HOF 01-083

本田財団レポートNo.83

製品の複雑性と持続的発展

スウェーデン未来学研究所所長、スウェーテン・ウメオ大学教授　オーケ・アンダーソン

■略歴

1936　スウェーデンのソルフテオーに生まれる。
1963　スウェーデン、イェーテボリ大学で経済学部経済史修士。
1967　スウェーデン、イェーテボリ大学で経済学博士。
1965〜67　スウェーデン、エルスボリ県地域計画部長
1967〜72　ストックホルム市経済分析所所長
1970〜72　北欧都市地域研究所（ストックホルム）、都市および地域経済学准教授
1972〜79　イェーテボリ大学、経済学部経済学准教授
1974〜75　ペンシルバニア大学、地域科学・交通・公共政策学客員教授
1974〜81　「地域科学並びに都市圏経済」誌（ノース・ホランド出版）の編集主幹。
1978〜80 & オーストリア、応用システム分析国際研究所(IIASA)
1984〜86　プロジェクト・リーダー
1975〜　「地域科学並びに都市圏経済」に関する叢書（ノースホランド出版）の編集主幹。
1979〜　スウェーデン・ウメオ大学、経済学部地域経済学教授。
1988〜　スウェーデン未来学研究所所長。

●他にＯＥＣＤ、欧州経済委員会、並びにスウェーデン政府の顧問を務める。

■主な著書

1970　Metropolitan Problem（大都市問題）
1984　Regional Diversity and the Wealth of Nations（地域的多様性と国富）
1988　The Future of the C-society（C社会の将来）
1989　Creativity-Future Of Japaniese Metropolitan Systems（創造性－日本の大都市システムの将来）

■編集した出版物

1984　Regional and Industrial Development Theories,Models and Empirical Evidence（地域と産業の発達理論、モデル、実証）［ノース・ホランド出版］
1993　The Cosmo-Creative Society（宇宙創造社会）［スプリンガー社］
1993　Dynamical Systems（動学システム）［ワールド・サイエンティフィック］

■Personal History

1936　Born in Sollefteå, Sweden
1963　M.A. in Philosophy, Economic History, Economics, University of Gothenburg, Sweden
1967　Ph. D. in Economics, University of Gothenburg, Sweden
1965〜67　Director of Regional Planning, County of Älvsborg, Sweden
1967〜72　Director of Economic Analysis, City of Stockholm
1970〜72　Associate Professor of City and Regional Economics at the Nordic Institute for City and Regional Planning, Stockholm
1972〜79　Associate Professor of Economics at the Department of Economics, University of Gothenburg
1974〜75　Visiting Professor of Regional Science, Transportation and Public Policy, University of Pennsylvania
1974〜81　Main Editor of the journal Regional Science and Urban Economics for North Holland Publishing Company
1978〜80&　Research Leader, International Institute for Applied
1984〜86　Systems Analysis, Austria
1975〜　Main Editor of the book series study in Regional Science and Urban Economics for North Holland Publishing Company
1979〜　Professor of Regional Economics, Department of Economics, University of Umeå, Sweden
1988〜　Managing Director of the Swedish Institute for Futures Studies, Stockholm

●Advisor to the Economic Commission for Europe, OECD, and the Swedish Government

■Major publications

1970　The Metropolitan Problem (in Swedish), Stockholm
1984　Regional Diversity and the Wealth of Nations (in Sewdish), Stockholm
1988　The Future of the C-society (in Swedish), Stockholm
1989　Creativity-Future of Japanese Metropolitan Systems (in Swedish)

■Edited books:

1984　Regional and Industrial Development Theories, Models and Empirical Evidence, North Holland, Amsterdam and New York
1993　The Cosmo-Creative Society, Springer-Verlag, Heidelberg
1993　Dynamical Systems, World Scientific

PRODUCT COMPLEXITY AND SUSTAINABLE DEVELOPMENT

Lecture at the Conferring Ceremony on the 17th of November 1995, in Tokyo

Professor Å E. Andersson
The Winner of the Honda Prize 1995
Managing Director of the Swedish Institute for Futures Studies
Professor of Regional Economics, Department of Economics, University of Umeå, Sweden

1 THE HISTORY OF INDUSTRIALIZATION

In the late 18th century and the early 19th century the industrial revolution generated a complete structural transformation of New England, Great Britain and Belgium. This first wave of the industrial revolution initiated an economic integration of the regions surrounding the North Atlantic Basin.

