Risk, Uncertainty and Economic Futures

by Hazel Henderson *

The socio-economic transition now underway in all mature industrial societies in Europe, as well as the U.S.A., Canada and Japan, is characterized by growing complexity, saturation of their traditional growth in rising social costs, and a "plateauing" of their historical trajectories of technological development, as I have described in *The Great Economic Transition, Technological Forecasting and Social Change*, March, 1976. This transition process is still so little understood that despite its ubiquitous recognition in most futures research, it is still conceived in "rear-view mirror" imagery, as an emerging "post-industrial" era. Daniel Bell, Herman Kahn and others use this term to imply a shift of the industrial system to a service and knowledge-based, tertiary economy¹. Alvin Toffler describes in *Future Shock* the social effects of a super-industrial future, and in his *Ecospasm Report* (1975) he vividly portrays the new global turbulences it can unleash. But, as Michael Marien points out in his *Societal Directions and Alternatives* (1976), other major interpretations of the "post-industrial" era, for example Hillaire Belloc's *The Servile State* (1913); Arthur Pentty's *Old Worlds for New: A Study of the Post Industrial State* (1917) and *Prosperity and Security* (1938) by Ralph Borsodi, have predicted a collapse of industrialized societies due to the vulnerabilities of excessive interlinkage and other factors. Such thinkers have sounded a continual note of caution during the intervening years, including Karl Polanyi in *The Great Transformation* in 1944, K. W. Kapp in his *The Social Costs of Private Enterprise* in 1953, and the late E. F. Schumacher in *Small is Beautiful* (1973) and more recently Amory Lovins in his *Soft Energy Paths* (1977) and my own *Creating Alternative Futures* (1978). These alternative scenarios of the future of industrial societies include decentralization of economic power and activities, and the spontaneous devolution of overgrown bureaucracies and centralized, capital-intensive technologies, as well as dis-intermediation of over-extended trading and exchange systems. They explore the concomitant shifts in the loci of control of societal function both *downward* to local levels for more precise implementation, and *upward* to global and regional levels for conceptual realignment of planetary coordination of functions beyond the management of nations individually, e.g. environmental affairs, oceans and space policies.

The first view of "post-industrial" life, typified by Daniel Bell, is essentially an extrapolative one: a relatively smooth transition based on, and arising from the assumed increasing efficiency of existing agriculture, resource-extraction and primary

* Co-Director, Princeton Center for Alternative Futures, Inc., Princeton, New Jersey. Paper presented at the 16th Annual Risk Management Conference, Risk and Insurance Management Society, New Orleans, April 12, 1978.

¹ Bell, Daniel, *The Coming of Post-Industrial Society*, Basic Books, N.Y. 1973.

production systems, i.e. continued growth along current pathways leading to a flowering of a tertiary, services economy. The second view involves major discontinuities, where nothing less than a shift of basic paradigm (i.e. world view) is necessary so as to reconceptualize the situation. The historical, fossil-fueled growth pattern creates technological complexity which is unmodelable, and therefore, unmanageable. Unanticipated social impacts and environmental depletion and proliferating bureaucratic attempts to *regulate and coordinate* the situation add to the general transaction costs, until the social costs of the system begin to exceed actual production. Since the social costs are *added* to the Gross National Product (GNP) instead of subtracted, the GNP goes up, while inflation begins to mask the declining situation. The simultaneous inflation and unemployment in such societies can no longer be viewed in terms of the Phillips curve, supposed trade-off between them, but is more related to the syndrome of social costs, which I have described as "The Entropy State" (*Planning Review*, April 1974) and the excessive capital and energy-intensity of their production processes. The best example of the syndrome was noted by the Morgan Guaranty Bank in its Monthly Letter, January, 1978, which noted that the U.S. economy had just passed the \$2 trillion GNP mark, but that while the first trillion required over 200 years, the second trillion was added in a little over seven years. "Of the second trillion, nearly two thirds was inflation."²

More importantly, the 200-year development of industrialism constitutes an irreversible evolutionary process, and notions of many economists that we can turn the clock back merely by such means as deregulation is a profound mis-understanding. The recently published analysis by Edward Denison of the Brookings Institution is a case in point. He correctly assesses the rising social costs of such increasing societal complexity and quantifies these costs quite credibly as approx. 2 % of GNP.³ But Denison then draws an incorrect conclusion from his data: i.e. that we should try to focus on reducing regulations and their costs, rather than deal with the much more structural problem of identifying and modifying the particular types of socially and ecologically disruptive technologies which inevitably *require* regulation, and where necessary, replacing them with more socially and ecologically compatible technologies, with fewer impacts.

These transition processes which late-stage industrial societies are experiencing are analogous to a class of systemic change processes familiar to general systems theorists as morphogenesis (i.e. structural transformations not inferrable from the existing state of a system or its properties or variables). Morphogenesis can be studied in biology (e.g. the process by which a chrysalis turns into a butterfly) and in engineering, hydrology and in human and animal behavior. As Magoroh Maruyama has shown, there are two basic types of cybernetic systems: 1) steady-state systems, which maintain their structure over time by negative feedback loops and deviation-damping mutual causal processes, and 2) morphogenetic systems undergoing structural evolution and governed by positive feedback loops and deviation-amplifying mutual causal processes.⁴ (See Diagram 1, on page 5.)

