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Some Thoughts on Uncertainty, the Transfer of Knowledge and Insurability

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1. Introduction

Does there exist an absolute, objective certainty or uncertainty? We cannot give a global, definite answer to this fundamental question. In the mathematical theory of recursive functions so called Turing machines of different complexity are introduced. It can be shown that a Turing machine can construct an infinite sequence of signs — we can think of a sequence of numbers — in such a way that no simpler, less complex Turing machine is able to find out whether the signs in the sequence were chosen by randomness or constructed, even knowing the initial signs of the sequence.

We raise here the question whether nature is not " created by a Turing machine " too complex for us to understand and whether we ourselves are not constructed as " Turing machines " too complex for our overall understanding. Here we regard ourselves on the one hand as " complex Turing machine constructions " and on the other hand as active, calculating, understanding, less complex Turing machines.

The question as to whether we understand ourselves, whether our brain can completely comprehend itself, is an old philosophical one which leads, in case of a negative answer, to other more specific questions.

If there are limits to what we can understand can we fix them? Immanuel Kant tried to do precisely that.

Can we understand all our own actions and those of society?

Can we predict and comprehend the consequences of our own actions and those of society?

These questions are not only of utmost importance to social sciences such as psychology, sociology and economics, but according to our present understanding also for natural sciences like physics, because we cannot separate ourselves from physical experiments. We can not be mere observers of a physical experiment; we are also part of it,

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influencing it through actions of which we may or may not be aware. This belongs — like the Heisenberg uncertainty relation — to the knowledge of modern physics, of quantum mechanics, as opposed to classical Newtonian mechanics.

Questions like the following now arise:

A: Is quantum mechanics in its present state absolutely correct final knowledge that will never be replaced by another theory?

B: Since — according to our present understanding — no factors of which we are aware are absolutely independent of us — either in the social sciences or in physics — is it admissible to transfer scientific findings from one field to another?

We certainly do not have a final all-embracing body of knowledge which we can prove to be really final and all-embracing and to which we can relate all other knowledge.

Therefore we can not repudiate the possibility that — in terms of the theory of recursive functions — a " Turing machine " created a world so complicated that we shall *never* be able fully to understand it. No answers exist, therefore, for questions A and B.

We can, however, say the following about question A:

For the physicist up to the end of the 19th century *Newtonian mechanics* described all physical phenomena in mechanics and all movements could be predicted deterministically in accordance with it. Albert Einstein, one of the most important contributors to *quantum mechanics*, always felt uneasy about the indeterministic features of that theory and did not believe that it would remain final and irrefutable. As long as no observation or experiment contradicts quantum mechanics we can define the Heisenberg uncertainty relation as being *objectively correct* without considering the fact that one day an exact deterministic theory — including quantum mechanics as a borderline case — may again be necessary to explain all phenomena.

With regard to question B, *we do not consider it admissible generally to transfer knowledge from physics to economics without substantial restrictions*; this will be discussed below.

Reflecting on questions A and B convinces us that the question " certainty or uncertainty " can not be answered *finally* and *globally* — either in physics or in economics. We have to be satisfied with *the most recent knowledge, in so far as we can prove that it is superior to or includes previous knowledge.*

2. Subjective uncertainty and consequences for insurance

Whatever is connected with *human activity* in *future* also involves uncertainty for the human beings concerned.

The term *uncertainty* is complementary to the term *certainty*. Whatever is not certain is uncertain, whether it is nearly certain or very far from being certain. All *degrees of uncertainty* are included in the term *uncertainty*.

Whereas in the introduction we tried to approach the term *uncertainty objectively* via comparisons with results from the theory of recursive functions or via the Heisenberg uncertainty relation, we will comment now on the same term from a mainly *subjective* viewpoint.

By a transfer of knowledge from quantum mechanics to economics we can maintain that a person can not *merely* observe any economic process because he is *always part of it.* The person concerned may not, of course, realize that this is so. He may regard himself as a mere observer of certain processes with which, he feels sure, he has no connection whatsoever. In the *subjective* approach *his opinion is decisive.* We can speak therefore in what follows of " observers ".

A person may judge whether he is able to forecast a process over which he has no or only partial control with certainty or not. Depending on that judgement the process in question is subjectively certain or uncertain respectively with regard to that person. If the person regards himself only as an observer the *concept of subjective uncertainty* is related to the observer.