In the second wave of the industrial revolution France, Germany and Denmark became the focal region of transformation into an industrial society. With the expansion into the interior of Western Europe of the new industrial society a similar expansion inwards of the North American continent took place.

With the third wave of the industrialization of the world the Scandinavian countries, Austria, northern Italy and Japan became fast growing parts of the new industrial society. At the same time the U.S. Midwest was industrialized and integrated into the new world economy of the late 19th century. Studies of economic statistics reveal that Japan and Scandinavia would become the fastest growing parts of the world economy if seen in a century long time perspective, starting in the 1870's. Contrary to widespread beliefs, the history of industrialization of Japan, Sweden and Finland shows that there is no development disadvantage in being located in the periphery of the world economy. Neither is there a disadvantage in being a late-comer in the restructuring of the global economy. The spectacular success stories of the Japanese and Swedish economies are good examples of the economic advantage of backwardness. By not being early, Japan, Sweden and Finland could avoid many of the mistakes of the early industrialized nations, while reaping the benefits of innovation of knowledge and technologies created and developed elsewhere.

Currently, industrialization of the world is phenomenal in large parts of East Asia. Countries like Korea, Taiwan and Malaysia are part of the fourth wave of the industrial revolution. It by now seems clear that the growth record of Japan and the Scandinavian countries will be broken by these extreme late-comers in the industrial revolution.

2 SLOW AND FAST PROCESSES OF ECONOMIC DEVELOPMENT

Based on Haken, I have launched the theory that the sometimes fast processes of economic and social restructuring cannot be understood within the framework of market analysis only. Market processes are very fast and can be understood with the help of static and dynamic theories of games. These games are played according to durable rules on a slowly changing infrastructural arena, subject to little or no change within the time perspectives relevant to the market games. Most of the time the infrastructural arena, including rules of the economic games, can be and is regarded as a stable environment by the actors of the daily life of suppliers and demanders regulating prices and quantities of services and products exchanged in the market place.

The dynamic process can be generally described as follows

$$
\begin{aligned}
dy/dt &= F_y(y, z, x), \\
dz/dt &= sF_z(y, z, x), \\
dx/dt &= \varepsilon fx(y, z, x),
\end{aligned}
$$

where y is a commodity production vector, z is knowledge infrastructure, x is network infrastructure, s and ε are adiabatic constants, and F_x, F_z and F_y are certain specified functions of x, z and y.

By s and ε, we may distinguish speeds of the variables in the system. For instance, when s and ε are extremely small, the commodity production is a fast process in comparison with the dynamic processes of knowledge and network infrastructures. For simplicity of illustration, let us consider the following special case of the general system.

$$
\begin{aligned}
dy/dt &= -y^3/3 + ry + x, &\text{"fast market equation"}, \\
dx/dt &= -\varepsilon y + ax, &\text{"slow infrastructure equation"},
\end{aligned}
$$

in which r and a are control parameters and ε is an extremely small positive parameter. In (1), we neglect knowledge infrastructure (assuming that knowledge is a much slower change variable). This system is a reformulation of the Van der Pol equation. It turns out that discontinuous changes in the value of y may be produced as the value of x moves slowly into critical parametric domains. Fig.1 illustrates a typical cycle for equation (1). Abrupt rises and falls in production by different industries are well documented, and may be precipitated by gradual changes in networks. It is significant to note that changes in the value of the "fast" variable may take place relatively quickly. Thus, if one were to observe the state of the system just before and just after the change, one may be tempted to conclude that the "slow" variable was not influential.