² *The Morgan Guaranty Survey*, Morgan Guaranty Bank of New York, Jan. 1978, p. 4.

³ *Forbes*, March 6, 1978.

⁴ *American Scientist*, Vol. 54, No. 2, June 1963.

Diagram 1

SIMPLE DIAGRAMS OF TWO MAJOR TYPES OF CYBERNETIC SYSTEMS

STABLE, EQUILIBRATING SYSTEM (morphostatic ; structurally stable)

e.g. thermostat-controlled mechanical system ; early agrarian or small-scale production economies (as conceived in market equilibrium supply-demand theories) ; reversible components and decisions.

System internally dynamic, but stable structure maintained and governed by *negative* feedback loops.

UNSTABLE, DIS-EQUILIBRIUM SYSTEM (morphogenetic ; evolving new structure)

e.g. living, biological systems ; human societies ; large-scale socio-technical economic systems ; rapid innovation and evolving structurally ; many irreversible components and decisions.

System internally dynamic *and* structurally dynamic, governed by *positive* feedback loops, which can amplify small initial deviations into unpredictably large deviations, which sometimes break through thresholds and push the system to a new structural state.

What does all of this mean to insurance companies and risk managers in general? You are well aware of the turbulent, intensified risk environment in which insurers and risk managers operate today. For some years the industry has focused on such underlying causes as inflation (itself an effect of even deeper underlying causes!) and its disordering effect on capital investment and all business decisions. Another problem is what many refer to as "social inflation"⁵: the mushrooming of tort liability problems, speculative claims, entrepreneurial lawyers, ever-more pervasive, third party interpretations of product liability, medical malpractice, as well as the increasing "psychology of entitlement" which has led to huge awards for wholly new classes of risks, such as ski accidents and the now famous Connie Francis \$2.5 million rape award against Howard Johnson's motel chain.⁶ All this is familiar and has led to many predictable responses from insurers, including higher-deductible policies, higher premiums, encouragement of self-insurance, broader risk management strategies and the development and growth of captive insurance companies, as well as the increasing outright avoidance of much high-risk insurance and the wise refusal to underwrite more than a fraction of massive untried programs such as the ill-fated government swine flu vaccine program.

Such responses have done much to stabilize the situation. But they have, in turn, produced many counter-responses, such as mandatory state auto insurance pooling and municipal property insurance pools such as the Fair Access to Insurance Requirements (FAIR) plans in New York and similar plans in other states, overseen by the Federal Insurance Administration. These plans are now under broad attack from consumers and government officials for their self-rating and high premiums, and what many see as a new form of "redlining" of many urban areas and their residents.⁷ The socializing of risks in the health care sector (now a staggering 8.5 % of GNP) has led to widespread abuse and an inflation-ridden quagmire. The insurance mess is fuelling citizen protest organizations, such as Massachusetts Fair Share, which not only fights high premiums but challenges the underlying concept of private insurance: the investment of premiums as the source of income to pay future claims.⁸ As a result of such citizen pressure the Massachusetts Insurance Commission agreed to include investment income in setting premium rates and determining the industry's rate of return. No wonder, in the light of today's situation, some insightful insurance executives are beginning to see the exhaustion of the logic of some of our current industrial assumptions. Roy R. Anderson, Vice President of Allstate, noted in a speech on *The Future of the Insurance Business in a Changing Society*, "We have broken loose from Western Industrial Society — our institutions are now changing — and a new society will emerge, probably within the next couple of decades. It is this concept of changing civilization that explains why some of the problems we have encountered in our systems of insurance seem to defy solution, that is, liability insurance, health insurance and

⁵ *Business Week*, "The Overload on the Nation's Insurance System", Sept. 6, 1976, p. 46.

⁶ *Forbes*, "Who Is Raping Whom?", Sept. 1, 1976, p. 61.

⁷ *New York Times*, "High-Risk Urban Insurance under Attack in State", April 24, 1977.

⁸ *Just Economics*, Vol. 5, No. 4, "Fair Share Stops FAIR Insurance Increase", May 1977.

Social Security... in each of them I see evidence of a systemic breakdown, of the possibility of an impending traumatic change." ⁹ (Diagram 1 provides a context for interpreting this change on which I will comment further.)