Uncertainty can be a consequence of indeterminacy or ignorance.

Subjectively, a person can recognize that he can not forecast a process out of *ignorance.* On the other hand it may be observed a posteriori that a person wrongly judged himself to be able to make certain predictions out of ignorance, for example, because he did not know all the elements influencing the process. The term *ignorance* refers rather to the concept of subjective uncertainty, whereas the terms *indeterminacy* and *unpredictability* rather refer to the very notion of objective uncertainty a priori.

Indeterminacy and unpredictability are terms used to denote processes which are objectively uncertain in principle, at least for a given time period, unless they are explicitly related to a person, i.e. to his opinion. Ignorance as well as indeterminacy, unpredictability or unverifiability are of great importance in economics.

Example :

A person may insure certain special risks and transfer *indeterminacy* to a professional risk carrier by paying a given premium. Another person may not insure similar special risks out of *ignorance*, because he does not know of the possibility of such an insurance cover or because he is not aware of the risks at all.

As W. A. Weisskopf [1] has pointed out, uncertainty is often associated with mystery, creating anxiety ; this leads in turn to the development of belief systems designed to protect human beings from anxiety. Such belief systems are set up according to A. H. Maslow [2] to satisfy a basic human need for " safety ".

Since subjective uncertainty is always related to the state of knowledge of some person, we have also to take into account the psychological anxiety aspect, because we can not separate the often interrelated knowledge and belief points of view sufficiently clearly in every case. Belief systems thus have not only mythological, theological or philosophical, but also economic importance.

Anxiety can give rise to belief systems which lead to an increase or decrease of subjective uncertainty.

This may lead on the one hand to insurance of risks for which cover is not actually needed, and on the other hand, to not insuring risks, even underrated ones, for which cover is very necessary. Such " objectively irrational " behaviour of the population has been observed by Slovic, Fischhoff, Lichtenstein, Corrican, Combs [3] and others.

These two opposite modes of behaviour arise from different individual characters. If a person's anxiety exacerbates his uncertainty he may overestimate his insurance needs and almost be disappointed if no claims occur. Having paid premiums, he wishes to receive claim payments for these premiums in order to have the correctness of his anxiety confirmed and to really feel some equivalent value for the premiums paid. Other persons — and they seem to be the great majority — seem to deal with anxiety by persuading themselves that nothing serious or catastrophic can ever happen to them. As a consequence they do not take out catastrophe covers which they may well need [3].

The two opposite modes of anxiety-motivated behaviour described above are, irrespective of the direction taken, disadvantageous for the insurance industry but difficult to combat. They either force the insurance industry into practices which are inconsistent with public policy, as has been shown by Berliner [4], or do not allow it to give cover where really needed, i.e. to fulfil its actual function.

3. On the transfer of knowledge to economics

We shall distinguish in this paragraph between the *immediate* or *direct* and the *indirect transfer of knowledge*, which are fundamentally different. Whenever we speak of transfer of knowledge we mean immediate, direct transfer of knowledge. We shall only define and concentrate on the indirect transfer of knowledge at the end of this chapter ; it will turn out to be a pseudo-transfer of knowledge.

In the introduction the question was asked whether the transfer of knowledge from one scientific field to another is admissible.

W. A. Weisskopf translated two antipodal principles in physics — characterizing classical and quantum mechanics — into economic paradigms which he calls the Newtonian or Newton-Cartesian paradigm and the Heisenbergian paradigm respectively [1]. Whereas the Newtonian paradigm is characterized by the concept of market equilibrium, by a deterministic line of thought connected with the conception of certainty, the Heisenbergian paradigm is symbolized by the principle of uncertainty, by the impossibility of obtaining a " complete causal determination of the future on the basis of available knowledge of the present " [1].

It is well-known that physics at the beginning of the 20th century (quantum mechanics and the special and general theory of relativity) had great influence on subsequent philosophical thought (Russell & Whitehead, Neopositivists, etc.). It is, however, questionable to what extent these views of nature can be transferred to other scientific fields like macro- and micro-economics, possibly with strong practical implications for the daily life of human beings.

Certainly a comparison of classical and modern knowledge in physics can be extended beyond the boundaries of physics and used for economic model purposes or for the description of changes in economic reality and/or knowledge. Finding such parallels may be quite useful in making new knowledge of new phenomena more easily understandable.