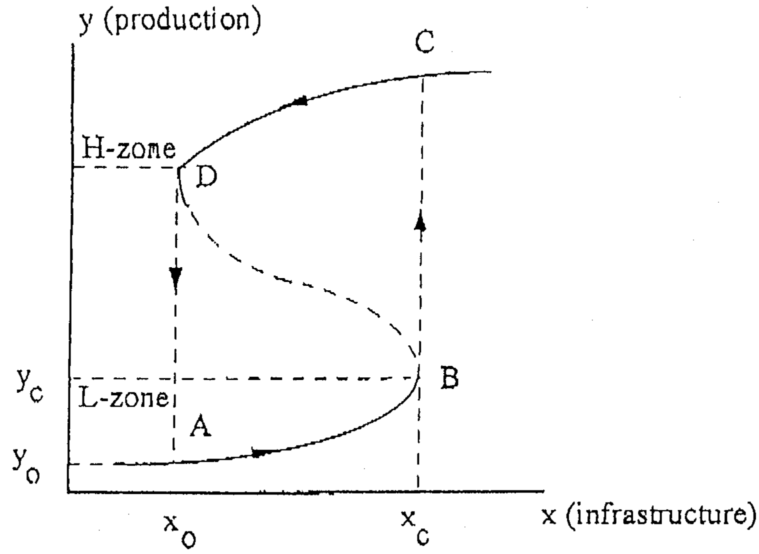


Fig. 1. Fast Production and Slow Infrastructure Dynamics

The slow expansion of network infrastructure, x, through investment in physical capital will follow the trajectory located in the L-zone of Fig.1. Let the system initially be located at A. As x is changed, eventually a point B is reached, beyond which the very nature of the structure of production changes markedly. At this point, the equilibrium loses its stability and a "phase transition" is underway.

The system has an inherently long-term cyclical nature. if network improvement stops once the H-zone is reached, and depreciation is then the dominant interactive effect, the system may follow the solution trajectory depicted on the H-zone until it finally turns at D and then drops back down to the L-zone. This cyclical process may be regarded as divergence, because a smooth but small change in the network infrastructure capacity can cause unexpectedly large fluctuations in the equilibrium value of commodity production. This comes about through a discontinuous change of state or a phase transition. The transition takes place no matter how slowly the network infrastructure increases. this implies that spatial economic restructuring may be triggered simply by the addition of one small but important link in the network, Slight differences in transportation conditions may result in large differences in the final production if the economic infrastructure is located at a critical state.

3 THE SLOWLY CHANGING ARENA

In the agricultural society economic rules tend to be based on rigid customs increasing predictability at the expense of a loss of innovative capacity. One of the general characteristics of industrialization is therefore the slow and steady substitution of these rigid rules in favour of deregulation permitting entry of new firms and the right of the individual to the profits of new economic activities. In symmetry with the new rights of entry into the market there also follows rules of forced exit if profits of an economic activity remain in the negative.

But new rules are not sufficient for a transformation into an industrialized society as suggested by the Nobel Laureate Douglass North. It is a necessary but not a sufficient condition.

There must also be an infrastructure in a more quantitative sense of the word. By infrastructure I mean stock variables that are slowly changing (in relative terms) and useful for a large number of households and firms, simultaneously. Infrastructure is thus a comparatively small set of variables of collective (or public) importance. It is similar to a catalyst within a chemical process.

Examples of infrastructure are:

1. Transportation networks.
2. Communication networks.
3. Pools of information.
4. Pools of knowledge.
5. Common value structures.

At the onset of the industrial revolution each country and region had achieved a critical combination of infrastructural capacities. The organization of the industrial society therefore has tended to be similar in each country and region and has been dictated by the constraints of the infrastructure permitting the evolution into an industrial society.

Central to the industrial society of the last century is the dominance of waterways and railroads for the transportation of resources and products as well as for the communication of information and knowledge. At the points or regions of connection possibilities between railroad networks and seaways the *potentially most profitable* points of industrial agglomeration were located. It is thus no accident that cities like Manchester, London, Antwerp, New York, Boston, and Philadelphia, early grew to enormous manufacturing cities. By similar forces Yokohama-Tokyo and Kobe-Osaka are simultaneously examples of industrial agglomerations and centers of transportation by sea and rail.

4 SIMPLIFICATION AND INDUSTRIAL MANUFACTURING

At the core of industrial organization was and is *division of labor*[1]. Division of labor is a means of *simplification*. According to this principle each production process must be subdivided into as many simple tasks as possible to be performed by laborers with a low amount of formal education and skills or by some simple machine. This was of course a necessity in the early industrial society, when on the average an employee could be expected to have three years or less of formal education.

The principle of division of labor can be applied at almost any level of industrial organization. At the individual level it is used in the decision making on optimal assignment of individual employees to different tasks according to their relative skill advantage. At the corporate level

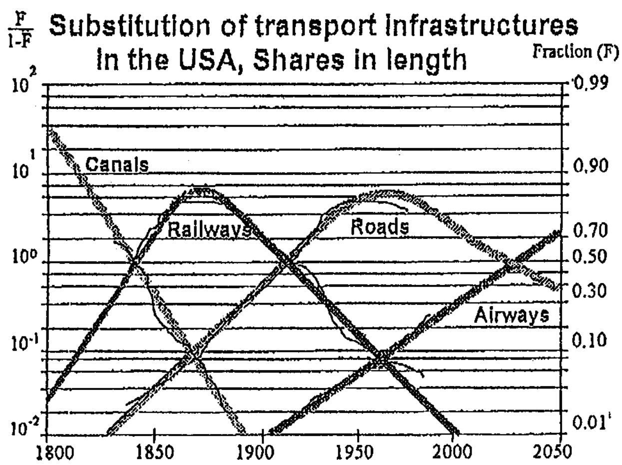
[1]Smith, A. (1986, from original 1776) *The Wealth of Nations*, Penguin Classic, London.