Under this growing pressure, it is fashionable for insurers and risk managers to emphasize their problems with tort liability and mandatory assignments, and what they often see as the increasingly unrealistic behavior of the public and its elected officials in demanding ever wider "pie-in-the-sky" protection from not only risk but "pain and suffering" to the point of denial of the daily uncertainties of life.¹⁰ I believe that while there is truth in this interpretation, that it blinds the industry to the need to recognize and address a set of much deeper, more structural problems: those involving systemic transition of industrial societies and their particular, capital-intensive, socially and ecologically disruptive technologies and the whole class of novel vulnerabilities they generate. These range from the systemic inflation and "stagflation" impasse and the unmanageable complexity I termed "the Entropy State", to the unsolved theoretical problems of modelling the new class of "ticking time bomb" risk probabilities, i.e. those ever more widely displaced in space and extensively delayed in time e.g. current research in recombinant DNA (dioxynucleic acid) and the resulting commercial development of new organisms that might unleash dangerous mutant viruses upon human populations with no immunity, according to Dr. L. Cavalieri of New York's Sloan-Kettering Institute.¹¹ Companies already engaged in this research include Miles Laboratories, Eli Lilly & Company, Hoffmann La Roche and the Upjohn Company. There is, of course, increasing pressure to underwrite such enterprise, as well as many other new technologies with the inherent potential for producing major and sometimes, as is the potential with DNA recombination, irreversible catastrophes.

Today's most ubiquitous "ticking time bomb" risks have been sneaking up on us for almost fifty years in the proliferation of technologies based on petrochemicals, from vinyl chloride and polychlorinated biphenyls to ever more exotic food drug and cosmetic compounds, polymers, plastics, pesticides and aerosols and the resulting increase in the burden of carcinogens in air, water and the human food chain.¹² Federal agencies charged with regulating toxic substances, the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA) and the Occupational Health and Safety Agency (OSHA) are attempting to coordinate their authority to regulate the some 30 substances already known to cause cancer in humans and to launch a program of confirmatory identification of an additional 2156 suspected carcinogenic agents.¹³ The Federal government, already under heavy fire for its bias toward funding research to "find a cure" for cancer, has been forced to shift to a preventive strategy, and now admits that of the 1000 American cancer victims that die each day, between 60 %

⁹ Anderson, Roy R., *The Future of the Insurance Business in a Changing Society*, speech before Alex Brown Conference, Feb. 23, 1977.

¹⁰ *Business Week*, "The Way to Ease Soaring Product Liability Costs", Jan. 17, 1977, p. 62.

¹¹ Howard, Ted and Rifkin, Jeremy, "Who Should Play God?", Dell Pub. Co., N.Y., 1977.

¹² *New York Times*, "Surveillance Widens for Cancer Research", May 11, 1977.

¹³ *New York Times*, "Agency Plan to Identify & Control Toxic Chemicals", March 5, 1978.

and 90 % of their cancers are caused by substances in the environment.¹⁴ However, the writing on the wall is clear for insurers of both life and casualty : the proliferation of carcinogens in workplaces, food, water, and air, together with tobacco smoke, increased exposure to radiation (which alone accounts for 22,000 cases of leukemia per year¹⁵) as well as countless additional stresses of industrial life, lack of exercise and poor diets is now in many subtle and cumulative ways, compromising the health of millions of citizens of such societies, and altering toward greater unpredictability the etiology of disease and the accepted actuarial calculations of life expectancy.

The recent banning of the fire retardant chemical TRIS¹⁶; the FDA's initiation of procedures to remove from the marketplace such sedatives as Cope, Compoz, Miles Nervine, Tranquim and Quiet World because they incur "risks for users with no demonstrated medical benefits"¹⁷; as well as the billions of dollars worth of damage suits filed against drug companies, doctors and hospitals by adenocancer victims of diethylstilbestrol (DES), a now proven totally ineffective drug thought to inhibit miscarriages¹⁸; and the incalculable insurance exposure of Hoffman La Roche Company of Switzerland stemming from the dioxin release incident in Seveso, Italy where claims may continue emerging for decades, are just a few specific cases in point in the drug industry. The latest horror story is that currently breaking over human exposure to microwave radiation from TV sets, microwave ovens, CB radios, burglar alarms, garage door openers and other consumer products, as well as workers' exposure to such radiation leaking out of video display terminals (VDTs) in banks, airline and hotel reservations offices. The Environmental Protection Agency has found that some high-rise city office buildings are constantly exposed to radiation several times greater than that the Soviets beamed at the American Embassy in Moscow.¹⁹ Blood disorders, hearing loss and dizziness are symptoms, as well as a rare form of cataract on the rear of human eyeballs are now being documented in operators of microwaves radar equipment including air traffic controllers, some of whom have early-stage blind spots which already impair their vision in tracking passenger planes on their radar screens. Microwaves disability victims are at last being awarded benefits by the Veterans Administration and many more claims are now being filed under Workmans' Compensation, according to Paul Brodeur in *The Zapping of America* (1978). The more pervasive nature of the microwave radiation problem involves defense radar installations all over this country and the world, as well as the reported Soviet weather modification experiments, thought by some to be affecting U.S. weather patterns, which involve microwave technology, based on theories of the late Nikola Tesla.²⁰

¹⁴ Ibid.

¹⁵ *New York Times*, "Panel Criticises U.U. on Radiation Hazard" (General Accounting Office Report to the Senate Governmental Comm.), Dec. 23, 1977.

¹⁶ *New York Times*, "Court Orders Chemical Concerns & Stores to Share TRIS Burden", May 4, 1977.