One impressive example of a parallel between economics and quantum mechanics is the impossibility of separating single parts from an integral system : by studying separately an element of an integral system, disregarding the interdependence between the system's element with other elements of the system, we shall never fully comprehend the particular element under study. It is impossible to extract an element from an integral system.

It is, however, not always easy to realize how comprehensive the full system is. An inference of quantum mechanics and the underlying principle of uncertainty is that in a physical experiment the physicist can not just be an observer or a spectator. He is an integral part of the experiment. He belongs to the experimental system set up by himself and cannot be detached from it.

In the special theory of relativity the Lorentz-transformations from one moving system to another lead to a mix-up between space and time. Time and space belong to the same integral system and cannot be separated. The physics of elementary particles leads us to very comprehensive integral systems and shows similarities to the comprehensive integral systems we meet in oriental philosophies and religions [5]. The idea that systems are integrated wholes that can not be decomposed into smaller units is also known in biology, where every living organism is an integrated whole.

By integrating man into the system he is observing we ultimately blur the distinction between observer and observed, between subject and object, which is a fundamental distinction in the Newtonian line of thinking.

In the field of economics we can recognize two components which confirm the previous statements, the influence of which has been observed to grow after World War II due to increasing technological development and vehemence of inflation and exchange rate fluctuations.

One component is the increasing degree of uncertainty and, fundamentally, the realization that economic developments can not be forecast exactly, deterministically. Uncertainty could even be observed in centrally planned and controlled economies, where real results are almost never identical with planned targets. The second component is a whole nexus of interrelations and interdependencies. We can identify a multidimensional structure of links, of interactions. One chain of interrelations is the dependence of a company on the trend in the branch, which depends in turn on the trend and situation of the whole market in a country. A second chain of interrelations is the dependence on world-wide economic developments outside the home country, due to international agreements, technological developments, the formation of multinational companies, etc. Whereas the first two chains mentioned here depend on *economic developments* at home and abroad a third chain of interrelations affecting economies is for example the dependence on social and political changes in regulations and laws and other non-economic developments. On the one hand the parameters within each of the chains are interdependent, on the other hand the chains depend on each other. Actually, they all form an integral, global system out of which neither small units like single enterprises nor large units like economic branches, national economies or even a world-wide monetary system can be extricated. Of course human beings can not be separated from the integral global economic system.

The two economic components " uncertainty " and " interdependence " are highly correlated. Growing interdependence generates a decreasing possibility for a person, a company or a country to influence the approximate achievement of planned targets. If we regard a prospective business result as a stochastic variable depending on different parameters with the planned result as an expected value, the standard deviation usually grows with growing interdependence, i.e. with growing dependence of the business on exogenous developments.

Growing interdependence increases in other words the degree of uncertainty.

The phenomena of uncertainty and interdependencies in economics and between economics and other related areas like politics, sociology, psychology, etc. are valid per se, because they have been observed and proven in practice again and again. The fact that they coincide with modern knowledge in physics is interesting from a philosophical point of view and can help us understand and describe phenomena.

We can explain observed economic phenomena in quantum mechanical terms but we can not use quantum mechanics as a proof for the existence of such phenomena in economics. Trying to derive economic phenomena from new knowledge in natural science is dangerous and not admissible. The Newtonian and Heisenbergian paradigms in economics described by W. A. Weisskopf [1] we interpret therefore as observed parallels to rather than transfers of knowledge from classical and quantum mechanics. Trying to find such parallels may also lead to detecting new phenomena in another field which were disregarded before.

The impact of the same phenomenon in economics and physics may be substantially different.

Example :

Macro- as well as microeconomics is rather comparable to macrophysics than to microphysics. It is possible for us to conceive of currency units as well as units like second, meter, centrigrade, etc. One billionth of such units we may write down, use for measurements and calculations in microphysics but it is difficult for us to have a really meaningful conception of them.

Since the Newtonian equations explain deterministic macromechanical phenomena excellently, a transfer of the deterministic Newtonian paradigm from physics to macro- and microeconomic models would be tempting — if only such a transfer were admissible. Then we could rely on the deterministic Newtonian paradigm in economics. The underlying uncertainties would be of a negligible order of magnitude in economics, as they are in macrophysics.