it is used in the allocation of product responsibility to different factories according to similar principles. At the regional and national levels it is used as an argument for specialization of production and exports according to the principles of comparative advantage, first introduced by the British economist David Ricardo. Later on it was developed into a full fledged theory of international trade and location by the Nobel Laureate Bertil Ohlin, who demonstrated that if countries would specialize on products using their comparatively most abundant resources, then global real income would be maximized and the trading of goods between specialized countries would act as a substitute for migration of labor.

Powerful as it is, this theory, based on simplification, is relevant to agricultural and industrial societies primarily, if not exclusively. This is closely related to the infrastructural arena perspective proposed above. In a society with ample unexploited natural resources available, with the limitations of knowledge and information and with transportation and communication networks, based on sea and railroad transportation, simplicity by division of labor and exploitation of comparative advantages is an inevitable outcome of an optimization process. Likewise, the agglomeration of manufacturing onto a few centers of maximal rail and sea accessibility is a natural outcome only with the transportation and communication networks of the classical industrial society.

5 THE NEW ARENA

Very slowly, but steadily, the infrastructural arena has been transformed during the hundred years of third wave industrialization. The networks for transportation of goods and people have become ever more dense by the successive introduction of new road and air transport links. As can be illustrated by the following diagram the development of the relative fraction of different network changes have been substantial.



·cs, theories,

a seemingly

ı the classical

ving figures,

Source: Nakicenovic (1989) in Transportation for the Future, *(eds Batten/Thord) Springer-Verlag.*

Fig.2. Substitution of transport infrastructures in the USA, Shares in length

The development in Western Europe and Japan has followed similar patterns with some time delay. The first shows that the network available for transportation of goods and people was totally dominated by railroads for intracontinental transportation and seaways for intercontinental transport at the turn of the century, when the industrialization was firmly established in North America, Western Europe and Japan. Total transportation capacity was, however, highly constrained and could in those days admit large volumes of goods transportation only. Personal transportation had to be heavily constrained as reflected in the high cost of personal transportation of those days. Labor thus belonged to the trapped resources (disregarding mobility in terms of permanent migration). The structure of international trade theory reflects this difference of mobility between goods and people. The Heckscher-Ohlin theory of comparative advantages specifically focuses on the possibility of goods trade as a wage rate equalizing substitute of mobility of labor.

The scene has changed. With the network evolution by investment in roads and airways the logistical conditions are dramatically different in the contemporary times. In the U.S., Western Europe and Japan roads and airways now dominate the relative availability of physical networks. The time is now ripe for the introduction of some new network, with some probability a combination of Shinkansen and Maglev technologies. Such a new network for fast ground transportation should, however, not be expected to play a dominant role within the next few decades. New networks always emerge at a slower and slower pace.

The most remarkable consequence of the development of the new infrastructure of transportation networks is the growth of capacity to transport people (and thus to transport knowledge). With the expansion of personal mobility it now not only possible to have a larger and larger share of work done by consultants. It has also become possible to release the service sector from the need to locate in the vicinity of housing. Location of services is becoming as foot-loose as location of manufacturing.

From an industrial organization point of view these is a further consequence of the change of transportation network density. It is now possible to combine the need for corporate economies of scale with the wish the wish to have a large number of small production and distribution sites. The new transportation networks have improved the possibility of creating viable global network corporations.

The communication networks have been slowly transformed into an even denser pattern with possibilities of global, almost instant communication of information from almost any point in the developed world. This further reinforces the possibility of achieving global large scale network corporations consisting of an ever increasing number of collaborating production and distribution units.

The third remarkable factor is the slow but steady growth of basic knowledge by education of the labor force of developed nations and regions. At the initiation of the third wave of the industrial revolution it has been calculated by Maddison that the average level of schooling in the (current) OECD countries was approximately three years. By the year 2010 this average is expected to have reached thirteen years of schooling in most OECD countries. While the natural resources base can be expected to decline, the knowledge base will continue to increase. The world is moving towards an abundance of knowledge and communication capacity and a shrinking availability of natural resources and energy. This calls for a rethinking of industrial organization principles.

