TECHNICAL PROGRESS AND ECONOMIC GROWTH



(A detailed descussion of this model may be found in the report "Understanding Innovation" by A.E. Hæffner, Stockholm, Sweden, 1972)

The degree of success of innovation is to a very large extent determined by the persons involved in the different stages of the innovation process rather than by the level of technology.

3. Innovation Management and the Innovation Process

Prof. Mintzberg of MIT says that what we need today are managers who are "thick", meaning that they have an in-depth knowledge in their field, but at the same time can listen to their instincts. They are thoughtful and have a strategic vision of how their company should operate. Since management is so messy in reality, Mintzberg believes that executives must rely as much on intuition as on analysis. He calls it "managing on the right side and planning or the left side" of the brain.

The left side processes information bit-by-bit; the right side views things simultaneously. This is particularly important when it comes to management of innovation. This view is quite close to the explanation presented earlier by Christopher Freeman.

Mintzberg thinks that our machinery - in the broadest sense, not just our technologies, but our social system and especially the organisations in the West - has dulled our senses driving out intuition and making it increasingly difficult to find our way out of our problems by original, creative thinking. "Society has become unmanageable as a result of management".

He refers to the "management" of the Viet Nam war by brilliant technocrats like Robert McNamara but he also refers to Lenin's application of Taylorism in designing the Soviet industry based on extensive financial planning and performance controls. Just as the giant overplanned, overcontrolled Soviet corporations have failed, Mintzberg thinks that many of the Western giant corporations will fail in renewing themselves.

According to him it is the Japanese who have discovered the right blend of bureaucracy and innovation. The Japanese have several cultural advantages. Their emphasis on group identity has produced companies with strong corporate cultures.

As a result, Japanese workers care about doing mundane things and treat seriously such concepts as quality circles. In contrast, the USA has built a system that has destroyed any feeling among the workers of participation, involment and commitment. They have thereby killed a strong corporate ideology.

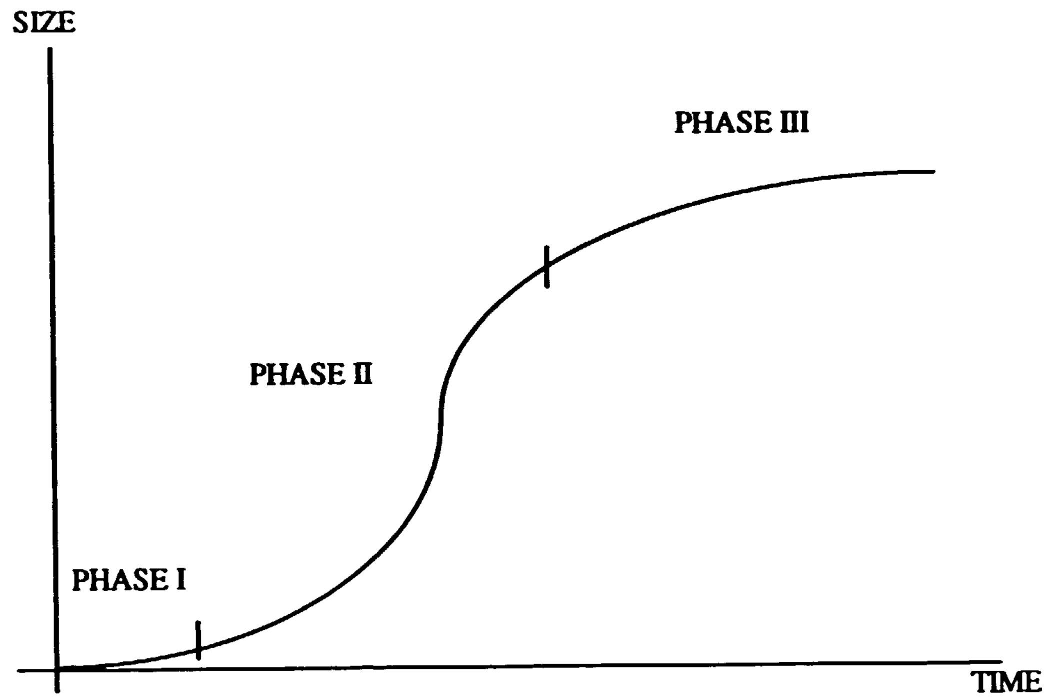
In Japan this shows up in quick response to the market place about needs of innovations and product development, because management allows ideas to filter up through the ranks of the organisation. Honda, for example, was able to capture a sizable share of the US motorcycle market because its salesmen in America found that the lightweight bikes they were using to visit customers were creating more interest than the heavy-weight bikes they had been originally told to promote. They informed the headquarters in Tokyo, which quickly switched to marketing the light bikes instead.

In addition, the Japanese companies don't separate functions when they plan. Designers, for example, will cooperate with the sales force in creating new products, since the salesmen usually have the best idea of what customers like. The management in Japanese companies is seen as a learning process rather than a control process as it is in the West.

Mintzberg thinks that while the Japanese have perfected the management of the industrial concerns, the Scandinavians are among the best practitioners of managing what he calls innovative structures.

Why are the Scandinavians so good at that? (If they are). Mintzberg concludes that they have a highly educated workforce, a long tradition of product innovation, a natural propensity to work in teams, and a humble attitude towards leadership.

The figure below summarizes the different phases of the innovation process and product development, and the main ingredients of the management at each of these phases.



<u>Phase I</u>
* Innovation
* Idea generation
* Reflective
* Discussing
* Knowledge accumulation

Management: Creative inventor

<u>Phase II</u>
* Activity
* Risk taking
* Ability to act
* Sensitivity to results
* "Blood, sweat and tears"

Management: Business Entrepeneur

<u>Phase III</u>
* Administrative
* Coordinating
* Law and Order
* Straight lines
* Volume, economy

Management: Administrator

The main message of this figure is that it takes different managent styles and personalities to go through the whole innovation process. In very few cases is it possible to find one and the same person who is suitable for all phases of the innovation process. The art consists in managing teams of people in a collaborative and harmonious way from the idea stage to the commercial stage.

* Total Quality Management, TQM

Related to the above description of the "management of innovation" is the concept total quality management, TQM. It is a delicious irony that Western companies, and their customers, have the Japanese to thank for refocusing their attention on quality. Delicious because it was three Americans, Deming, Juran and Feigenbaum. who in the early 1950s exposed Japanese managers to the principles - primarily statistical - of quality control. The Japanese, who - as we know - are best in TQM have repaid Deming by naming a prize in his honour. Today it is the most coveted award any Japanese company can win.

4. Strategy of Innovation

We know that very few of new ideas will result in successful innovations. Booz Alan and Hamilton once made an investigation and found that only 1 idea in 40 led to a successful product.

It is therefore necessary to start from a very large number of primary ideas and suggestions if even one is to arrive at one product idea.

Innovation is a combination between a needs idea and an idea about a technical possibility. Experience shows that it essentially depends on the company's management if the company will have enough willpower to handle a large number of ideas. The first step is to create an understanding that it is necessary to treat a very large number of primary ideas in order to have a chance to find one that may lead to commercial success. Below are presented some crucial ingredients of a company's innovation strategy.

(1) The management must stimulate a strong flow of ideas and to establish a clear product policy which facilitates the sorting out of ideas.

(2) The management must promote technological curiosity and improvement, actively support needs investigation, and stimulate active play and confrontation with new expertise.

(3) The management should separate and limit innovation projects from the on-going development projects.

(4) The management must have excellent technical capabilities to be able to stimulate and evaluate innovations without being dependent on the belief and judgement by others.

(5) The Chief executive officer should act through his authority and create innovation constellations within the company.

(6) The management should create independent innovation groups with sufficient collective know-how and resources, but without political tensions. These groups should be able to work until the innovation projects can be evaluated before next steps are taken.

(7) The project leader - entrepeneur - should be allowed to follow the project all the way to market introduction. His job is to hold the project together with active support by the top management.

(8) If the company is large (like 3M) a New product management division should be responsible for innovation projects. In a smaller company it might be necessary to have someone in the company management take a personal responsibility for a less structured project.

With positive and curageous management it is possible to create a spirit of creativity and joy throughout the organisation. Under these circumstances a constructive polarity may be created which results in an idea pressure from below on the company management.
With dynamic leadership it will be possible to avoid the destructive tensions and confrontations between innovators and new ideas on the one side and the "normal" product development on the other. In some instances, specially large companies, it may be necessary to create a special organisation for the development of new ideas from inside or outside the company. There is no given formula for this, however. The most important factor is the support of the management of both idea generators and enthusiastic entrepeneurs.

We will present three examples below from Swedish Industry.

The Perstorp Company is a large Swedish company with petrochemical and biotechnical products (not pharmaceutiacal or medical). Perstorp was the first Swedish Company to apply the 3M-model for internal entrepeneurship (intrapeneurship) which we discussed above.

In the early 1970s the Perstorp management realized that the distance between market and R & D in the company was too large. Furthermore, a strong decentralisation of the company had resulted in short-sightedness and incremental product development. Long-term development and renewal had been ignored.

The Perstorp decided to introduce the following measures:

* Creation of a Research Foundation with an independent research council.
* Introduce a contact person for new ideas and innovations (innovation ombudsman)
* Create a foundation which the Managing Director should control.
* Create a special account for new programs.
* Create a special company, Pernovo, for new business development.

The different decentralized divisions of the Perstorp company can apply at the new research foundation for funding of long-term development projects.

The innovation program and search for new product ideas was also made externally, at universities and research institutes within or outside Sweden.

During the first 10-year period (1973-83) some 300 innovation projects were evaluated and financed. These projects correponded to 35 % of the total sales of Perstorp and most of the new products introduced on the market had their origin in this approach.

The Perstorp approach to innovation and entrepeneurship is considered to be one of the most successful in Sweden and has been tried by several other companies in Sweden.

When the Swedish Telecom Company Ericsson in the early 1970s was faced with the transition from mechanical switching to electronic switching it made a very extensive evaluation of its technological capabilities. Ericsson is a typical multitechnology company and it was necessary to determine in which areas the company should concentrate its R & D and innovation efforts. More than 100 technologies were identified within the company. The "map" of technologies were divided in three main groups.

* Core technologies (eg. switchingtech)
* Basic technologies (eg. semiconductors)
* Enabling technologies (eg. computers)

The crucial question was in which area Ericsson should select partners for cooperation (eg. semiconductors) and in which area the company should rely on its own expertise (eg. switching technology).

In the early 1970s Ericsson thought that its main competitor, the US Corporation ITT, was ahead in SPC-technology (Stored Process Control). This led to a decision by Ericsson to concentrate its R & D efforts on the AXE-system. This led to a "semi-digital" system as a "gap filler" to bridge the discontinuity in the forecasted curves for development toward a new generation switching technology.

ITT tried to "jump over" this discountinuity to full digitalization through its System 12. This proved to be too ambitious and the more cautious step taken by Ericsson became the winner.