¹⁷ *H. E. W. News Release*, June 21, 1977. U.S. Dept of Health, Education & Welfare.

¹⁸ *Time*, "Taking DES to Court", May 9, 1977, p. 44.

¹⁹ *New York Times*, "The Air Pollution You Can't See", May 6, 1978, p. 64.

²⁰ *The Application of Tesla's Technology in Today's World*, Investment research report by Lafferty, Harwood & Partners, Ltd. Members Montreal Stock Exchange, Jan. 27, 1978.

The capital-intensity and scale of many of today's energy technologies create catastrophic levels of risk, whether nuclear fission power plants, liquified natural gas (LNG) tankers and oil transport by supertankers. The essential uninsurability stems from the fact that, according to the report issued by the U.S. Congress Office of Technology Assessment in October, 1977, "The igniting of a spill of this extremely volatile substance is quite beyond the capabilities of any known fire-fighting methods to extinguish it".²¹ The weak link in such a vulnerable energy supply is not so much in LNG tanker construction as in poor traffic control methods in busy harbors and waterways. The recent collisions of oil supertankers in busy shipping lanes highlight their vulnerabilities.²² In addition, some naval engineers have voiced the possibility that technologically speaking, these ships have pushed too far too fast, already ominously suggested by the serious buckling that many of them had incurred before or after launching and on sea trials. Noted marine scientist and presidential advisor Dr. Edward Wenk Jr. states in his *The Politics of the Ocean* (1972) that "The very use of supertankers needs re-evaluation".²³ Noel Mostert notes in *Supership* (1975) that for the largest class of tankers, Ultra Large Crude Carriers (ULCCs), insurance now accounts for 70 % of their operating costs.²⁴ He contends that these ships may be fatally flawed as a species, and that little prior thought was given to the fact that they also offered an entirely new and incalculable set of fire and explosive hazards. Likewise, undersea oil drilling blowouts incur such enormous liability that in the case of the April 1977 North Sea blowout of the Phillips Petroleum drilling platform, the stock of the company dropped almost five points on a 302,800 share turnover in one day on the New York Stock Exchange, until Phillips spokespeople were able to calm investors that its insurance coverage was adequate to meet all claims.²⁵

Similar incalculable risks inhere in nuclear power and were recognized over a decade ago in their socialization via the Price Anderson Act, which was extended in 1975 to cover these uninsurable risks until 1987. It is interesting to note that the Congress' extension of the Price Anderson Act was based on the now largely discredited Nuclear Regulatory Commission report, headed by Dr. Norman Rasmussen, known as WASH-1400, which calculated the probabilities of a range of nuclear power plant failure modes using independent analyses of separate components rather than the more likely scenarios of systemic interdependence in actual operating conditions.²⁶ WASH-1400 used fault-tree analysis methodology, which the National Aeronautical and Space Administration had discarded ten years ago after it was found to have underestimated the failure rates of the ill-fated Apollo engines by over 40 to one. The earlier Brookhaven study, WASH-740 in 1965 was more forthright. It stated, "There is no objective quantitative means of assessing that all possible paths leading to catastrophe have been recognized and safeguarded, or that safeguards will in every case function as intended when

²¹ U.S. Congress Office of Technology Assessment, OTA-O-53, Sept. 1977.

²² *New York Times*, "Supertankers Collide Off S. Africa and Catch Fire", Dec. 17, 1977.

²³ Wenk, Edward Jr., *The Politics of the Ocean*, Univ. of Washington Press, Seattle, 1972, p. 419.

²⁴ Mostert, Noel, *Supership*, Warner Books, Oct. 1975, p. 168.

²⁵ *New York Times*, April 26, 1977.

²⁶ Nuclear Regulatory Commission, WASH-1400, Reactor Safety Study, Oct. 1975.

needed.”²⁷ WASH-740 was withheld from the public until a suit under the Freedom of Information Act forced the Atomic Energy Commission to release it in 1973. In the WASH-1400 study, which persuaded the Congress to extend the federal underwriting of nuclear power plant risks, the probability of reactor meltdown was calculated at 1 in 20,000 per reactor year. But, as pointed out in a review by the Union of Concerned Scientist, this was based on a mistaken application of statistical theory (the use of the median in log normal distributions) which introduced a factor of 2.5 understatement.²⁸ Correction of this error alone increases the probability to 1 : 8000 per reactor year, in addition to the understatement errors of the fault-tree analysis and other problems caused by over-optimistic assumptions. Thus private insurers sensibly avoided shouldering such admittedly incalculable risks while an unsuspecting public now bears them.