The randomness underlying the macro- and microeconomic development is, however, of utmost importance — as the existence of insurance companies for several centuries proves — but has been neglected in economic theories for a long time.

As we shall see later an indirect, pseudo-transfer of knowledge from one field to another is admissible if the knowledge in both fields can be derived from a universal logical principle.

A direct, immediate transfer of knowledge is, however, not admissible. If a direct transfer of phenomena from physics to economics were admissible this should be true for *every phenomenon* because no limit exists between phenomena which may admissibly be transferred and all the others. Such a limit would *characterize* in a direct way certain physical phenomena via economics. Such a characterization is very far-fetched and has never been observed.

We shall describe now a special physical experiment and the danger of transferring the result uncritically into economics.

Imagine a small hollow glass tube, open-ended on both sides. At one end of the hollow glass tube we have a small soap bubble with radius *r*, at the other end a large soap bubble

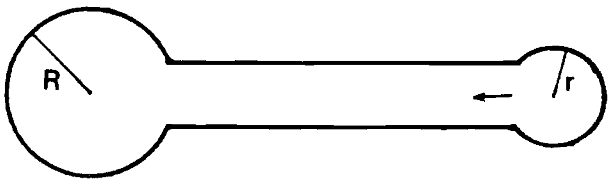

Figure 1

with radius *R* (Figure 1). Since the pressure inside a bubble varies inversely with the radius of the bubble, air will flow from the small soap bubble — due to over-pressure — through the tube to the large bubble and this process will accelerate the smaller the small bubble becomes. The large bubble is " swallowing " the small one with accelerating " greediness ". This experiment can be repeated many times. The result will always be the same.

If we imagine an equilibrium between a saturated solution and two solid crystals, one of which is larger than the other, we shall arrive at a similar result. The big crystal will " swallow " the small one at a constant temperature in an accelerating way.

It is tempting to assume that certain economic processes also follow the laws of physics in this respect. But is it true?

The market power of big business seems to grow steadily in the Western world and mass producers seem to swallow small producers.

This phenomenon is part of the disintegration of the old capitalistic system and leads to a corporate, *monopolistic capitalism*. A shift from small private enterprises run by their owners to large companies where managers of other peoples' assets make the basic economic decisions can be observed. Prices are no longer determined merely by supply and demand but by the decisions of corporate managers who also bear in mind strategical market considerations like growth, image building, etc. [1].

So far the development of the capitalistic system of the 20th century *seems to confirm* the validity of the physical experiment described before in economics and to certify the *admissibility* of the *transfer* of the experimental results and the line of reasoning from physics to economics. Studying the reasons for the growing strain on small enterprises to stay profitable and even survive we meet problems like inflation, recession, competition, money shortage and increasing difficulty in obtaining credit at good terms — which we can interpret as the *pressure* exhausting the vital energy of the small enterprises. Large enterprises have the same troubles, but for them they amount to a much lower pressure. They can not only survive but can take advantage of the situation by increasing their influence and market share by buying up other enterprises and decreasing the pressure of competition. Such an interpretation is possible by transferring the term *pressure* from the physical experiment to the economic sphere and redefining it in economic terms.

Last but not least, we can find a last parallel to the experiment : increasing recession means increasing pressure on small enterprises, whose reserves and possibilities to survive are exhausted with increasing speed. Their giving up or their ruin is accelerated.

The parallels drawn are interesting and can also be informative as long as we keep in mind that economic development is uncertain and completely independent of the physical experiment and that the parallels are fortuitous. Otherwise they can be dangerous because they show only part of the picture and can seduce us into disregarding other phenomena and possible developments which contradict the physical " counterpart ".

We shall specify now some contradictions or lines of thought that would not fit into an interpretation in terms of the specific physical experiment described before.

A. The early capitalistic structure was characterized by pure price competition between many small enterprises. It was determined by the rules of supply and demand and was described in classical theories as a market system striving towards stabilization and equilibrium, i.e. towards a static situation. Such theories were, with regard to the conviction towards a static situation, quite close to the Marxist theory. Innovations, inventions, new sources of supply and demand, new technologies, speeding up and strongly fluctuating money circulation have demonstrated the dynamic, indeterminate, unforeseeable character of economies open to free initiative; these have led in part to the managerial system described earlier. But the early capitalistic structure was in no way describable by the physical experiment of the hollow tube and the soap bubbles and if we accept the dynamic nature of economics, ruled by uncertainty, we can also not predict to what extent the capitalistic, free market economics will be describable by the physical example in future.