A study of various multi-technology companies in Sweden concluded that the managerial capabilities of Ericsson can be summarized as follows:

* Very good at continuous environmental scanning (forecasting) of technologies, competitors, market, etc.
* Determine the rate and direction of emerging technologies.
* Capable of resolving conflicts between technological sub-cultures within the company.
* Organizational ability for new technologies.
* Know how to work in parallel with different technologies.
* When decentralisation of business areas and R & D had been done one should not go back to a centralized structure.

There are, however other limitations than management of R & D and innovation in a multi-technology company. Today the costs for R & D is one such limitation. The trend is to cooperate with other companies in R & D and later compete on the market through "systems competititon". Ericsson cooperates - and competes - with General Electric in USA.

A third example of idea generation and innovation is the so called "Idea Pool" of the car division of VOLVO.

It is based on economic awards to the best innovations. Each middle management boss can decide on evaluations and awards. The "Idea Pool" has the capacity to make the evaluations and preliminary tests very quickly.

This project lasted 3 years.

13000 employees made 5160 proposals (1978), about 40 proposals per 100 employees. Some 4560 proposals were evaluated in three years, and 874 were approved and awarded. Totally 3.454 mill. SEK were awarded.

Total saving for VOLVO due to these proposals was 17.424.000 SEK during the first year of the "Idea Pool". Total accumulated saving for Volvo Cars was 52.272.000 SEK.

The main conclusion from these and similar innovation programs in other companies is that idea generation and corporate culture, leadership and staff policy must be intimately integrated.

5. Types of Innovation

In a recent book by IFIAS (international Federation of Institutes for Advanced Study) called "Technical Change and Economic Theory" Freeman and Perez discuss a taxonomy of innovations by distinguishing between

* Incremental innovation,
* Radical innovation,
* New technology systems,
* Changes of techno-economic paradigms.

By incremental innovation they refer to such innovations that occur more or less continuously in any industry or service activity although at different rates in different industries and different countries.

They may be the result of any deliberate R&D activity, but as the outcome of daily inventions and improvements suggested by workers and engineers directly involved in the production process.

Although the combined effect of incremental innovations is extremely important in the growth of productivity, no single incremental innovation has dramatic effects, and they may sometimes pass unnoticed and unrecorded.

Radical innovations are discontinuous events and in recent times are usually the result of long-term R&D in enterprises and/or in university and government laboratories. There is no way in which nylon could have emerged from incremental improvement of the production process in rayon plants or the woollen industry.

Radical innovations are unevenly distributed over sectors and time and the findings of Freeman et al. do not support the view of Marchetti or Mensch that their appearance is concentrated in particular periods of recession or with 50-year time intervals. Radical innovations do often, however involve combined product, process and organizational innovation, and they do bring about structural changes in the micro- or macroeconomy in that they give rise to new industries and services. Synthetic materials industry or the Semiconductor industry are such examples.

Changes of the "technology system" are far-reaching changes in technology, affecting several branches of the economy, as well as giving rise to entirely new sectors. They are usually based on a combination of radical and incremental innovations, together with organizational and managerial innovations in several sectors.

Examples are the cluster of synthetic materials innovations, petro-chemical innovations, machinery innovations in injection moulding and extrusion, and innumerable application innovations during the 1920's, 30's, 40's, and 1950's.

Changes in "techno-economic paradigm"

Some changes in technology are so far-reaching in their effects that they have a major influence on the behavior of the entire economy. We may speak of a technological revolution.

A change of this kind carries with it many clusters of radical and incremental innovations. A vital characteristic of this type of technical change is that it has pervasive effects throughout the economy, ie it affects almost every branch of the economy. We may call it a "meta-paradigm" which is 'techno-economic' rather than only 'technological'. It is in this connection we may introduce the notion of 'long cycles' or Kondratiev cycles. However, it becomes established as a dominant technological regime only after a crisis of structural adjustment, involving deep social and institutional changes, as well as the replacement of the motive branches of the economy. Such changes are usually irreversible, and are the result of prolonged search in response to perceived limits, and not on the basis of perfect information but on the basis of trial an error.

Examples of techno-economic paradigm shifts are the microelectronics revolution and the new energy and resource technologies that will emerge as a response to the global environmental challenges.

There is a tendency for new innovator-entrepreneurial small enterprises to enter the new rapidly expanding branches of the economy and in some cases to initiate entirely new sectors of production.

6. Forecasting and transition to a new technological epoch

For hundreds of years mankind has used heat and mechanical force to transform non-living material into new shapes and forms that never existed in nature (steel, concrete, plastics, etc.). These "brute force" technologies constitute the backbone of industrialization which has transformed our societies from agricultural self-sufficiency to mass-producing industries and massconsuming societies. Steelworks, cement factories and giant petrochemical complexes are economy of scale dependent, energy and resource wasteful, dirty and often inhuman. In most parts of the world this is still the dominating technology and little is done to change it. However, the 'brute force' technologies are now gradually being transformed and substituted by scientifically based technologies which are less economy-of-scale dependent, less wasteful and thus environmentally more sound and perhaps also more human. Micro-electronics and biotechnology are examples of such technologies. It is another - and more philosophical - question whether technology in general makes us happier. This is a question posed by Jacques Ellul in his latest book "Le Bluff Technologique"(1988). It is sometimes argued that developing countries have an opportunity to make quantum jumps into the future with the help of modern technologies and thus avoid the "brute force" technologies typical for industrialization of the past. I don't believe this will be easy more than in a very few rare cases, eg. Singapore and South Korea. It takes a long time to educate enough experts, to build a nation wide infra-structure and to adapt the population to the new technologies. We tend to confuse the rapid scientific and technological development in the laboratories with the introduction on the market, which is a slow and expensive process, precisely for social reasons. Not even electronics, the most rapidly changing technology, is spread in the market as quickly as we tend to believe.

7. Transition technologies

I believe that we will see a gradual modification and upgrading of the 'brute force' technologies in many mature sectors of industry. Look at the automobile. It has not changed very much as a technological concept during the past 50 to 100 years. What has changed dramatically, however, is the gigantic infrastructure upon which the use of cars depends. Mass production, roads, petrol distribution and all kinds of services. And the mass utilization of cars has been possible because the economic standard has been 'dramatically' improved for an increasing proportion of the population. But the car is still the same piece of unsophisticated technology, 1000 kilos of steel on four wheels. People don't buy cars because these are technically sophisticated.

In my view the automobile industry has been extraordinarily successful in marketing a rather mediocre product. This is a typical 'brute force' technology for which we now have to pay a very high environmental price. If the Otto engine had been invented today I doubt that it would have been accepted. But the automobile is also becoming a good example of a transition technology. It is being improved in efficiency, safety and comfort by introducing new materials (eg plastics) and electronics. But we cannot speak of a 'new' automobile until we have an entirely new concept. Liquid hydrogen as fuel or an electric car with long-distance capacity. This development has just begun and it is industry who has the capital and the know-how to carry it out.

8. Future technologies

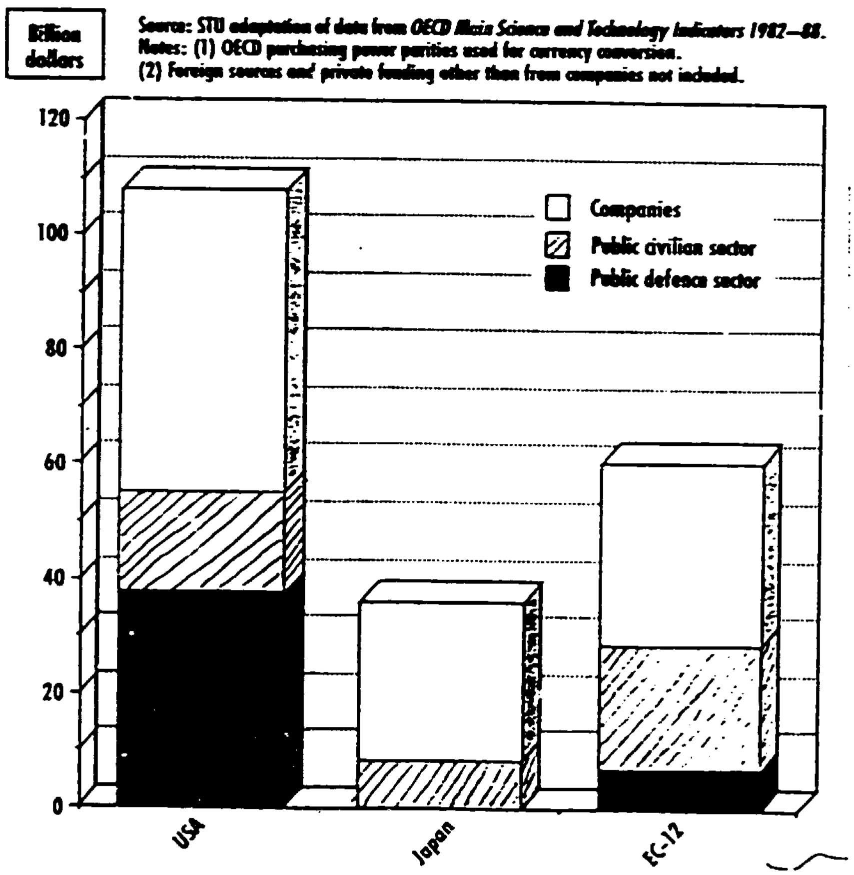
The options of future technologies are infinite if only imagination is the limit. However, as pointed out already, the introduction of a new technology on the market where it will have a socio-economic impact depends more on sociopolitical factors and vested interests than on technology.

By 'Future technologies' I mean technologies which are conceptually very different from prevailing technologies, and which therefore represent a new era of energy and resource saving and of environmental and human appropriateness.

The so called Brundtland commission has added the dimension "Sustainable development" which will probably also influence the development of future technologies.

9. Financing of Research and Innovation

Now basic technologies to an increasing extent characterize the change and growth of industry. These new technologies are more closely connected with scientific research than earlier industrial technologies and tend to have a more truly international character. They therefore bring about new conditions for a national policy and financing of research and innovation.
In the diagram below is shown the funding of R & D in Japan, USA and the 12 EEC countries in 1985.



A few comments to the diagram.

Within R & D programs organised jointly be the Ministry of International Trade and Industy (MITI) and technical research consortia there has been extensive collaboration between Japanese firms and national research institutes since the early 1960s.This collaborative research has become the most noted aspect of the Japanese R & D system and is regarded as an important reason why Japanese industry has attained such a prominent position.

It has been claimed that R & D grants from MITI give Japanese companies unfair advantages. Actually the Japanese Government directly finances only two or three percent of company-conducted R & D, which is a considerably lower proportion than in most other industrial countries.

New ways of supporting collaborative research have been introduced in the 1980s. The most important is the establishment of the Japan Key Technology Centre (JKTC), which is a semi-governmental organization under the aegis of MITI and the Ministry of Post and Tele-communications. One of JKTC's major objectives is to contribute to funding joint research companies, i.e. it makes capital investments or gives loans to companies formed to carry out long-term R & D programs. A great number of such companies of various sizes have already been founded.