6 COMPLEXIFICATION OF PRODUCTS

The basic principle of the industrial society was simplicity by the application of principles of division of labor and allocation by comparative advantages. The new principle, compatible with the new arena, is *the principle of increasing complexity.*

Complexity is basically (in this context) a three dimensional concept. The first dimension - blueprint complexity - is closely related to computational complexity, as defined by Kolmogorov and Chaitin. By blueprint complexity I mean the length of the shortest possible instruction needs to produce another copy of a given product. In this sense a description of the procedures necessary to produce a 1995 model of a standard Japanese car is much longer than the descriptions needed to produce an exact copy of the T-Ford, Thus, according to this definition, a 1995 standard car is a much more complex product than the T-Ford, It is a product of greater blueprint complexity. Similarly, any late model personal computer is much more complex than earlier versions. We must at this point make a very clear distinction between product complexity and user complexity. Very often an increased product blueprint complexity is needed in order to decrease the user complexity of the product.

No blueprint is independent of the knowledge of the user of the blueprint description of the production procedures. Some blueprints require a very high level of formal and informal education and achievement of skills by the labor force used to make a product. Thus, the education needed in order to produce a copy of a given product according to a given blueprint is another measure of product complexity.

A third aspect of complexity of products is the multitude of components and other physical inputs needs in order to produce an exact copy of a given product. Products of great blueprint complexity often require a very large number of different inputs, available at distant locations only. Diversity of inputs is thus a third measure of complexity. With the expansion of the availability of information and knowledge and with the expansion of transportation and communication capacity it has become increasingly possible to expand product complexity in all the three dimensions, specified above, And furthermore- **complexity is a substitute for energy and material inputs**. Increasing complexity and decreasing inputs of energy and materials is in the current world of expanding communication, transportation and knowledge infrastructure a profitable economic response to a changing arena.

Increasing complexity can only be achieved by increasing synergy and a decreasing degree of division of labor and application of comparative advantages. This was foreseen already by Adam Smith in his criticism of the principle of division of labor:

In the progress of the division of labour, the employment of the far greater part of those who live by labour, that is, of the great body of the people, comes to be confined to a few very simple operations; frequently to one or two. But the understandings of the greater part of men are necessarily formed by their ordinary employments. The man whose whole life is spent in performing a few simple operations, of which the effects too are, perhaps, always the same, or very nearly the same, has no occasion to exert his understanding, or to exercise his invention in finding out expedients for removing difficulties which never occur. he naturally loses, therefore, the habit of such exertion, and generally becomes as stupid and ignorant as it is possible for a human creature to become. The torpor of his mind renders him, not only incapable of relishing or bearing a part in any rational conversation, but of conceiving any generous, noble, or tender *sentiment, and consequently of forming any just judgment concerning many even of the ordinary duties of private life. Of the great and extensive interests of his country he is altogether incapable of judging; and unless very particular pains have been taken to render him otherwise, he is equally incapable of defending his country in war. The uniformity of his stationary life naturally corrupts the courage of his mind, and makes him regard with abhorrence the irregular, uncertain, and adventurous life of a soldier. It corrupts even the activity of his body, and renders him incapable of exerting his strength with vigour and his own particular trade seems, in this manner, to be acquired at the expense of his intellectual, social, and martial virtues.*

But in every improved and civilized society this is the state into which the labouring poor, that is the great body of the people, must necessarily fall, unless government takes some pains to prevent it.

It is otherwise in the barbarous societies, as they are commonly called, of hunters, of shepherds, and even of husbandmen in that rude state of husbandry which precedes the improvement of manufactures, and the extension of foreign commerce. In such societies the varied occupations of every man oblige every man to exert his capacity, and to invent expedients for removing difficulties which are continually occurring. Invention is kept alive, and the mind is not suffered to fall into that drowsy stupidity, which, in a civilized society, seems to benumb the understanding of almost all the inferior ranks of people. (Adam Smith, The Wealth of Nations,1776)

The organization of research and development activities clearly points in the direction of synergetic organization in which complementarity of different ideas and solution principles can be exploited as has been pointed out by Edwin Mansfield. Research and development activities in industrial corporations tend to benefit greatly by being located close to people engaged in marketing activities. Similarly it can be shown that research and development activities within the research community benefits greatly by collaboration between different research environments (Beckmann, Andersson and Persson).

7 CREATION OF COMPLEXITY

Increasing complexity is the outcome of some creative process at the individual, corporate or even social level. In order to increase the internal complexity of a product, i.e., a commodity or a service, there should be a need for invention. The precondition for creativity are, as remarked by Adam Smith, completely different from the preconditions of productivity in manufacturing of products.