Similarly, taxpayers now shoulder an increasing burden of investment risk in nuclear construction through tax credits to utilities and new subsidies such as the passing forward to utility customers the “Construction Work in Progress” charges on their bills. These construction investments are now at a standstill, not primarily due to the opposition of their environmentally-aware investor/consumers, but due to rising capital costs, engineering problems and unforeseen snags, such as sites chosen at earthquake fault lines or those where droughts have reduced cooling water available to below operating requirements.²⁹ Such was the case of the \$5 billion reactor now at a standstill in the San Joaquin Valley, California, which if it is ever built, will compete bitterly with irrigation farmers for its required 20 billion gallons of water annually.³⁰ The point of elaborating on such cases is merely to illustrate that in today’s mature industrial societies, whole classes of their capital-intensive technological trajectories are now encountering systemic dis-economies of scale, social costs and pushing boundary conditions rooted in the basic laws of thermo-dynamics and natural systems. (See my example of another growth-dependent industry, packaging, encountering similar limits, *Human Resources Management*, Spring, 1977, Graduate School of Business Administration, Univ. of Michigan.)

If all of these types of literally uninsurable risks are viewed as stemming from a specific class of technologies now encountering visibly diminishing returns, we see a deeper structural pattern affecting risk management. These technologies have recently and rapidly evolved from the much slower development rate of industrial production methods over the past 200 years. As Dr. Orio Giarini, Secretary General of the International Association for Risk and Insurance Economics Research in Geneva has so well shown, the discipline of economics has neither captured this increasingly dynamic technological development in its equilibrium models of supply and demand, nor has it noticed that these rates of innovation along current pathways are now encountering

²⁷ *The Risks of Nuclear Power Reactors*, Study Dir. Dr. Henry W. Kendall, Union of Concerned Scientists, Cambridge Mass., Aug. 1977.

²⁸ Ibid.

²⁹ See for example, *Power Plant Performance*, Council on Economic Priorities, N.Y., 1976.

³⁰ *New York Times*, “Western Drought Imperils Building of World’s Biggest Nuclear Plant”, May 9, 1977.

diminishing returns.³¹ This fact is not surprising, since economic models generally consider technology as an *exogenous* variable, a *coordinate* to their linear conceptual scheme, a point also articulated by François Hetman in his *Society and the Assessment of Technology* (O.E.C.D., Paris, 1973).

Let us now refer back to Diagram 1 showing the two basic types of cybernetic systems analogous to the late-stage industrial societies with which we are dealing. Economics is still undergirded by simple models of mechanical locomotion, such as the equilibrating model of supply and demand, however baroque the input-output and econometric models spun from such concepts appear to the uncritical eye. The equilibrium model of supply and demand undergirding the free-market, laissez-faire philosophy is now a too atomistic, and linear concept, lacking the systemic consideration of a host of new variables its practitioners still consider "exogenous". As Nicholas Georgescu-Roegen showed in his *The Entropy Law and the Economic Process* (1971), economics still uses arithmetical and reversible models of locomotion to portray many components of economic systems. Inasmuch as these components can be studied separately, such micro-economic views may be adequate. However, when one views economic processes in extended time/space dimensions, one sees that they are not separate and reversible processes, but evolve symbiotically and structurally, as they have for the past 200 years of the Industrial Revolution. As I have tried to elaborate in *Creating Alternative Futures*, this misapplication of micro theory to the interacting macro-economic system introduces order-of-magnitude errors, now accounting for the denouement of macro-economic management in all mature industrial countries.³² Economists still conceive of this rapidly evolving, dis-equilibrium macro-economy as if it were still an equilibrium system that could be managed with the simple hydraulics of aggregate supply and demand.

Thus, while economics has begun to learn from general systems theory that industrial societies are non-linear, cybernetic systems governed by thousands of feedback loops, they are naturally still more at home dealing with equilibrium, "thermostat" type systems that maintain their structure by negative feedback loops (Type 1), than with the now-emerging understanding of *dis-equilibrium* systems governed by positive feedback loops (Type 2), which are in the process of irreversibly transforming themselves into *improbable* new structures. If, as I contend, late-stage industrial societies are of the second, morphogenetic type, in constant *dis-equilibrium* and evolving toward, by definition, unpredictable new states, this would require a completely new theoretical basis for risk management. One of the conventional assumptions underlying risk management probability calculations (including that of nuclear safety study WASH-1400), is that the greater the catastrophe the less likely its occurrence. This may be warranted in static or slowly-moving equilibrium systems, where deviations are damped by negative feedbacks. However, as Maruyama has shown, in morphogenetic systems, deviation-amplifying, positive feedback mutual causal processes govern. In such systems, the normal laws of causality must be revised to state that similar conditions may result

³¹ Giarini, Orio, *Economics, Vulnerability and the Diminishing Returns of Technology*, The GENEVA PAPERS on Risk and Insurance, No. 6, Oct. 1977.