In the 1980s Japanese research and technology policy has been thoroughly reviewed and reorientated. The earlier policy was characterized by efforts to emulate the technological progress of the West. One side-effect of this was the creation of a remarkably systematic and efficient global system for checking up on scientific and technical development in other countries. However, the more Japan has come to play a leading role in the technical development of an increasing number of fields the more obvious it appears that its goals cannot be formulated only be reference to research and technical development abroad. Instead the Japanese will have to develop their own visions of possible and desirable technological futures. The Prime Minister's Council for Science and Technology has a key role in formulating guidelines for Japan's R & D policy. In a series of reports the Council has made proposals for a new policy and suggested what steps should be taken to realize them. The main outlines were presented in the autumn of 1984 and have later been followed by more detailed and concrete information. The reports are largely based on material produced by various ministries, especially the Science and Technology Agency and MITI. The following overall objectives for Japan's future R & D policy in the field of science and technology have been laid down by the

Council:

* The focus should be on original innovation.
* Special attention should be given to internationalization.
* Development should take place in harmony with man and society.

USA has long had an undisputed leading position in most areas of science and technology. This leading position can also be expected to be retained in the foreseeable future in spite of the fact that Japan has appeared on the scene as a powerful rival. In production technology, which American industry has neglected, Japan has even surpassed the USA, but strong efforts are being made, especially by the semiconductor industry, to catch up. The combination of bold entrepreneurs and venture-capital that created Silicon Valley has come to be a symbol of the innovative power of American industry. It was therefore a hard blow when preciesly in the field of semiconductors Japanese companies began to gain an increasing share of the market.

To counter the Japanese competition all the leading American semiconductor companies in 1988 jointly formed an R & D consortium, SEMATECH. The purpose is to collaborate in developing a production technology for future generations of highly integrated circuits. For example, by means of development contracts the competetive power of American manufacturers of equipment for producing semiconductors should be enhanced. The fear of becoming dependent on Japanese manufacturers of equipment has also been mentioned as one of the chief reasons for IBM's active participation in SEMATECH.

SEMATECH is up to the most far-reaching example of collaborative R & D initiated in the USA in the 1980s. It was clearly inspired by Japanese models and represents a new line of development in that its costs are shared by industry and the Department of Defence, each making an annual contribution of 100 million dollars. This means that although the explicit aim is to produce technology for commercial production, the federal funding is channelled through the Department of Defence. The explanation is that no suitable civilian authority exists and that therefore the interpretation of the American defence policy has been stretched to also cover the competitive power of high-technological industry producing goods for dual civilian and military use. In this way the Department of Defence has acquired an explicit role in shaping the country's industrial policy. An example of new programs which are under discussion and to which high hopes are attached is high-definition television (HDTV), to which special attention is devoted in spite of the fact that the USA has a minimal number of manufacturers of TV-sets. The US National Science Foundation (NSF), which primarily finances scientific and technical research, has been very active in promoting the development of multidisciplinary research centres. As early as the 1970s NSF initiated research collaboration between universities and industry. In 1985 these experiments were followed up in a more ambitious way by the establishment of Engineering Research Centers. When in 1988 the first decisions on so-called Science and Technology Centers were taken, the engineering centres served as models. NSF looks upon these multidisciplinary centres as a necessary development of the research organization of American universities.

In Western Europe collaboration in research and development has been gradually expanding since the 1950s. In high-energy physics and space technology a very large proportion of West European R & D is conducted today in the form of international teamwork.

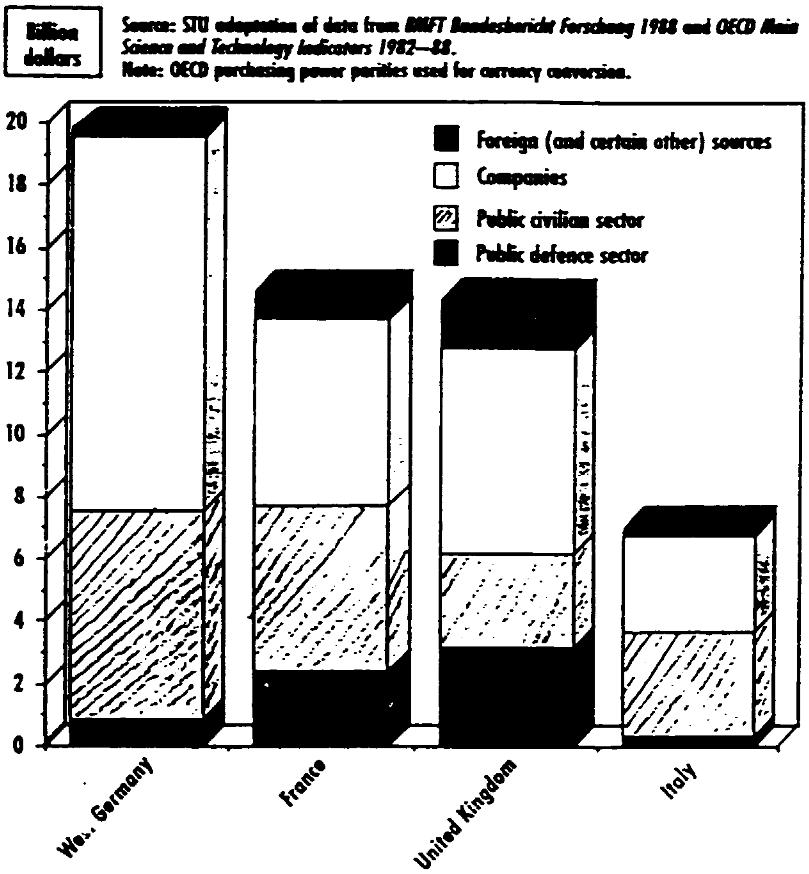
A new trend in the 1980s is the intensification of industry-oriented R & D collaboration. Whereas attention was earlier directed primarily to extremely expensive development projects in fields like nuclear energy or civil aviation, the new R & D programs apply to industries operating under more normal commercial conditions. This new type of collaboration above all characterizes the R & D programs of the European Community and the so-called Eureka project. It is also worth mentioning that an uncountable number of joint R & D efforts constitute a normal feature of interfirm relations.

The significance of the European R & D cooperation varies between different countries. Firms and researchers in the smaller countries are offered collaboration with partners with a competence they can sometimes only find abroad. They also have the opportunity to participate in R & D projects on a scale that is not possible on a national basis. The larger countries, on the other hand, normally choose and organize the programs and because of the wider range of their industry and research they are usually able to make better use of the results.

Swedish firms and researchers are anxious to have the opportunity of active participation in the European R & D cooperation. Since this interest has been the focus of serious discussion only during the last few years, there is still considerable uncertainty as to what possible obstacles might prevent or complicate participation. Here follows a list of such possible obstacles:

* With few exceptions Swedish participation in the EC's R & D progra ns is at present limited to the project level. In some cases Sweden is not admitted at all.
* In many important areas cooperative constellations without Swedish participation have already been consolidated within the framework of different EC programs.
* Sweden has not yet established a sufficient number of bilateral R & D relations in Europe. Bilateral agreement often constitute an important link to participation in multilateral cooperation.
* The geographical position may cause countries in central and southern Europe to regard Sweden as a less attractive collaboration partner.
* Swedes conducting R & D in small groups or with a heavy burden of short-term commitments have difficulty in finding sufficient resources for participation in comprehensive international cooperation.
* The engagement of Swedish research institutions in European industrial R & D depends as a rule on the possibility of participating together with Swedish companies. This can in certain cases be a strongly prohibitive factor.
* Technologically leading Swedish companies are not dependent on having Sweden as the base for participation in international cooperation.
* It is not yet clear whether Swedish companies will be able to participate in European R & D cooperation on the same financial conditions as apply to other companies.

In the diagram below is presented the Funding of R & D by four EEC countries in 1986.



As the figure shows, the R & D systems of the four largest EEC countries display great differences. The West German R & D system is characterized by considerable variety as regards performing organizations, funding bodies, and forms of support. One is truly impressed by the broad and deep capabilities of West German industry, which no doubt has a more "complete" structure than that of any other European country. Industrial efforts in R & D are very much larger in West Germany than elsewhere in Europe; in fact they reach the same level as in France and the UK together.

A special feature of the West German R & D system is the division of roles between the Federal Government and the States. The latter are responsible for the universities and finance approximately 70 percent of their research, the remaining 30 percent coming mainly from federal funds. In spite of the fact that in West Germany the universities are conducting more research than in the UK, West Germany has also a large number of research institutes receiving about the same amount of public research support as the universities. However, in their case the larger contribution, 80 percent, is from the Federal Government and only 20 percent from the States. The R & D results of the Fraunhofer insitutes and the institutes for cooperative research can most easily find industrial application and accordingly derive a large part of their funding from industry. The thirteen "Grossforschungseinrichtungen" (institutes for large-scale research) constitute the largest group of institutes with 20.000 employees, almost half of whom are researchers. Their activities cover a broad spectrum of advanced scientific and technical R & D. Finally, West Germany has sixty Max Planck institutes which conduct basic research intended to complement that of the universitites. Their special emphasis is on opening up new research areas.

The West German Science Council, which was founded by the Federal Government and the States in 1957, has as one of its task to give recommendations for the future structural development of the universities. In a recent report the Council points out that the public research policy has undergone a shift in emphasis since the late 1970s. The relevance of research is being more stressed and areas of research with no "technological relevance" are finding it difficult to obtain sufficient resources. On the whole, however, the Council considers this development natural and even desirable. It also emphasizes that basic and applied research should not be regarded as alternatives but as each other's prerequisites: "The close connection between basic research and technology is reflected by the fact that many areas of physics and biology have unexpectedly become technology-oriented".

West German technological policy is characterized by an expressly restrictive attitude to public intervention in industrial development. Nevertheless, there is no doubt that the Federal Government and the individual States are actively trying to stimulate technical innovation. West Germany's position as the leading industrial EC country and the fact that Swedish industry often finds West Germany to be its main competitor motivate an interest in Government efforts in that country to promote R & D in industry. In 1987 the total R & D allocations of BMFT (the Federal Ministry of Research and Technology) amounted to approximately SEK 26 billion. ($ 5bn).

In the UK foreign companies conduct R & D to a greater extent than in the other three countries included in the Fig. The UK Government concentrates its R & D support on its defence and its universities. A key agency for the funding of civilian research is the Science and Engineering Research Council (SERC). This council has emphasized the importance of promoting inter-disciplinary research. Among its own steps in this direction have been attempts to coordinate support to technical and scientific research in areas where fundamental research and the development of industrial technology interlock. The most notable examples so far are molecular electronics and biotechnology. Recently similar steps have been taken in the area of materials research. One of SERC's objectives up to 1991 is to contribute to the creation of some twenty university-based interdisciplinary research centres.

A recently established framework for combining public and industrial appropriation of resources for strategic research is LINK. Its funding rules resemble those applying to the Swedish cooperative research programs, but the research programs supported by LINK are in most cases of a considerably more basic character. Hitherto most of the public funds for LINK have come from either SERC or the Department of Trade and Industry.