The creative process at the individual level has been analyzed by a number of cognitive psychologists and maybe most profoundly by Gudmund Smith and his associates[2]. According to these psychological studies, individual creativity is to a large extent a personality trait that is genetically inherited or developed during the personality formation years of childhood and adolescence. Thus, the family and schooling environment could be an important determinant or possibly a constraining factor in the development of a creative personality.

Individual creativity is primarily related to three different mental capacities:

[2]Smith, G. J. W. and I. M. Carlsson (1990) *The Creative Process*, Psychological Issues 57, International University Press, Inc. Madison, CT, and "The Creative Person" by GJW Smith in *The Cosmo-Creative Society* (1993) ÅE Andersson, DF Batten, K Kobayashi and K Yoshikawa (eds.) Springer-Verlag, Berlin, N.Y., Tokyo.

1. a capacity to resolve paradoxes
2. a capacity to recognize and reconstruct and see new patterns
3. a capacity to synergistically combining different ideas, i.e., pictures, theories, models.

What do we mean by a capacity to resolve paradox? A paradox is a seemingly inconsistent pictorial or conceptual set of interconnected elements. One example is the classical statement "I am always lying". Another set of examples is given by the following figures, provided by the Swedish artist Oscar Reutersvärd.

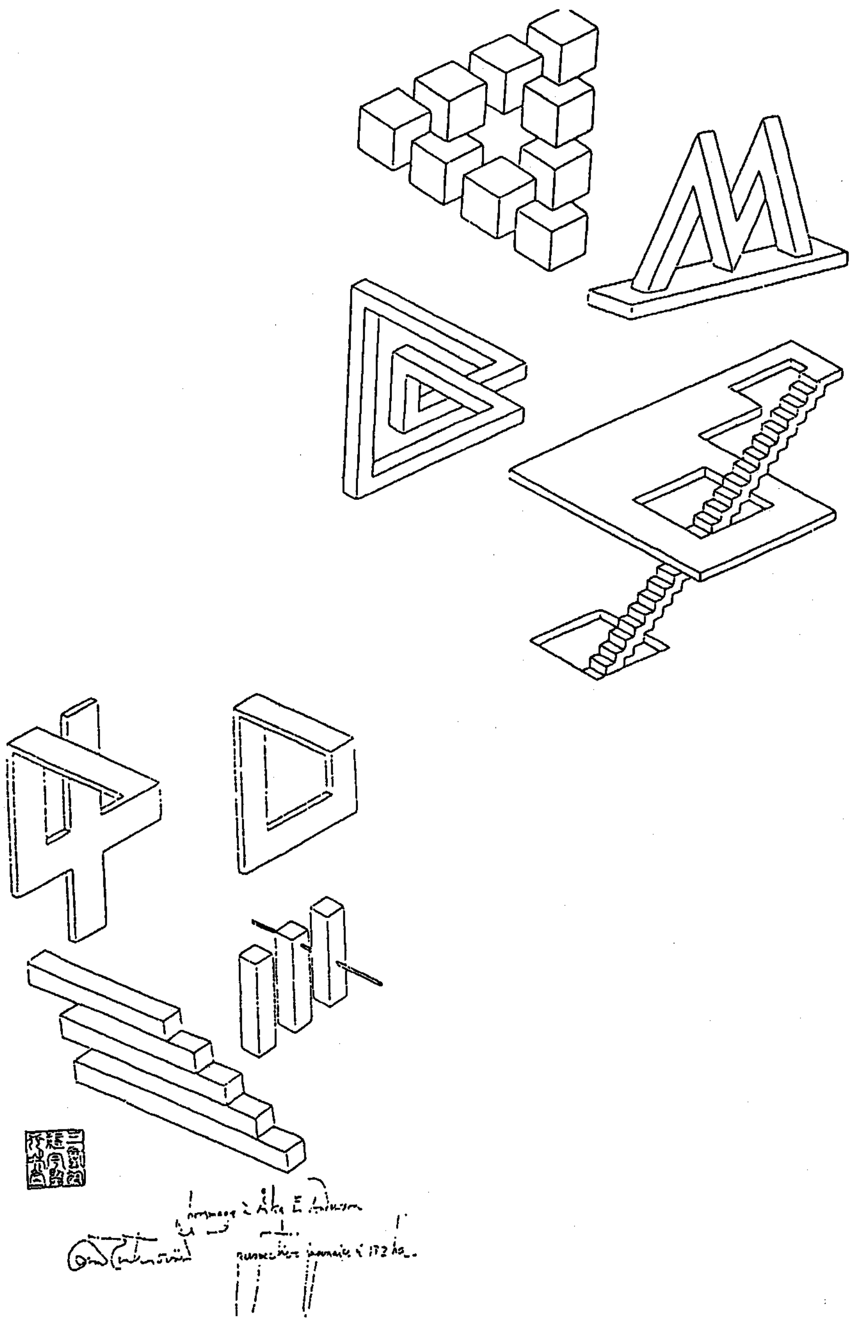


Fig.A

These paradoxical figures, e.g., the staircase, have one interpretation if recursively started from one point, e.g.,climbing the ladder, while it would have a different interpretation if started at another point, e.g., on the upper floor of the building. A computer would have problems in resolving this paradox, while the creative person would possibly see it as an interesting starting point for some creative thinking about geometrical perceptions in the human mind. The problems of structural instability of perception can be illustrated by the following set of eight pictures.

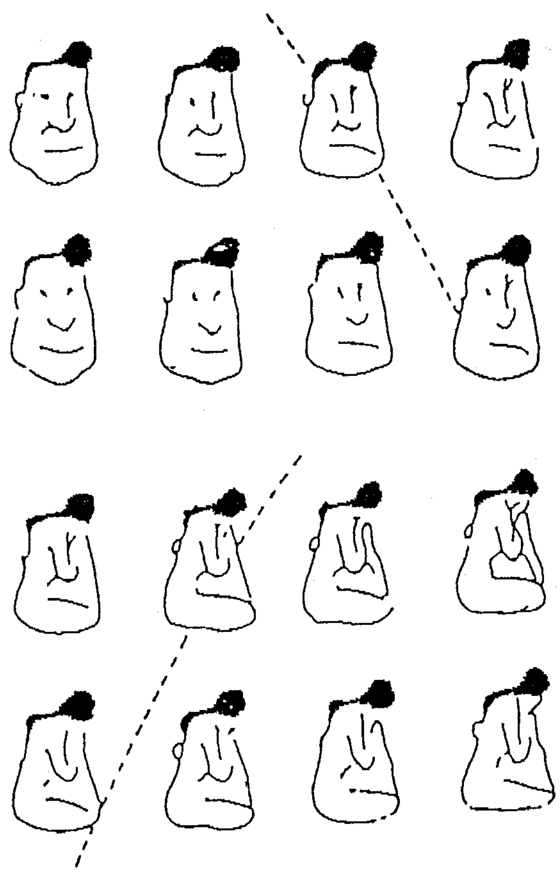


Fig.B