³² Henderson, Hazel, *Creating Alternative Futures*, Part 1, the End of Economics, Berkley Paperback, N.Y. 1978.

in *dis*-similar outcomes. Maruyama adds: "It is important to note that this revision is made without the introduction of indeterminism and probabilism. Deviation-amplifying mutual causal processes are possible even within a deterministic universe, and make the revision of the laws of causality even within the determinism. Furthermore, when the deviation-amplifying mutual causal process is *combined* with indeterminism, here again the revision of the basic law becomes necessary. The revision states: *A small initial deviation, which is within the range of high probability, may develop into a deviation which is very improbable within the framework of probabilistic uni-directional causality*".³³

It is this set of deviation-amplifying probabilities that set apart the class of capital-intensive, excessively inter-linked, high-risk technologies I have mentioned. Under such conditions, it might well be that the greater the accident the *greater* the chance of its occurrence! The point is that we do not know, and the theoretical foundations of statistical probability modelling are now inadequate. *Until they are re-formulated, insurance in this sphere has become indistinguishable from gambling.* Research in this area is proceeding: in conditional probability modelling, cross-impact analysis, technology assessment, as well as time-dependent conditional probability modelling. But time sequence is the key to determining absolute, conditional and joint probabilities, and there is still a need, as pointed out by Roy Amara, President of the Institute for the Future, to develop a calculus for such time sequence interactions.³⁴ As M. McLean, a technology forecaster, noted in *Futures* (1976), "By concentrating attention on the manipulation and refinement of probability estimates, the cross-impact approach lost sight of the fact that such estimates can only be temporary substitutes for an understanding of the *causal structure* of socio-economic processes" (*italics added*). Since the proliferation of cross-impacts characterizes such socio-economic processes, we must note the caveat of Prof. Mury Turoff of the New Jersey Institute of Technology in *Technological Forecasting & Social Change* (1972) that "traditional probability relationships are irrelevant to cross-impact studies."³⁵ A key to the time sequence problem is the fact that in complex, non-linear systems, distinguishing between "cause" and "effect" becomes almost impossible — the now familiar modelling and decision problem of proliferating "chicken and egg" type situations. For example, as mentioned, risk managers view inflation as a "cause" of their problems, but inflation is also an "effect" of deeper structural "causes", which in turn, are "effects" of yet other "causes", and so on. This illustrates the inadequacy of the simple "trade-off" view of inflation in economic theory and the conceptual confusion of believing that we *understand* a phenomenon by *naming* it! Economics is not a substitute for thought, computation cannot substitute for conceptualization, nor do correlations imply causality.

The most spectacular work on modelling morphogenetic systems is growing out of the qualitative mathematics of Rene Thom in his *Structural Stability and Morphogenesis* (1972, English translation 1975) and his catastrophe theory. This has led to

³³ Maruyama, Magoroh, "Paradigmatology and its Application", *Cybernetica* No. 2, 1974.

³⁴ *Technological Forecasting and Social Change*, quoted in "Subjective Conditional Probability Modelling", Mitchell and Tydmann, Vol. 11, No. 2, 1978, p. 134.

³⁵ *Technological Forecasting and Social Change*, An Alternative Approach to Cross-Impact Analysis, M. Turoff, No. 3, 1972, p. 311.

an explosion of interest and later work in this field by others is now available in *Catastrophy Theory 1972-1977* edited by E. C. Zeeman.³⁶ Other "qualitative modelling" based on biological and ecological theories, rather than on inert, physical theory, is that of such systemic theorists as C. S. Holling, Roy A. Rappaport, H. H. Pattee, Gregory Bateson, Erich Jantsch, Ingemar Falkehag and the late Conrad Waddington, as well as the brilliant theories of "order through fluctuation" in dissipative structures of physicist Ilya Prigogine.³⁷

Time and its flow is also the key problem in modelling morphogenetic systems. As Maruyama points out, the error in current laws of causality involves the assumption of *the uni-directional, orderly flow of time*, giving us the underlying "uni-directional causal paradigm" and the "random process" paradigms of Western science and culture. Maruyama describes the unidirectional causal paradigm as "that which has become fashionable since the discovery of indeterminism and informational indeterminabilism in quantum mechanics ... and remains fashionable in the philosophy of science and sociology, even though physical and biological sciences have already moved out of it. According to this paradigm, there is a one-way flow of influence from cause to effect, but occurring with some probability rather than with certainty." Effect can be predicted from cause with some probability as can cause be likewise inferred from effect. Maruyama notes that the "scientific-method" consists in discovering the probability distribution and in establishing the limits of accuracy of observation. He adds "multi-variate statistical analysis, correlation analysis, regression analysis, etc., can be attempted for phenomena not completely amenable to laboratory experimentation, e.g. weather or tropospheric scattering of electromagnetic waves. If statistical relations between two variables are found, this may be due to one of the following unidirectional causal relations: a) one causes the other with some probability, either directly or through other intermediate variables, or, b) both are influenced by some common cause, with some probability. However, the causal direction cannot be known from statistics alone and must be determined by *logical* considerations."³⁸ (i.e. a priori). Maruyama describes the second paradigm as the "stochastic paradigm" or the random-process paradigm thus: "This paradigm is due to the development of thermodynamics in the 19th century, based on the logic of coin tossing, where each toss is considered to be independent from other tosses. Thus the outcome of the first toss should not influence the outcomes of the subsequent tosses. This paradigm is similar to the distribution of temperature in thermodynamics and the 2nd law of increasing entropy: the higher the degree of homogeneity in temperature the higher the entropy. There is some degree of continuity in the sense that the state of the system at a given time is related to the state of the system at a previous time —related with a certain probability distribution, i.e. this type of change is termed "stochastic process".³⁹

Maruyama, a Japanese, can clearly point out such contrasting, but not necessarily mutually exclusive paradigms of time and causality in Western vis-a-vis other cultures.