So far this international survey has dwelt mainly on industrialized countries with economic resources that are many times larger than those of Sweden. Research and development in these countries certainly constitute an important framework for the activities of Swedish firms and researchers. However, to get the right perspective of what is possible for Sweden it is also necessary to study the situation in the smaller industrial countries. A country which will be especially looked at here is Switzerland, which in terms of its R & D system resembles

Sweden in many respects.

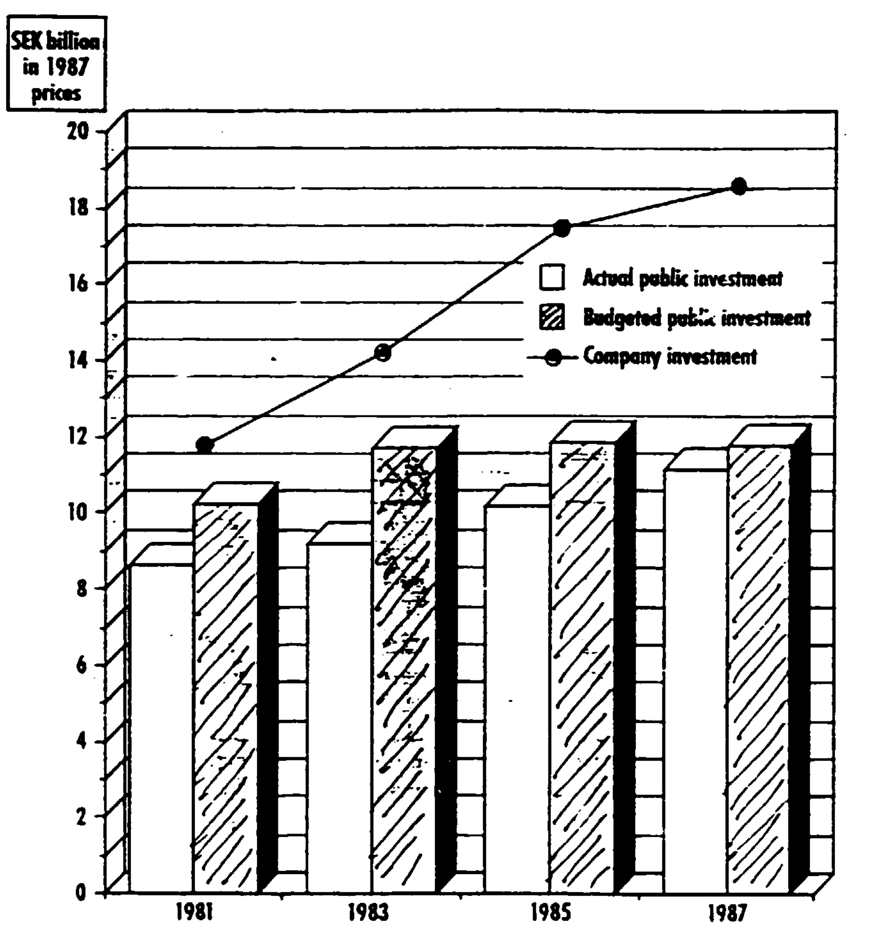
Just as in Sweden, universities and institutes of higher education in Switzerland receive most of the public research funding. The technical universities, in particular, cooperate closely with industry and efforts are made to strengthen these bonds. Among the smaller industrialized countries Switzerland and Sweden allocate the largest resources to R & D in relation to their total economies. This high input is primarily due to the comprehensive R & D performed by industry. The industrial contribution is especially notable in Switzerland, for although the population is only four-fifths of that of Sweden, Swiss companies spend somewhat more on R & D than their Swedish counterparts do. An important component of the Swiss research system are the so-called "annex institutes", which are attached to the technical universities. They have close to 1.500 employees and account for about 40 percent of the R & D performed by these universities.

The allocations of resources in the smaller European countries are in a strikingly high degree directed to the same technological areas as in the larger countries. However, the aim of the smaller countries is more seldom systematic development of new basic technologies. Instead efforts are concentrated on various ways of developing the use of such technologies. National technology programs are organized and are partly funded by the respective governments for the purpose of promoting cooperation.

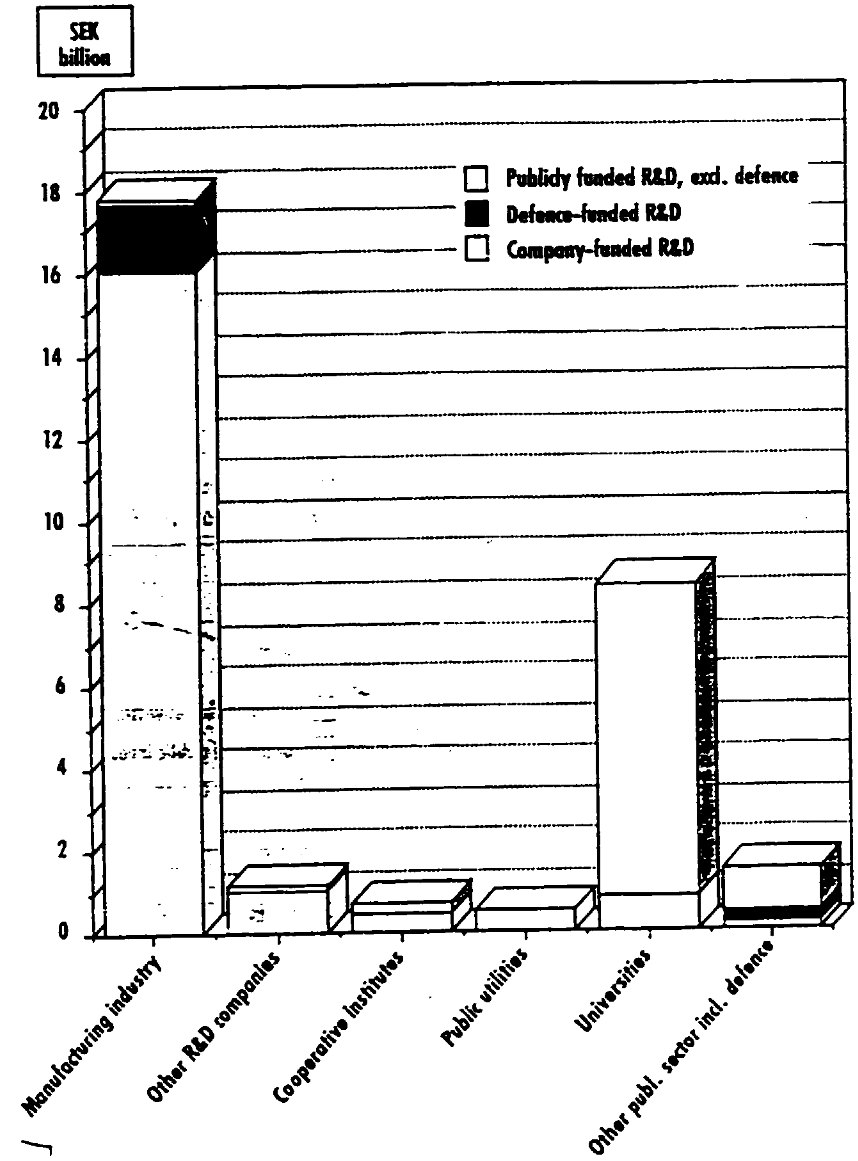
A large part of the OECD report Science and Thechnology Outlook 1986 is devoted to questions concerning the use of new technology. These questions are considered to have so far been neglected. For the economic development of a country the ability to make efficient use of technology is claimed to be more crucial than the ability to develop it. West Germany, Switzerland, and Sweden are adduced as examples of countries which have particularly emphasized the value of measures promoting the use of new technology.

Swedish R & D have increased considerably during the 1980s. In 1987 the total amount was 31 bill. SEK, ie. approximately 3 % of the GNP, which is among the highest in the world.

The fig. below shows the distribution of funding of R & D in Sweden in the period 1981 - 87.



In the Fig. below is shown the Swedish R & D expenditures by source and performance in 1987.



The Responsible agency in Sweden for government sponsored R & D has been STU (Board of Technical Development). From 1 July 1991 a new and stronger agency (NUTEK) is responsible for R & D, Energy research and Industrial development. Its total budget will be about 3.5 bill. SEK. ($ 600 mill.)

One of STU:s functions has been to complement other R & D activities, which is reflected by the fact that grants given by STU only amount to 30 % of Sweden's total R & D expenditure. Planning and implementation must be based on cooperation with entrepeneurs and other capable agents outside STU. About 800 experts representing industry, research, different organizations and authorities take part in STU activities.

STU:s role has been formulated as three programs intended to stimulate Swedish industry to achieve the following objectives:

* Creation of a fund of new knowledge and strengthening of the scientific base within areas of strategic importance to the future growth of Swedish industry;
* Development of new technology to be introduced into established industrial sectors and disseminated to different parts of the country,
* Establishment of companies manufacturing technology-based new products with high growth potential.

Since the end of the 1970s STU has given priority to the development of basic knowledge within information technology, biotechnology, biomedical technology, materials technology, and mechanical engineering. This priority is still valid, but STU is also highly interested in other areas of importance for Swedish technical development. Work for a better environment is becoming more and more important in most industries and increased support for researchers and companies engaged in finding solutions to environmental problems is necessary. Since the early 1980s STU has been active in the field of technology procurement and found it to be a good way of strengthening technical development. STU (NUTEK) is also expected to continue its efforts to promote a more effective energy technology in industry and transport.

10. <u>The Universitites as a knowledge base - the Swedish case</u>

Business enterprises all over the world are finding it increasingly necessary to locate their strategic R & D and knowledge-intensive production in countries and regions where they can find advanced research environment and good possibilities of recruiting technically competent personnel. It is true that this has caused some Swedish companies to place part of their strategic R & D abroad. However, most technically advanced business enterprises, even those engaged on the world market, have so far retained Sweden as their base. Under these circumstances it is natural that the technical-scientific foundation must be more comprehensive in Sweden than in technically less advanced countries or in countries with a more limited industrial structure.

The university system is of greater importance and has more essential functions in Sweden than in many other countries. It comprises not only the traditional universitites but also a large variety of colleges and institutes of higher education. The latter categories are in the following discussion subsumed for the sake of brevity under the designation "university". The Swedish universities are divided into sectors corresponding to the needs of society and this enables them to serve as a primary resource for both basic and applied research. Today technical development is proceeding at an increasing pace and the research in new areas that is constantly needed is in the first place assigned to the universities. It is their task not only to provide education for future qualified researchers and engineers but also to perform research that produces valuable results and to disseminate results achieved in international research. The universities are expected to accept externally funded assignments and to assist whenever there is a need for expertise and advice in solving scientific problems. One reason why the Swedish universities have acquired this central role as a competence base for long-term technical research is that Swedish companies do not invest in this kind of research to the same extent as do companies in other countries.