Contrary to this line of thought the experiment can be repeated any time and its results will remain the same, independent of time.

B. We have mentioned economic phenomena like recession or difficulty in obtaining credit that favour the theory of large enterprises buying up or taking over small companies. This process has been observed recently many times. However, we have also observed booms and periods when it was easy to get credit at very favourable conditions. Such conditions favour initiative and the establishment of new enterprises. Moreover, many governments are supporting — if it accords with their politics or seems necessary — small free enterprises, private initiative and the founding of new companies. Thus, exogenous factors may be *more or less* favourable for big enterprises swallowing small ones and by accepting the economic doctrine of indeterminateness we can not predict whether the free market will end up in a monopolistic, capitalistic system ruled by one or a few conglomerates, and whether such a process may be irreversible or not.

The experiment with the bubbles, on the other hand, which is macrophysical and therefore deterministic, is exactly predictable.

C. Some laws like anti-trust laws in different countries prevent a priori one enterprise in a branch from " swallowing " all other enterprises in the same branch. If, on the other hand, the tube in our experiment had had many arms ending in soap bubbles the largest one would have swallowed all the others.

We have seen that an uncritical, unrestricted direct transfer of knowledge from physics to economics is not admissible. However, trying to find parallels between physics and economics can lead to detecting new phenomena in economics or to revealing new aspects and interpretations of phenomena already observed before.

Moreover it may happen that phenomena are derived from a *universal logical principle* being interpreted in different terms in the different scientific fields which may formally make an *indirect transfer of knowledge admissible.*

A significant and important example is the *maximum-entropy principle.* The maximum-entropy principle is one popular formulation of the second law of thermodynamics and was derived from physical observations in statistical mechanics subject to additonal assumptions such as ergodicity and equal a priori probabilities.

We can, however, *assume a philosophical statistical approach* and consider statistical mechanics as a form of statistical inference rather than as a physical theory [6]. The maximum-entropy principle is a universal logical principle according to which the best estimate that can be made on the basis of the information available is that which is maximally non-committal with regard to missing information. It is the least biased estimate possible for a given set of information [6].

Let us consider a stochastic variable X that can assume the values $(x_1, ..., x_n)$ with probabilities $(p_1, ... p_n)$ and denote the corresponding distribution function by $F(x)$ and a quantity that would reflect the uncertainty inherent in $F(x)$ by $H(p_1, ..., p_n)$. For this measure to be unique (within a constant factor) and consistent only the following three conditions are required [7] :

— H is a continuous function of the p_i.

— If all p_i are equal, $H(\frac{1}{n}, ..., \frac{1}{n})$ increases monotonically with n.

— The composition law is fulfilled.

$H(p_1, ..., p_n)$ has the property of measuring the uncertainty or missing information inherent in the distribution $F(x)$.

$H(p_1, ..., p_n) = -k \sum_{i=1}^{n} p_i ln p_i$ is exactly the same function used in statistical mechanics for measuring the entropy.

The *identity of H in thermodynamics and information theory* is not only formal but *a consequence of the same logical concept.*

The concept of maximum entropy, also known as Jaynes' Principle of Minimum Prejudice, takes care of the following — often overseen – fact : " It is obvious enough that failure to take into account all the available knowledge relevant to a problem could be disastrous ; failure to recognize frankly the full extent of our ignorance, and to take this ignorance explicitly into account, can be just as disastrous " [8]. Since the maximum entropy concept provides a constructive criterion for setting up a probability distribution on the basis of partial knowledge it is useful for practical application and can be used for example in fields like communication, engineering [8], asset depreciation [9] and insurance [10]. It can also be used for the explication of observed phenomena [10].

We have now mentioned the existence of a universal logical principle which can explain phenomena in different fields by considering these fields as forms of statistical inference. Via this universal logical principle a special transfer of knowledge from physics to economics may be admissible.

If we consider knowledge in physics and economics as a *consequence* of a universal principle we call the " transfer of knowledge " from physics to economics via this universal principle *indirect*. It is actually no transfer of knowledge but realizations of the same universal logical principle in different fields. If we would not realize the source of these fields of knowledge we could subjectively speak of a transfer of knowledge. We could, however, not know then that this " transfer " is indirect and possibly admissible.