Watching these pictures from the left to the right, picture by picture, most people would only see a successively distorted male face, while turning to the next page looking from the right to the left, picture by picture, most people would see a reclining woman on all these pictures. In fact, the dotted line signifies a bifurcation zone within which any interpretation is possible and where the perception system tends to be structurally unstable. This structural instability of the brain seems to be a critical precondition for creativity.

Structural instability of the brain is an important reason why synergy of different ideas tends to be a typical characteristic of creative people. Very often two different models, seemingly focusing the same phenomenon, can be inconsistent with each other and yet provide the starting point for a creative process that might lead to a completely new theory, which would resolve the paradoxical inconsistencies between the two models triggering a creative process.

Systematic studies of creativity at the organizational or social level rarely exist. However, history can provide a number of case studies of the evolution of creative environments, often at the level of a city or a region. Approximately two and a half millennia ago, Miletos and Athens provide two such examples of creative cities. Similarly, Florence of Italy and Bruges of the Flanders are examples of creative outbursts in cities of the European Renaissance period. Other examples are Amsterdam and London of the 17th century. A number of well documented creative environments are also available from the history of the industrial revolution in Europe. Some pertinent examples are given by Vienna, Berlin and London at the turn of the century. These historical examples can of course not give completely reliable sets of preconditions for creativity at a social level, but they can provide us with some of the necessary conditions for expansion of creativity at a social level.

The primary precondition for creativity seems to be a combination of wealth and structural instability of the social system. A stable social or institutional environment, within which any disturbance is quickly compensated by countervailing forces, would never be ripe for acceptance of completely new ideas. A number of historical examples would support such a conclusion.

In all the regional cases mentioned, the creative expansionism tends to go hand in hand with expansion of inter-regional communication associated with growing trade or migration flows. The increasing diversity of people, ideas and products tends to provide some of the necessary conditions of synergy.