STU has not performed any R & D of its own but played an important role in initiating university R & D in areas of great technical-scientific and industrial significance. But the cooperation goes still further. All the STU steering and reference groups include members representing Sweden's leading university researchers. These representatives also participate actively in the initial stages of new STU programs. When major program changes are envisaged, questionnaires are widely circulated to establish the opinions of university researchers. Before STU's previous three-year plan such an enquiry was made, and the intention is to repeat the procedure in planning the next three-year program. STU also has an Industrial-Scientific Council which invites foreign researcher to make scientific evaluation of STU's coordinated research programs and helps STU to draw the right conclusions from these evaluations. In cooperation with the Industrial-Scientific Council STU arranges biennial academic symposia where general research issues are debated and STU's plans for future program activities are discussed from the point of view of an overall research policy. Moreover, working groups propose guidelines for STU's support to programs and projects.

Technical research is becoming more and more comprehensive and expensive, at the same time as the amount of knowledge continues to grow at an increasingly rapid rate. In many areas the gap between new knowledge and industrial application is narrowing. In other areas scientific theories and models are being constructed on the basis of empirical knowledge. Many of the new technologies are complex and call for interdisciplinary contacts, and this increases the need for communication and cooperation between researchers in different fields.

The comparatively limited resources set aside for R & D in Sweden make great demands on the efficiency and innovation of the R & D system. The following points are in STU's view of crucial importance:

* Weighting of R & D areas in order to establish a priority order;
* Specialization in different areas of R & D at universities and other compentence centres;
* Collaboration between researchers, industry, and society in planning and conducting research;
* Dissemination of results through suitable channels and promotion of contacts between researchers and users of results.

Regional universities whose teaching staff are also engaged in ongoing research constitute a valuable resource for the regions in which they are situated. Many regionally important research areas are also of great significance for the national build-up of competence, STU considers it to be a vital Swedish interest that any future appropriation of resources for the purpose of strengthening regional expertise should take place in areas where the regional universitiets can cooperate with the larger universities.

ICS Course on Research and Innovation Management
Trieste, October 1991

Financing of Research and Innovation Projects

by
Peter Lindström
Innovation Institute, Sweden

With higher demands on the efficiency and output of the captal invested in scientific research and innovation, the management of funds and risk capital becomes of critical importance.

When discussing risk capital the term "venture capital" is most often used as an overall termanology. But what is "Venture Capital" and how can it and the system behind it be used in the best manner in the financing a development project? The following discussion will be divided into two major sections.

First of all more theoretical section where we discuss what venture capital is an how it has developed during the past two decades. I will try to show that although it has often been considered as a successful form of financing, the activities outside of the US have often been directed away from "risk/development projects" and that emphasis has instead been placed on companies which, although in need of capital, are in essence fully developed. At present, the traditional risk capital market is no longer a viable arena for the majority of the long-term research and innovation projects. (Emphasis on the European continent) In this section I will also show the reasons for this development and what is needed to reestablish a true "risk capital" market.

In the second section I will be showing how the Innovation Institute has managed to survive as a risk capital financier and developer of risk projects. Several cases will be given as examples of projects in which the Innovation Institute has been involved and how we have responded to best develop these from various stages in their development to be fully developed companies with marketable products and a good potential for success.

In conclusion I will summarize my ideas of what is important and necessary if a risk project, even those that have obtained financing, is to succeed.

What is Venture/risk Capital - an historical perspective

I feel that the best total definition of risk capital is given by Dr. Neil Cross, former Chairman of EVCA. According to "Introduction to Venture Capital Finance" he is quoted accordingly.

"The provision of risk bearing capital, usually in the form of a participation in equity, to companies with high growth potential. In addition, the venture capital company provides some value added in the form of management advice and contribution to overall strategy. The relatively high risks for the venture capitalists are compensated by the possibility of high return, usually through substantial capital gains in the medium term". (Dr. Neil Cross, former Chairman of EVCA)

A study on risk capital financing of small sized companies has been carried out by the Swedish Department of Industry which has found similar results. According to this study a risk/venture capital financier is interested in:

* investing primarily in companies which are not listed on the stock exchange,
* that the investment is made in the form share capital or convertible loan. Other forms of loans without security are often considered as a complement to share financing,
* that the investment should give a minority position in the company including representation on the board of directors,
* that although they are prepared to add additional capital the investment should be limited in regards to time span,
* in supporting the company with other forms of competence,
* that profit on the investment be realized first through the increased value of the company, secondly through dividends and interest.

What does this say in clear terms:

That risk financing is usually in the form of equity, i.e. an overprice paid for shares in a company. If the company is unsuccessful, the money invested is lost.

The company should have a high growth potential making the risk involved worthwhile in comparision to placing the monies in other forms of investment which give a steady income potential. A general basis for investment is often:

* The investment should have a payback in ca. 3 years with a 40% turnover on investment. This 40% is divided accordingly:

Forfeited opportunity (interest)	10% or higher
allowance for risk	30%
REQUIRED RATE OF RETURN	40%

According to the majority of Swedish risk capital companies, the desired return on investment is similar, often wishing a steady 30% increase per year. (ca. doubling of investment in three years)

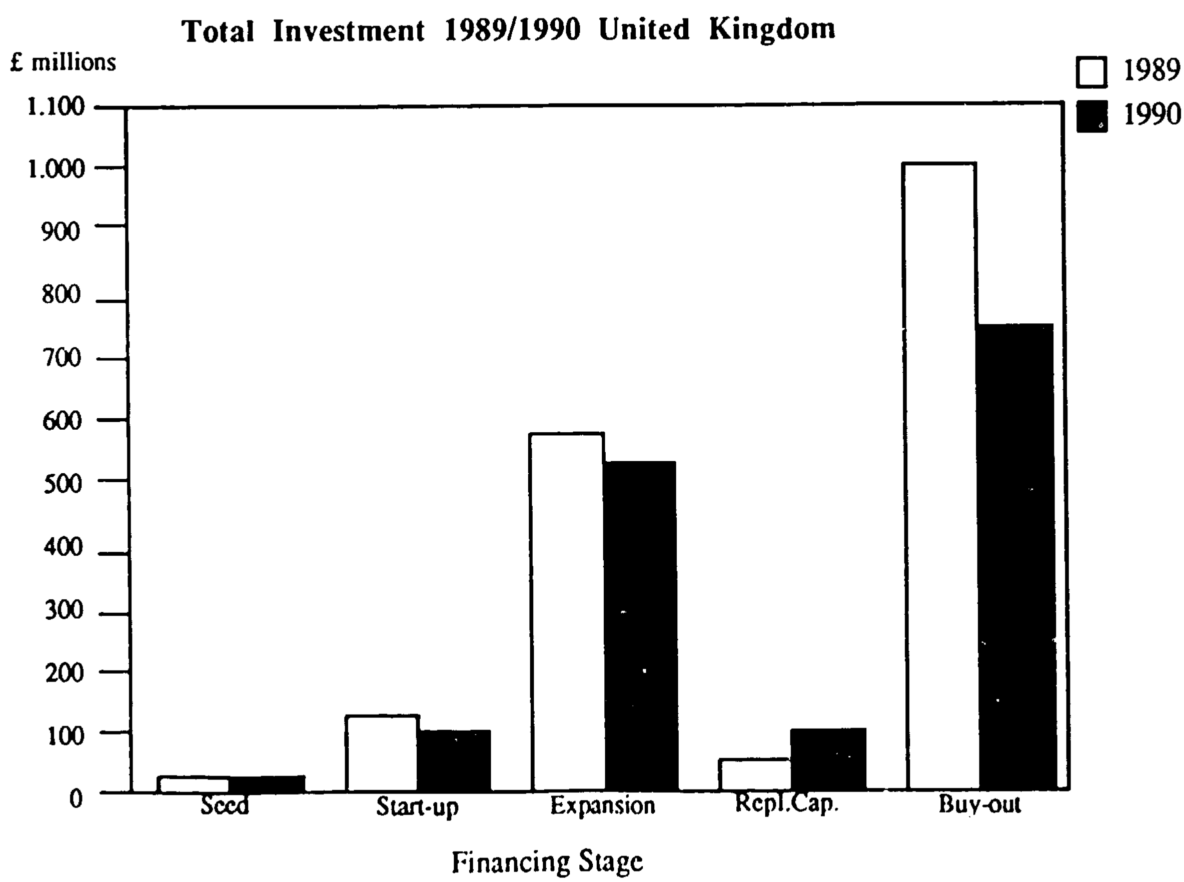
The investor is not only interested in supplying financing, but also in taking an active role in the development of the project/company. This does not mean that they are interested in becoming involved in the day to day operational responsibility, prefering instead to hold a seat in the board of directors where their knowledge and contacts can be best used in leading the project/company in the desired direction.

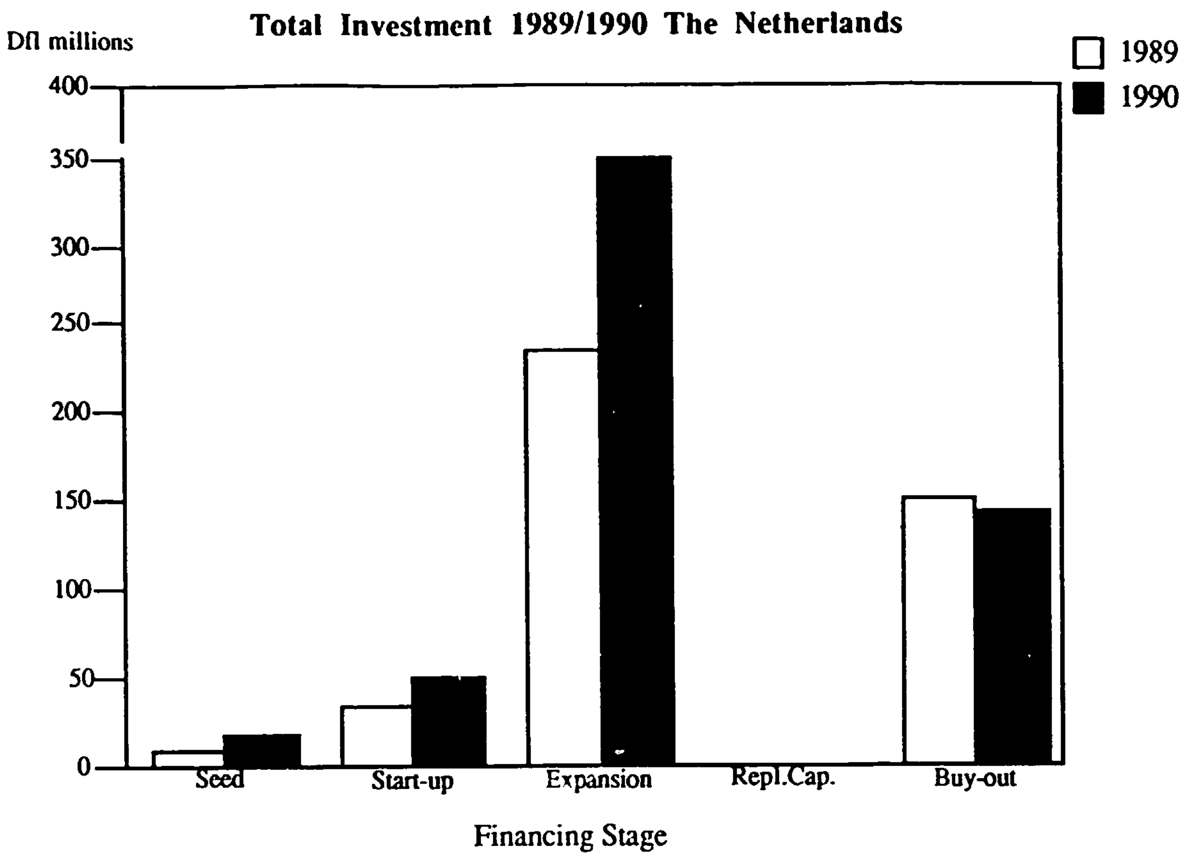
If we at the same time take into consideration what the majority of those that are looking for financing are interested in obtaining, we find that the wishes from both sides complement each other. This should form a basis for success, but in reality the pictures is much different.