³⁶ Zeeman, F. C., *Catastrophy Theory 1972-1977*, Addison-Wesley Pub. Co., 1978, Mass.

³⁷ See for example, Contributions to *Evolution and Consciousness: Human Systems in Transition*, Eds. Erich Jantsch and Conrad Waddington, Addison-Wesley, 1976.

³⁸ Maruyama, op. cit., p. 145.

³⁹ Maruyama, op. cit., p. 146.

Similar insightful contrasting of paradigms in physics has been expounded by theoretical physicist Fritjof Capra in *The Tao of Physics* (1975). In today's situation it would appear that risk managers must first be aware of the extent to which paradigms of thought are the conceptual tools underlying all of our theoretical models, and secondly, in dealing with various probability problems, determine how to select appropriate paradigms for developing alternative theoretical approaches. In Diagram 2 on page 15, I have adapted from Maruyama's *Simplified Table of Three Pure Paradigms* from his paper in *Cybernetica* (1974) entitled appropriately, "Paradigmatology and its Application".⁴⁰ Traditional Western logic is still most often grounded in the first two paradigms described above. However, the needed research for prudent risk management during the transition decades ahead for late-stage industrial societies will probably involve much deeper explorations of the behavior of cybernetic and morphogenetic systems. They are best viewed from the vantage point of Maruyama's Paradigm 3, the "mutual causal paradigm" portrayed in column three of the Diagram. This newer paradigm is derived from Norbert Wiener's 1949 formulations of cybernetic processes and Stanislaw Ulam's mathematical formulation for morphogenetic systems in 1960, which showed that complex research on morphogenetic systems mentioned earlier breaks further ground within this same paradigm.

Meanwhile, in the real world, risks continue to proliferate, despite the lack of needed theory. Pragmatically, as more and more classes of risk fall into the category of the theoretically uninsurable, pressure mounts to socialize them at higher levels in the society, from municipal property insurance pools to auto insurance assignment at the state level, and finally, to the proliferating demands for the federal government to legislatively act as "insurer of last resort". We see a new "Tragedy of the Commons"⁴¹ scenario unfolding with these demands coming from a widening array of sectors of our national life: from the forerunners in nuclear power liability, federally insured bank deposits, Workmans' Compensation and Social Security to the new pressures for socializing comprehensive health care and medical malpractice, compensation of crime victims, underwriting municipal debt as in the case of New York City, bailing out faltering corporations and real estate investment trust speculators, to the many enormous capital investment schemes for energy development, from synthetic fuels to nuclear fusion. This does not even include the costs of moth-balling aborted energy projects, such as the Clinch River Breeder Reactor, which has recently been appropriated the \$80 million needed to close it down,⁴² or the horrendous costs of de-commissioning some of the nuclear fission light water reactors now becoming obsolete, so far wildly underestimated. Recent reports with actual de-commissioning in

⁴⁰ Maruyama, op. cit., p. 143.

⁴¹ The tragedy of the commons refers to the parable of the use of a common grazing pasture in feudal England, by all the peasants for grazing their sheep. It was not long before some peasants discovered that it was possible to increase the number of their own animals grazing the commons. However, once all the rest began to follow suit, the commons became over-grazed and was soon destroyed for everyone. Garrett Hardin cast this in rigorous terms in his much footnoted article in *SCIENCE*, Dec. 13, 1968, p. 1243, entitled "The Tragedy of The Commons".

⁴² *New York Times*, "Carter Signs Appropriations Bill: Will Close Clinch River Project", March 8, 1978.

Diagram 2

SIMPLIFIED TABLE OF THREE "PURE" PARADIGMS, after M. Maruyama

	1. Unidirectional Causal Paradigm	2. Random Process Paradigm	3. Mutual Causal Paradigm
Science :	traditional "cause" and "effect" model	thermodynamics ; Shannon information theory	post-Shannon information theory
Information :	past and future inferrable form	information decays and gets lost ; blueprint must contain more information than finished product	Non redundant complexity can be generated without pre-established blueprint
Cosmology :	predetermined universe	decaying universe	self-generating and self- organizing universe
Logic :	deductive, axiomatic	inductive, empirical	complementary
Perception :	categorical	atomistic	contextual
Knowledge :	belief in one truth, if people are informed they will agree	why bother to learn beyond one's own interest	polyocular : must learn different views and take them into consideration
Methodology :	classificational, taxonomic	statistical	relational, contextual analysis, network analysis
Research hypothesis and research strategy :	dissimilar results must have been caused by dissimilar conditions. Differences must be traced to conditions producing them.	there is a probability distribution : find out probability distribution	dissimilar results may come from similar conditions due to mutually-amplifying network. Network analysis instead of tracing of the difference back to initial conditions in such cases.
Analysis :	pre-set categories used for all situations	limited categories for individual's own use	changeable categories depending on situation
Assessment :	"impact" analysis	what does it do to me ?	look for feedback loops for self-cancellation or self-reinforcement

* Adapted from : M. Maruyama, *Paradigmatology and its Application*, p. 143, reprinted from *CYBERNETICA*, 1974, § 2.