With structural instability of the economy of a region or a country there tends to be imbalances and disequilibria emerging rather abruptly. Such situations of imbalances and disequilibria are instance of excess supply and excess demand for different products. Such disequilibria are regularly perceived as unresolved needs. One of the examples of such disequilibria, associated with massive migration flows, is housing shortage. With housing shortage there tends to be spontaneous or forced emergence of congestion in public spaces, that would provide the necessary intensity of unplanned meetings between different artists, scientists and other intellectuals. One of the best documented examples of this phenomenon is the Vienna café culture of the decades around 1900.

8 COMPLEXITY AND ECOLOGICAL SUSTAINABILITY

One of the ideas behind the creation of the Honda Foundation was Eco-Technology as a means of achieving technological, economic and ecological sustainability. The current transformation into a post-industrial C-society is potentially beneficial to the environment and fulfills the requirements of evolution according to eco-technological principles. The transformation into an economy based on complexity of products rather than large inputs of materials and energy is beneficial to the environment, especially at the location of production. The smoke-stack factory was the metaphor of the industrial production of simple products in congested manufacturing towns. The complexity oriented factory inherently a cleaner factory than the industrial counterpart. And the decreasing use of energy and materials per unit of product has recently become obvious in the highly industrialized world. In Western Europe there has in the period 1970 to 1990 been an approximate growth of real value per ton of export of eight to ten per cent per year, implying a corresponding decrease in the use of resources per unit of export value (at constant price level)

A word of warning must be voiced at this point. With the emerging society of communication, creativity and complexity, new environmental problems will also emerge, while we are successively combating the environmental problems of the industrial society.

The reasons are the following:

1. Increasing complexity implies important changes of the production and logistical structure.
2. A larger number of components per unit of output are normally required and have to be transported from a larger number of often increasingly distant locations. This leads to greater transportation burdens on the global ecological system.
3. It can be shown that greater unit value of each product is associated with requirements of higher speeds of transport, which also increases the environmental impact of global transportation systems.
4. A greater complexity of the final product is normally associated with greater problems of recycling, at the time of scrapping of the product.

The increasing complexity of products is thus transforming the classical locally environmental problems into their global or network counterparts. The complexity of the emerging new C-society simultaneously reinforces the economic and ecological interdependencies of the world. It is quite conceivable that with increasing complexity of our products we will pass from an industrial, ecological problem of different localities that we are increasingly able to solve, into a milder but diffused ecological stress that we are technologically and institutionally unprepared for.

There are positive signs of a realization of the new environmental dilemma. Very encouraging steps towards recyclability of complex products are currently being taken in Germany, Japan and Scandinavia, Increasingly, corporate R&D programs are directed towards design of the new, more complex products so as to include complete recyclability, e. g. in the currently most advanced car production plants.

Furthermore, the air, car and truck transportation corporations are devoting increasing resources to the development of less energy demanding engines and engines for transportation equipment that can be run on ethanol and other ecologically more benign fuels.

9 CONCLUSION AND ABSTRACT

Advanced countries like Japan, Sweden and Switzerland as well as advanced regions of North America are entering a new stage of their economic development. They are leaving the industrial society with its reliance on simplicity of production and products and the heavy use of natural resources and energy. They are entering the C-society with an increasing reliance on creativity, communication capacity and complexity of products. Increasing complexity of products goes hand in hand with increasing real user value per unit of production. Recent statistics indicate that the countries of transformation are increasing the value per ton of manufacturing production at a rate of close to ten per cent, annually. This implies a massive reduction in the use of natural resources per unit of GNP in the production processes. Consequently, the transformation into the post-industrial C-society implies great potentials for ecologically sounder manufacturing of products.

However, the exploitation of the new infrastructural arena for complexity oriented manufacturing also implies risks of new forms of ecological stress. Complexity and only be increased by research and development efforts and efficient research and development requires communication and transportation of ideas a multitude of sophisticated inputs, often to be found only at distant locations, further implying transportation burdens. It can also be show that the higher the value of a commodity the faster and more precise must be the transportation to the ultimate consumer of the product. Complex products also require much more concern about recyclability than their simpler counterparts.

Thus, while the transformation into a complexity oriented post-industrial society will give increasing possibilities of reduction of environmental pollution from manufacturing, there is an increasing need for consideration of the now emerging network pollution problems, associated with the increasing complexity of products. Eco-Technology considerations as once formulated by the Honda Foundation have to be reformulated so as to provide improved possibilities of ecologically benign transportation technologies as well as advances of the economically viable technologies for recycling of increasingly complex products.