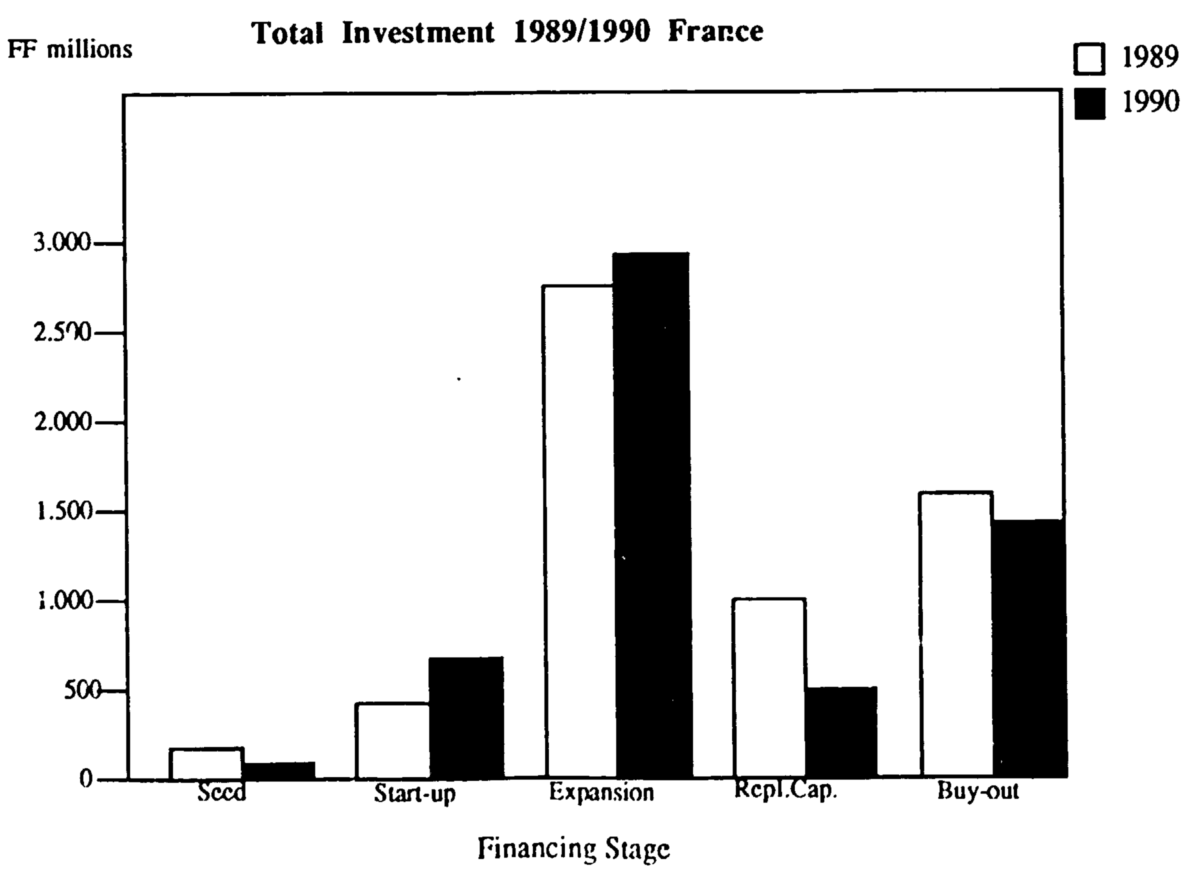
There are 7 major accepted steps in the financing of risk projects, starting from seed capital to an idea and through to final financing before going public.

1. Seed capital
2. Start-up capital
3. Early stage finance
4. Second round finance
5. Expansion capital
6. Management by-out and buy ins
7. Mezzanine finance

If we examine figures from the member state included in the EVCA, we see that the development in Europe is one which has gone away from support for research and innovation development project (steps 1 - 5) to the financing of companies in the position relating to steps 5 through 7.




Total Investment 1989/1990 The Netherlands
Dfl millions
1989
1990
400
350
300
250
200
150
100
50
0
Seed
Start-up
Expansion
Repl.Cap.
Buy-out
Financing Stage


Total Investment 1989/1990 France
FF millions
1989
1990
3.000
2.500
2.000
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500
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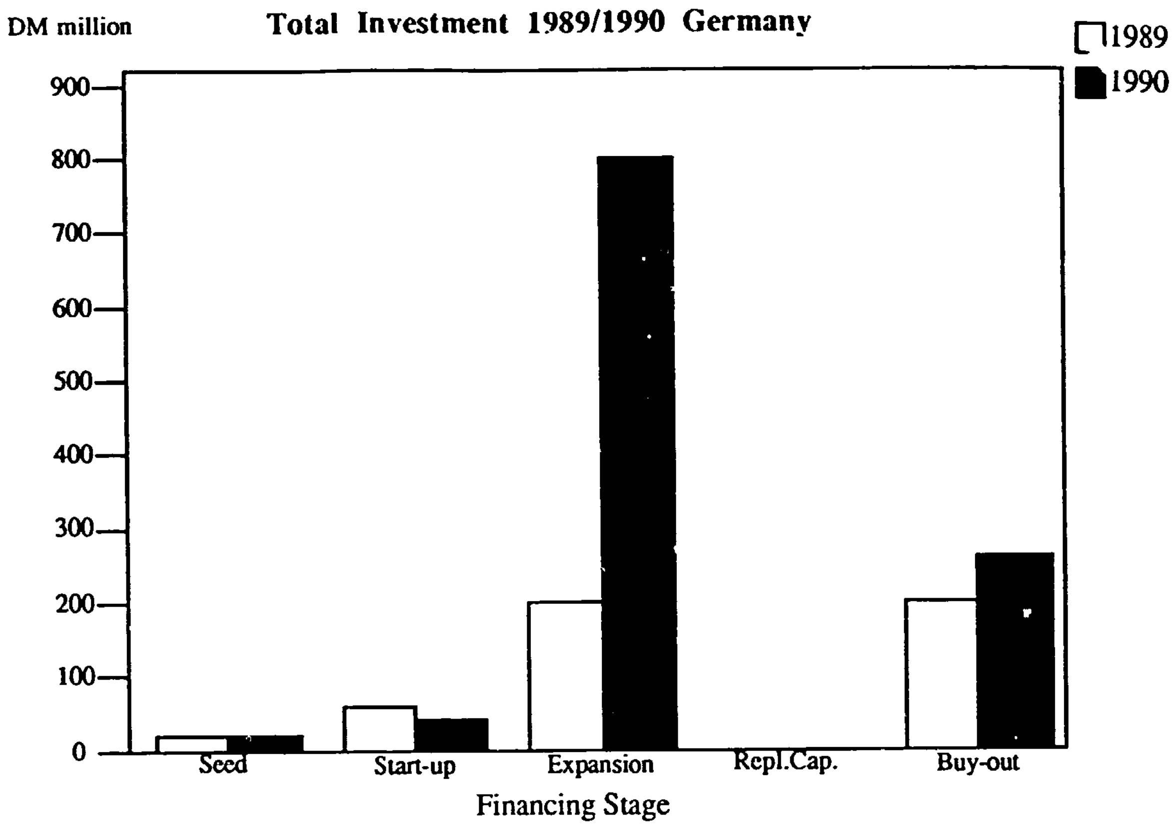
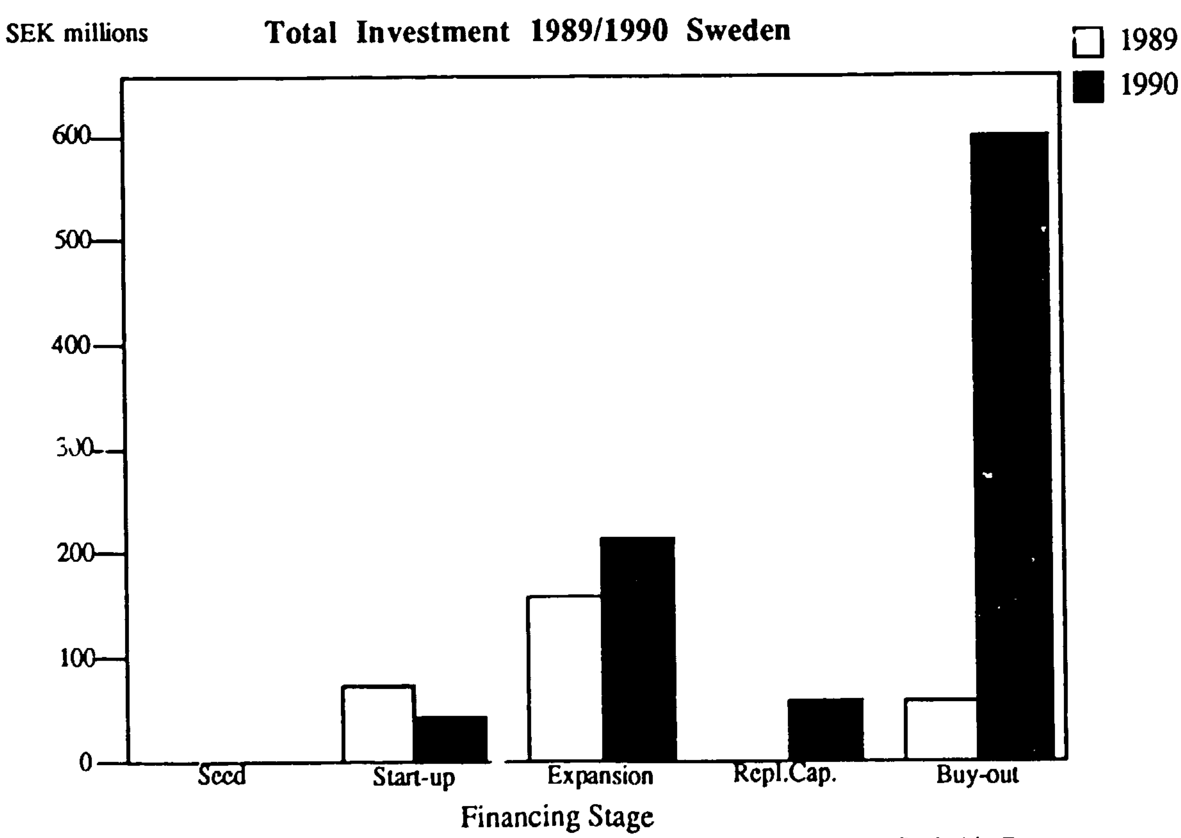
Seed
Start-up
Expansion
Repl.Cap.
Buy-out
Financing Stage





Source: Venture Capital in Europe.