4. Some features of the influence of insurance on economics

The economy embraces the primary, secondary, and tertiary sectors. We shall now give attention to certain secondary products (industrial products) and tertiary products (insurance services).

If we concentrate on *one industrial product* on the market, the forces of supply and demand will establish a price. After a time of balancing out the demand (dynamic phase) the price will remain unchanged (*static phase*) if the demand for the product does not change, if the competition agrees to its share and does not try to gain ground by reducing the prices unreasonably and if no new and more attractive competitive products come out in the market. Such prerequisites are more theoretical than realistic but over the long run they may nevertheless hold for some time. For the period of time during which they hold after entrance into the static phase we can speak of a conditioned static period (conditioned to the prerequisites above). The more frequently the economic situation, the quantity and velocity of the money circulation, the inflation, the rates of exchange (for products sold abroad) fluctuate and the quicker new technologies develop, the shorter the conditioned static period for industrial products will become.

The momentum of these phenomena and their influence on the economy can neither be predicted nor totally controlled. In fact it is questionable and a matter of relativity whether phenomena like inflation are controlled by humankind or vice-versa and this remarkable statement seems to be correct (with different degrees of influence) independently of the socio-economic system.

The exogenous factors that influence the static phase seem to have steadily increased their speed of fluctuation since the Industrial Revolution and to have decreased on average the conditioned static period for most products. The increase of the dynamics in economics we can observe is more pregnant in the secondary than in the tertiary sector. It becomes more and more vital for the producer in the secondary sector not only to observe his competitors but also to keep well informed on new technologies in his branch and to constantly develop new ideas and new competitive products. The pressure to keep well informed on new developments is for the producer, of course, much higher than for the consumer, but the latter will also spend time gathering information on products he wants to buy in order to best utilize the money he spends.

A consumer will, with high probability, neither change his character nor his wealth to an extent that will drastically change his behaviour and way of life. His behaviour may usually be described as static and he usually has the urge to remain in a static phase which is characterized by security.

There are two groups of people who do not wish to remain in the static phase : the people living in poverty and those who are never satisfied with the state they have already achieved. The latter group is often characterized as " dynamic ", whereas the former group usually tries to achieve an acceptable static phase of security.

The static phase is usually more stable and of more permanence and longer duration for the consumer than for the industrial producer. But the consumer's security can be shattered by family events (marriage, divorce, births, deaths) or by random events. One of the greatest and socially most important tasks of the tertiary sector is to keep the consumer in his static security phase in times of no special events (e.g. wealth should not be eaten up by inflation or otherwise, due to bad or no investment) as well as in times of special events. Keeping the consumer's security in times of special random events is an obligation of the state and/or the insurance industry to which we now want to turn our attention.

Insurance companies are helping to keep an individual or his family in a static security position in reality as well as psychologically by covering different kinds of special random events that may reduce his wealth and/or income. If such a random event strikes him, he is remunerated to a degree agreed upon in advance. The remuneration should keep the individual or his family, at least economically, in a static security phase, irrespective of the kind of covered event and the related amount of cover involved.

By offering and giving such covers that compensate or at least mitigate possible random buffets of fate the insurance industry accomplishes a most important psychological as well as sociological task. It reinforces the static (security) feature in the life of an insured person compared to the dynamic moments that he wishes to avoid and over which he himself has no control.

In order to fulfil such tasks the insurance company must also be able to guarantee that it fulfils, practically with certainty, its obligation at any time, irrespective of the number of claims and the levels of amounts to be paid during a short period of time. The consumer is not only protected by his insurance company's reserves, portfolio distribution, reinsurance cover, etc., but also by the supervisory authorities of the state which ensure that the insurance company follows all the regulations set up by the state for the consumer's protection.

The insurance industry offers not only the consumer but also the producer certain covers like property and business interruption covers or, also in favour of the consumer, products liability covers. However, the professional risk carriers have their own limits of insurability of risks and can usually offer producers only a smaller relative decrease of their total uncertainty than consumers.

As with guarantees the insurance industry intensifies with its services — which we interpret as special tertiary products — the static compared to dynamic features of secondary products for consumers as well as producers [11].