*Electrical World*⁴³ suggest that such costs in some cases, can exceed the initial investment cost of the plants themselves.

Whenever risks are socialized at successively higher levels in society, some time is bought to work out solutions, but at the trade-off of greater systemic vulnerability to cascading breakdowns due to the greater inter-linkage, as well as eventually resulting in pathological diffusion of responsibility. At the private, local and individual level there is stability in the widely-dispersed, large universe of small, de-coupled risks. Each time such risks are socialized at a higher level of societal management, there is a greater aggregation of risks into fewer, larger units, i.e. the *universe* of risks grows smaller as the agglomerations of risks grow more unwieldy. Finally, at the federal level, there are few checks on the *simultaneous* socializing of diverse risks, and few conceptual overviews are available to legislators as to the *total* federal exposure, other than that inferable from monitoring total debt, projected federal budget deficits and general inflation rates. From such ominous statistics we might calculate what proportion of these statistics might be accounted for separately as a "socialized risk fraction" or indicator. However, until government statisticians produce such a new index, we might err on the side of caution and assume that we have already mortgaged a large portion of our foreseeable "social risk future". Such a view, of course, is reflected finally at the international level, where the tribulations of many mature industrial countries undergoing similar systemic transitions, are reflected in the instabilities of the international monetary system itself. The "risk aggregation buck" stops eventually at the level of the national currency. Today, with our energy habit still un-curbed and our grandiose technological plans blinded by lack of theory to looming future scenarios of rapidly eroding returns, one might say, in a very real sense, that part of the declining value of the U.S. dollar is attributable to the excessive socialization of risk. We may have reached the point where we are blinded to this fact, since, to paraphrase an old adage: Everybody's Risk has become Nobody's Risk. At least, the danger is that nobody is making it their business to assess it systematically.

Lastly, if any of the foregoing analysis seems relevant, which might risk managers do about it? I will dare to offer some modest prescriptions:

1. Hire some thermodynamicists to check your economists' models, particularly regarding their assumptions as to future capital productivity, investment decisions and inflation causes beyond the Phillips curve trade-off interpretation: see for example, my "Inflation: the View from Beyond Economics" *Planning Review*, March, 1977).
2. Fund through professional and trade associations further research on the behavior of dis-equilibrium and morphogenetic systems.
3. Examine innovation options in inherently lower-risk, decentralized technological modes: e.g. solar, wind and geothermal energy, conversion of electric power to co-generation modes with district heating, as well as magnetohydrodynamics for improved generating efficiencies, as well as recycling systems, bioconversion of wastes and investments in energy conservation. I have prepared a set of Criteria for such

⁴³ *Electrical World*, "De-Commissioning Nuclear Reactors", Gordon D. Friedlander, McGraw Hill Publications, Feb. 15, 1978, p. 44-8.

investments in my Testimony before Joint Congressional Hearings, Senate Commerce Committee, Feb 14, 1978.

4. Continue refusing to underwrite unnecessarily hazardous technologies, whether nuclear power, LNG tankers or recombinant DNA research, or ill-advised government crash schemes, such as the Project Independence energy scheme (later proved infeasible because of unrealistic capital requirements) or the swine-flu fiasco. Forcefully bring to the attention of the public and their legislators the *reasons* for refusing to privately insure such risks, and explain that neither should the government underwrite them in spite of the railroading and lobbying by special interest groups and their "research".

Finally, it is encouraging to note the self-adjusting, healing mechanisms already at work in late-stage industrial societies. They include the trend toward decentralization of technologies, urban areas and their populations typified by the "Small is Beautiful" movement of followers of the late E. F. Schumacher.⁴⁴ There is a new surge of interest in greater personal self-reliance, autonomy and responsibility, as documented by Carter Henderson, in "Living the Simple Life", *Human Resource Management*, Fall, 1977. And, as Ronald Inglehart has shown in his *The Silent Revolution* (1977), similar movement exist in most mature industrialized countries, where the diffusion of "post-materialist values" is matched by the growing political skill of these movements. Scenarios of spontaneous devolution, where formerly delegated authority is recalled to more functional levels and re-localized should be welcomed rather than feared. Societies with smaller-scale enterprises may prove more systemically efficient, and the recent trend toward self-employment (10 % of the increase in employment during the fiscal year 1977-78 was due to this factor), as well as to neighborhood economic revival, the mushrooming of co-operatives (50 million Americans now belong to some form of co-op), and the growth of "self-insurance" implicit in the phenomenal popularity of the health, fitness and better nutrition movement, may help in the transition of today's crisis and conflict-ridden industrial societies into saner, healthier "post-industrial" patterns for the future.

⁴⁴ *Business & Society Review*", The Big New Small Is Beautiful Movement", Hazel Henderson, Fall 1977, p. 41.