Fund Raising and Investment Activity for Europe: Five Year Trend

All Amounts ECU x 1.000	1986		1987		1988		1989		1990		5 Year	Total
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
Stage distribution of investment in year												
Seed	10.576	0.5	29.982	1.1	9.238	0.3	38.686	0.9	30.782	0.7	119.264	0.7
Start-up	325.058	16.9	313.828	11	423.237	12.3	383.069	9.0	319.718	7.7	1.764.910	10.6
Expansion	1.105.853	57.5	1.431.862	50.4	1.427.681	41.4	1.698.649	39.8	1.987.813	48.2	n/a	n/a
Replacement Capital	n/a	n/a	n/a	n/a	259.904	7.4	239.287	5.6	269.941	6.5	n/a	n/a
Expansion - Replacement Capital	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	8.420.990	50.7
Buy-out	481.843	25.1	1.066.436	37.5	1.331.144	38.6	1.911.312	44.8	1.517.465	36.8	6.308.200	38.00
Total	1.923.330	100.0	2.842.108	100.0	3.451.204	100.0	4.271.003	100.0	4.125.718	100.0	16.613.363	100.0
Syndication of investments in year												
No syndication	938.867	48.8	1.134.428	39.9	1.489.795	43.2	1.757.323	41.1	1.649.927	40.0	6.970.339	42.0
National syndication	900.772	46.8	1.505.113	53	1.763.024	51.1	2.190.572	51.3	1.638.748	39.7	7.998.229	48.1
Transnational syndication	83.691	4.4	202.567	7.1	198.385	5.7	323.108	7.6	837.044	20.3	1.644.795	9.9
Total new investments	1.923.330	100.0	2.842.108	100.0	3.451.204	100.0	4.271.003	100.0	4.125.718	100.0	16.613.363	100.0
Geographical distribution of portfolio												
Domestic	1.738.997	90.4	2.548.040	89.7	3.184.352	92.3	3.756.272	87.9	3.572.269	86.6	14.799.930	89.1
Other European countries	80.687	4.2	85.185	3	149.202	4.3	378.661	8.9	443.522	10.8	1.137.257	6.8
Non-European countries	103.645	5.4	208.882	7.3	117.650	3.4	136.070	3.2	109.927	2.7	676.174	4.1
Total new investments	1.923.330	100.0	2.842.108	100.0	3.451.204	100.0	4.271.003	100.0	4.125.718	100.0	16.613.360	100.0

Why has this trend developed in regards to venture capital in the accepted meaning and what can be done on an international level to better this position? I believe that it is primarily due to four main reasons.

* Started in the US, where tax system was very beneficial and only those cases which were very successful were brought into the open. As a result attempts were made to use same system in Europe where they saw "high-tech risk projects" as a chance to make quick money.
* In Europe the tax legislation was much different from the United States making it necessary to use taxed monies for risk investments. This in turn meant that output/profit on the invested capital was placed under much higher demands.
* Payback time in about 3 years which is much too short for the majority of development projects in one of these first five steps.
* The investees were primarily interested in return on profit which means that there must be some form of exit whereby they could realize a profit on the investment.

The gap between in-house and university research, as Sam talked about yesterday, and the present use of Risk Capital includes the first five steps in the risk capital system.

1. Seed Capital - The financing of the initial product development or the capital provided to an entrepreneur to prove the feasibility of a project and qualify for start-up capital.

Characteristics

* the absence of a ready to market product
* the absence of a complete management team
* a product or process which is still in the research or development stage.

(High risk and greatest potential profit)

The attributes required for successful seed capital investing would appear to be:

* project management skills
* a degree of technical competence on the part of the investor
* a very long (perhaps 7 - 10 years) investment horizon
* an ability of the venture capitalist to work with scientists and technologiest as opposed to managers

2. Start-up Capital - Capital needed to finance the product development, initial marketing and the establishment of product facilities.

Characteristics

* the establishment of a compa~y, whether by incorporation or partnership
* the establishment of some - but not all - of the management team
* the development of a business plan, and a prototype product or fully developed idea
* the absence of a trading record

(Venture capitalist's investment criteria shifts from the idea behind the company to the people behind the company and the market opportunity represented by the management's realisation of the idea).

3. Early Stage Financing - Finance provided to companies that have completed the product development stage and require further funds to initiate commercial manufacturing and sales. They will not oe generating profit.

Characteristics

* Little or no sales revenue
* Cash flow and profits are still negative
* A small but enthusiastic management team which consist in most cases of entrepreneurs with a technical or specialist background and with little experience in the management of a growing business.
* Short term prospects for dramatic revenue and profit growth

(Fully assembled management team and marketable product. Change from main risk from internal to external factors) However, the existence of a product and a management team considerably reduce the fundamental risk facing the equity investor with patience.

4. Second Round Financing - Second round or "follow-on" finance can be defined as the provision of capital to a firm which has previously been in receipt of external capital but whose financial needs have subsequently expanded.

Characteristics

* A developed product on the market
* A full management team in place
* Sales revenues being generated from one or more products

* Losses on the income statement or, when it is breaking even, a negative cash flow.

(Negative points may be: * costs over-runs in product development * failure of new products to live up to sales forecasts * the need to reposition products through an new marketing campaign * the need to refine a flawed product once its deficiencies are revealed in the testing ground of the market place.

Note:

* As a shareholder rather than a creditor, it may be necessary to provide financing to an investee on more than one occasion prior to realisation
* Not withstanding the above, investors must be careful to avoid the "if only" syndrome. Second round and later financing should be supplied only if the additional capital commitment can be shown to have quantifiable benefits in the foreseeable future.

5. Expansion Capital - refers to the finance provided to fund the expansion or growth of a company which is breaking even or trading at a small profit. Expansion or development capital will be used to finance increased production capacity, market or product development and/or to provide additional working capital.

Characteristics

* Investment in companies that have been substantially self-financed since the foundation, and are seeking outside equity to the first time.
* The provision of second round finance to a company that has already received at least one round of early stage capital from other sources.

Characteristics

* Returns which will tend to be lower than for earlier stages of venture investments
* Financing needs which will typically be larger than for earlier stages
* Returns from investment which will typically be realised sooner. (2 - 5 years)

Note: This is seen by many as being the first step when financial skills are essential. I do not agree with them at all. If anything it is up until this stage that financial stage that it is necessary to have these skills, along with of course a good auditor and a lot of imagination.

A comparision between the time scales involved with projects in these steps and the short-term goals, payback in three years, makes it quite obvious that the two are not compatible. If we are, however, to regain a risk capital market which is compatible for projects in these first five steps I feel that the following is needed:

* New tax laws allowing for the use of untaxed capital.
* A serious attitude among investors in which they realize that, although the profit potential is great, it is unrealistic to expect a return on investment in a realitivly short time span.
* New "exit" systems be established, preferably with tax benefits for investors.

With this historical perspective one can ask the question, Why is the financing of the new high risk projects and companies still interesting. The main reason is obviously that it is these types of companies that are the backbone for future industrial growth. This has finally been realised and steps are being taken in various European countries which look positive.

In England, for example the Business Expansion Scheme (BES)/Business Start-up Scheme (BSS) has been in use since 1981. This is a system by which private persons, primarily in the higher income bracket, are allowed to transfer funds of up to £40.000/annum into companies that are younger than 5 years. The Swedish Department of Industry has now recommend that governmental funds to regional development organisations be increased with 1.8 billion SEK and the new government in Sweden has promised better tax conditions for risk capital investments. Plans are also being made for the establishment of some form of stock exchange where trade in small and risk company shares can be handled.

Similar trends are developing on mainland Europe, headed primarily by Germany and the European Community. In 1989 the European community's "Directorate for Enterprise Policy" has earmarked capital for and so called "Seed Capital Scheme" which allows for interest free loans to be granted to venture capital companies that are primarily involved with newly started companies. These loans can be written off it the companies are unsuccessful.

There are of course other reasons, on the personal level, which make such financing interesting.

1. Difficult or slower to finance self. (Many of these projects must be realized in the short time span to gain optimal profit). NEVER go in privately with a bank guarentee.
2. Form for entrepreneur to retain control of company while financing development or expansion.
3. With a good selection form and careful control of the projects, their are great profit potentials.

Even though the conventional venture/risk capital companies are not applicable for the time being, there are financers to be found IF the proper care is taken in finding them and they are presented with the proper information, i.e. a full and complete business plan as discussed two weeks ago.

The Innovation Institutes works within the first 5 steps in the financing of risk projects. Depending upon the project, the Innovation Institute sometimes finds itself in the position of the financier while other projects demand that it functions as the raiser of risk capital. This wide range of activities has placed the Innovation Institute in a very unique seat, forcing it to take consideration of all aspects involved in risk capital financing.

Although there are very many points that are similar for all projects, no two projects are ever exactly the same. The Innovation Institute is primarily involved with projects in Sweden. Although the political criteria is more or less similar from year to year, the technical, market and financial aspects differ greatly from project to project.

This, together with the fact that you will not only represent various financial viewpoints, from the entrepreneur to the financier, but you also represent very many different cultures, political systems and investment regulations. For these reasons it is impossible to give a tailor made plan for the financing of risk projects. What is possible, however, is to give some guidelines which will assist in your own projects and perhaps some new ideas that can help with these projects.

As a financier of risk projects the following can be mentioned:

* Gather the right board of directors. The members should not only have experience with leading and developing small companies but also experience with industry and industrial development.
* Limit the board of directors to a managable number.
* Make sure that the share holders are fully familiar with the time and energy involved with developing products and companies.

* Try to get share holders who are morally involved with the idea behind the development of new companies, not just financiers.
* Have enough start capital
* Decide upon the business idea and establish a investment policy regarding direction and size of individual investments.
* Establish a balance in your portfolio of companies. Spread the risk between the age of the companies/stage of the development and between the area of the investments.
* Don't jump into investments. Make sure that you have all information on the company and area of activity (market, competitors, etc) before investing.
* Expect the level of investment to be much higher than anticipated.
* Have a steady control over your cash-flow.

As a risk capital financier, the Innovation Institute has placed top priority on establishing a diversified base of projects/companies, with a balance between infrastructural projects, consumer goods and industrial products, and also between the level of investment and time scale involved, i.e. between the five steps in the financing of projects. Perhaps, however, the most important reason for the Innovation Institutes success is that we budget that NONE of our ongoing project will in themselves give a positive cash-flow to the Institute until they are sold elsewhere. Our cash-flow is established through other activities, for example consulting.