Actually external regulations and internal rules force an insurance company to offer producers a reduction and consumers to a large extent a removal of increasing dynamics and uncertainty due to the effects of exogenous economic factors mentioned earlier. Examples of such rules are:

1) The state often prescribes to a certain extent how the insurance company's reserves should be invested.
2) In the European Common Market there exist rules prescribing a minimal solvency margin for property/casualty insurance companies.
3) Premiums are fixed in life insurance for the periodical payments (e.g. annually, quarterly) once the contract has been signed.

Insurance not only operates against increasing uncertainties and dynamics; in many economic branches it also contributes by its very nature, as we shall see, to increasing competitiveness, resisting existing tendencies toward monopoly. In different cases insurance contributes, therefore, to natural (not enforced) equilibrium (an equilibrium between statics and dynamics, between certainty and total uncertainty, a competitive market equilibrium) resisting extreme economic solutions (exclusive dynamics, total uncertainty, monopoly).

Let it also be mentioned here that insurance activity represents an interesting equilibrium between supply (premium) and demand (claim) over an uncertain period of time [12].

In an insurance cover the insurance company may put its capacity at the disposal of producers and independent professionals. Covers like products liability may enable and encourage producers to risk production and sale, thus increasing competitiveness, and covers like professional liability may enable, for example, medical doctors or lawyers to open a practice supporting free enterprise and free professions.

By putting its capacity at the disposal of its ceding companies a reinsurer enlarges their acceptance possibilities and the number of potential risks that they are able to cover [13]. The existence of reinsurance capacity enables small insurance companies to compete with large ones, also in the coverage of large risks.

We conclude that insurance and — to an even larger extent — reinsurance contribute by their very nature to increasing competitiveness and to resisting the tendency towards monopoly. This contradicts the physical law observed in the experiment with the soap bubbles in the last chapter. It also contradicts the transfer of this experiment's thrust to economics which predicts a tendency towards managerial, monopolistic capitalism, a view taken by many economists [14]. Cairncross writes for example that industry may evolve monopolistic forms without control of public policy [15].

If an economy wants to prevent the development of monopolies in different economic branches without introducing too many control instruments it will welcome the natural contribution of insurance and reinsurance to competitiveness. This property of the insurance industry will on the other hand not be welcome to a government that wishes to monopolize the economy partially or totally by nationalization. The insurance industry is in fact one of the economic branches most exposed to nationalization.

The sound conduct of the insurance and reinsurance business requires an extensive distribution of risk capacity over many mutually independent risks. This requirement often leads, especially with regard to reinsurers, to a geographical distribution of risks beyond national borders, thus supporting the development of the world-wide economic interrelations which we called in chapter 3. the second chain of interrelations.

In contrast with chapter 3. we do not now assume a philosophical statistical approach for deriving the maximum-entropy principle and consider statistical mechanics as a physical theory rather than as a form of statistical inference. As is usually done, we interpret entropy as a measure of disorder, whereby the second law of thermodynamics asserts that the disorder of a closed system is a non-decreasing function, i.e. the entropy is not decreasing with time. Since the general economic development is not a realization of the universal logical principle called " maximum entropy principle ", a general transfer of knowledge from thermodynamics to economics is not admissible. We wish however to *translate* the measure of disorder and the second law of thermodynamics to economics.

The only closed economic system is the global economic system. Every subsystem such as national economies, economies in a certain economic branch, etc., has an interaction with other subsystems and can never be completely separated from them. It can, therefore, never be totally controlled and planned with certainty. *Economic disorder* varies inversely with economic power concentration and increases with increasing economic interactions between subsystems. By contributing to world-wide economic interrelations insurance increases economic disorder. By resisting the tendency towards monopoly, i.e. economic power concentration, and by increasing competitiveness insurance/reinsurance is either resisting a decrease or supporting an increase of economic disorder.

The more equally energy is distributed over particles in a closed system the higher are entropy and disorder. The task of insurance is to distribute the consequences of risks over the insured population. By doing so it again increases economic disorder or " economic entropy " respectively.

Last but not least, the second law of thermodynamics states that by reaching the maximum possible entropy, the universe would arrive at a " death of heat ". Equally distributed energy with no potential drop would not allow for any activity, for any action. Analogously, a completely static economy which would allow for no activity of development would mean an " economic death ". On the other hand exclusive economic dynamics which allow for no static rest whatsoever would mean an economic blow up.

We have seen that the special tertiary products called insurance services increase the static as compared to dynamic features for consumers and producers thereby increasing the " economic entropy ".