A typical example of an over ambitious risk capital company is InnoCap AB (Innovation Capital), give background including the tile factory that went bankrupt at the same time as product was packaged and ready for IKEA.

In regards to the financing of the individual projects/companies which the Innovation Institute is involved in, it is very seldom the we finance the entire project ourselves. Our expertise lies in the area of evaluating, selecting of projects and, with limited financing, building up a development and financial strategy, which can then be used to attract further financing. However, we do not leave the project at this stage. If anything tne Innovation Institutes becomes more active, using its experience to assist in problem solving, market contacts, and financial advice.

As I have mentioned above, it is absolutly impossible to give advice or a strategy which is applicable for all risk projects. What I can, however, is present several case projects in which the Innovation Institute is involved and examples of how we have, based upon the particulars of each project, responded to make the most of the position.

VNP - From a need to a marketable product

In 1972 a study was carried out to evaluate which types of products would be necessary in the period up to 2000. In the study it was found that, due to environmental damages caused by inorganic fertilizers and in turn the fact that these fertilizers would either be taxed with penalties or totally forbidden, there would be a need for organic based fertilizers. At the same time it was found that waste products would become a growing problem for both developing and developed countries.

All current fertilizer producers in the Scandinavian region were contacted. Not only were they approached regarding potential financing but also with a request to give their ideas of what would be needed of such a product in order to meet future market needs.

Not one producer was interested in financing in any form. They did however give their ideas of what such a product would need if it were to be accepted on the market. As a result, a project group was designed with the goal of developing a marketable product concept in the field of organic fertilizers and based upon the use of organic waste material. Although a future market was seen, there was no immediate market due to the fact that the price for inorganic fertilizers was to low. We had no finished product and no management team. Only a product idea brougt forth by a group of "crazy scientists".

Based upon this information, the Innovation Institute approached STU, the Swedish Board of Technical Development which was presented with a project plan and strategy. The goal of the project was to bring forth a product, compile all major technical and market information, i.e. a business plan which would form a basis for further financial activities.

Based upon this project plan, the Innovation Institute was granted 2 x 200.000 SEK. This does not seem like much money, but with careful control it was enough to cover a majority of the work of the management team, production of a small amount of the product by way of lego production and carry out a three year study at the Swedish Agricultural University in Ultuna. During this time a patent application was submitted which resulted in a principle patent.

If this would have been advanced in the form of a company it would have eventually led to a case for the bankrupcy courts. Due to the fact that we were able to realize that it would not generate any income for quite some time, we were able to balance the costs excessive of the financing from STU, with Innovation Institute financing. At the same time we were able, primarily due to the market contacts and patent, to place a financial value on this development which could be taken up in the Innovation Institutes balance sheet.

This strategy to develop the product in a project form has proved to have been a rather lucky decision as the Innovation Institute was incorrect in its judgement of time to market. It was not untill 1989 that the anticipated financial penalties were finially imposed. If we had rushed out and invested large sums of money in production machinery, employees, buildings, etc. it would have cost much more than either the Innovation Institute or STU would have agreed to finance. Rather than being forced to continually discuss a negative budget and ways to reduce costs, we have instead been able to retain a positive attitude with small but steady moves forward.

Based upon the continual advancement of results we were able to once again appraoch producers of fertilizers and received a positive response from Scandinavien's largest producer, SLR. We were also able to gain positive responses from Sweden's second largest waste control company and Sweden's largest construction company. This was quite a different result from that 10 years earlier and primarily due to:

* the fact that the project now had a market that would accept our price.
* the results of many years tests and market contacts which proved the positive advantages.
* a strong patent, including secondary patents.
* a strategy that was attractive to financiers (the strategy not only offered potential profits, but also direct association with the financiers business ideas which in turn increased direct profit.

This project is now, after 18 years, in a position to carry it's own costs and will, in the near future, be converted to a company form.

STRAX - A case for first round financing

Strax is a newly established company whose business idea is to develop systems based on microwaves, used in the localization of persons who are lost/injured and in need of assistance. The company's product is primarily directed towards avalanche victums, but other markets have been discovered and exploited.

From 1980 - 1989, two of the share holders in the newly established Strax owned and operated their own company working with the development and sales of similar systems. These systems were sold through a retail & distribution company which had been granted an exclusive sales agreement by the development/production company. During this period the company had accomplished a sales totally nearly 750.000 reflexors and 110 detectors.

In most cases, a company with this history and market position would be considered a receiver of 4th or possibly 5th step financing. Unfortunately, the situation was quite the opposite. Sales were going so well that the retailer/distributor opted to breach its contract with the producer and instead arrange with lego production in the hope to increase its profits.

Suddenly the two were left with production capability, no established market contacts and a competitor with a similar product. It was at this stage they approached the Innovation Institute in the hopes of receiving advice and possible financing.

Of special interest in our evaluation was the fact that production equipment with a book value of nearly 2.000.000 SEK was included in the development/production company. However, in the event of a bankrupcy, i.e. no production and market, this equipment would be worth much less.

By way of a very small financial input and bank securities, we were able to finance participation in showings, on spot tests with end users and other forms of direct market contacts. These direct market contacts gave us a basis on which to continue discussions with the two initial owners and together with them we were able to develop a product specification which we were confident that we could accomplish and which would meet the market needs. Based upon a limited market study it was found that, if we were able to present a new generation system which not only offered a better application system but also a greater control distance, we could not only regain a good deal of the market but also widen it to other areas. Cooperation was immediately started with new distributors which would, upon completion of the new application system, represent the product in Scandinavian and Europe.

STRAX was incorporated with the business idea mentioned above. With the goal of developing a second generation system and in turn reestablishing of the market we could take advantage of the book value of the machine park. This together made for an attractive proposition for the continuation of the project. STRAX was approached by a good number of financiers offering to become involved, however, it became evident that the majority of these were primarily interested in a short term gain rather than following the project through to its full realization.

Even with a serious product specification and market contact, there was still a need for financing of further development of the product system and market as well as the covering of rolling expenses. In order to cover these expenses a progresive shareholders/financing agreement was signed granting financing of the next stage upon completion of the previous stage.

Of the various financing options we were offered, STRAX was able to select two which were not only established names in the development of companies, but also one of these which could contribute with technical know-how and development contacts in this field. This financier has now become a part of the project in the form of capital, a bank guarantee and technical assistance both on a day-to-day basis and by way of a seat on the board of directors.

FERROLUX - A project with a bright future

The companies business idea is to produce, sale and develop Ferrolux light panels (panels which are lighted by way of electroluminicencse-EL) for use as bearers of text and design information in for ex. advertising.

The product is made up of 1mm thick rost free steel, covered with five different layers of enamal and glass. One of these layers contains small crystals of zink sulfer which light up when electrical pulses are applied. The resulting light is even throughout the entire surface which gives an extremely good contrast. Different colors are possible.

Background

In 1989 the Innovation Institute was approached by representatives of a small Swedish consortium which had the opportunity to sign an exclusive production and sales agreement for this technique in the commercial market. The technique had been proven and used in the military sector but no attempts had been made towards other markets.

All that was available were samples of military products, a very rough prototype and an Letter of Intent. Based upon this information we were given one month to make a decision regarding the purchase of a small share post and option for controlling shares.

A study was immediately carried out in which contact was taken with representatives representing both the technical point of view and market aspects. The result of this study showed that there was a great potential IF two technical criteria could be met, i.e. a stronger light and longer active life cycle.

The Innovation Institute purchased shares and the option, and took control of the continuation of the project. A management contract was signed between the Innovation Institute and this company. By way of this management contract the Innovation Institute would be able to cover its share capital input if we succeeded in raising the necessary capital for the continuation of Ferrolux.

Extensive contacts were taken with the developers regarding the two criteria and a business plan and development strategy were decided upon. This work resulted in the establishment of a funding raising document which was presented to selected financiers. 100% of the desired start-up capital was obtained with confirmation of additional financing (Early stage financing) upon completion of the product development. Although the Innovation Institutes risk had now been reduced to a minimum, we retained our active leadership of the company by way of seats on the board of directors and through the managing director who comes from the Innovation Institute.

Development, test and production facilities have been established in the south of France and extensive and growing contacts have been continued with the market. Although development costs, patents, etc. are most often accepted by auditors as an asset in the balance sheet, they are often seen as extremely uncertain. In order to reduce this uncertainity to the minimum we have put much emphasis on tying up our market contacts in the area of advertising with either direct orders or development contracts.

Many of these contacts and developments will not be fully realized financially until a later date when our customers have had a chance to evaluate test results. In the mean time the running of the company costs money. In order to obtain a larger cash flow, other products have been developed which do not place the same demands on the strength of the light or the active life time and which can be sold directly through established distribution and retail chains.

CONCLUSIONS

As was seen from the above, there is a great difference between how the Innovation Institute reacted to the various projects. VNP, because of the extremely long time perspective and need for changes in environmental regulations demand that we use governmental risk financing with repayment being made only when and if the project was a success. If it would have been run in a company form from the beginning it would most assuredly become itself a case for the bankrupcy courts.

In regards to STRAX, the Innovation Institute bypassed other financing in striving to find the optimal financier who could not only fill the financial needs but also take an active role in the technical development. By making use of value of the machine park we were able to remove a great deal of the risk, making a capital investment in the project much more interesting for the financier.

Ferrolux called for a totally different strategy with all emphasis being put on connecting the product to the market giving the monies spent on the development of the finished product suddenly a true value in the company's balance sheet. The differences in respect to Feredyn and Stålbetong i Sala, which Sam presented yesterday, also accounted for still different approaches to the financing of the project.
What all of these projects do have in common is that a very great amount of time was placed into defining the goal and developing a strategy that was applicable for each of the individual projects, taking consideration to both the internal and external criteria which effected and would effect the development. Once the goal and strategy were established, they were sought after and followed respectively.

Similar emphasis and energy was placed on the selection of a financial partner(s) which were not only interested in investing at that particular time and could contribute with technical or market knowledge and contacts, but who had also an expressed interest in following the development with future financing.

Lastly, each project established a market contact at the earliest stage, and emphasis was placed on getting a cash flow going then worrying about a detailed prognosis and budget.

In conclusion I want to stress:

* Find as much information as possible about the product/company, the market, competitors, etc.
* Great emphasis and energy should be placed on designing a development and financing strategy and that once these are established, keep to them.
* Put the same amount of energy and emphasis in finding not just A financial partner, but the RIGHT partner.
* Make an early tie between the product and the market.
* Strive primarily to achive a steady cash flow and secondly to build up the value of the project/company.
* Gather to the company a Board of Directors which meets the strategy planed, an accountant that is familiar with development projects or at least understands the value of the work being done.
* A detailed budget and prognosis are good, but of more interest for large companies with an established market. Don't get so lost in these details that you loose track of reality.
* And most importantly, NO two projects are exactly the same. Use as many guidelines as possible, but be prepared to use your own imagination as well.