Contrary to thermodynamics no clear-cut tendency towards an increase of " economic entropy " exists on the basis of the world-wide economy, which is the only closed economic system. Some economic forces support the increase, others the decrease of economic disorder.

As we have shown insurance is supporting on different levels by its very nature the increase of an economic disorder, of economic diversity and variety and contributes to balancing out equilibria and resisting extreme economic solutions.

5. Insurability and uncertainty

There are risks that can not be insured and therefore there exist limits of insurability of risks of professional risk carriers. Where these limits lie has been studied as well as where they should lie and how they can be changed [4].

When an insurance company fixes its business policy and thus directly or indirectly its limits of insurability it must always think of keeping the stability required for the safety of the insured and prescribed by the authorities. Moreover, the insurance industry in fact guarantees the fulfilment of important social accomplishments and is for the population an anchor of trust in the free market economy. We encounter here an apparent paradox : *The insurance company's paradox :* The business of an insurance company is to take over uncertainties, called risks, for premiums. Out of the *risk acceptances* it is required to *build up* the required *stability.*

Is the fulfilment of this paradox possible ?

Reality proves that the answer is yes and the observation that the stability of a company usually even increases with a growing number of risk acceptances even intensifies the supposed paradox.

The paradox is not a real one but a *pseudo-paradox*, and the fact that with an increasing number of expected claims a professional risk carrier can decrease the expected fluctuation of his technical results relative to his premium income, i.e. increase his stability, is like the maximum-entropy principle in chapter 3., the consequence of a universal statistical principle.

If the risks in the portfolio are mutually independent and identical we can apply the *law of large numbers* [16] directly as a statistical inference to prove that by a transfer of a risk *both the insurer and the insured can improve their stability and reduce their uncertainty.*

This statement is correct with respect to the insurer whenever it can reduce its net portfolio's expected standard deviation in relation to its net premium income (after administrative, reinsurance and other costs) by accepting new risks (which must neither be identical with nor independent of the risks already included in the portfolio). The universal principle which we apply here we may call the *principle of relative risk reduction.*

An insurance company can only make use of the universal statistical principle that leads in a special case to the law of large numbers — and increase its stability — by reasonable risk-portfolio selection (cumulation control, sufficient mutual independence and claim frequency of the insured risks, capacity control, etc.) and by a reasonable premium policy (no underrating, etc.). The law of large numbers can also be applied in physics to experiments the outcome of which is random and can be repeated again and again.

As in the case of the maximum entropy principle we have here different realizations of the same universal principle (law of large numbers) which we called in chapter 3. indirect transfer of knowledge.

The principle of relative risk reduction relates to the *objective* point of view of uncertainty (independent of subjective risk assessments) and is the *main reason* for the *possibility of insurance to exist at all.* It is an important reason for the *advantage of distributing risks.*

The idea of distributing the risks of individuals over a community that can carry them better by risk exchanges is very old and was already realized in practice thousands of years ago. In. M. Slae's book [17] we read : " The history of insurance, from Halacha sources, dates from the Talmud (Baba Kama 116 b), therein being described as a system of mutual insurance in practice among donkey drivers on caravan."

The question arises whether uncertainty can not be totally eliminated by going on and on distributing risks via insurance, coinsurance, reinsurance, retrocession, etc. The answer is theoretically as well as practically no.

There exists only a limited number of risk carriers who have only a limited time for placing and " atomizing " a risk. The relative uncertainty of every insurable risk and of all insurable risks can be reduced via distribution for every participating risk carrier but it can never be eliminated. The uncertainty of every producer and consumer consists of insurable and uninsurable risks, and the uncertainty inherent in the uninsurable risks (e.g. taking certain decisions in conflict situations) the respective individual has to carry alone.

From a practical point of view we can state that an upper limit of distributing a risk is achieved when the costs of any further distribution would surpass the advantages gained through further risk reduction by further distribution.

Finally we wish to point out that the universal principle of relative risk reduction upon which insurance activity is based also enables the insurance industry to meet future requirements by releasing cover capacity. If an insurance company fixes for example its probability of ruin and reduces that probability by reasonable portfolio selection and expansion, reasonable reinsurance and rating policy, it has at its disposal additional cover capacity which can be used for new covers as long as the fixed probability of ruin is not reached [4].

Since the risks and the requirements for cover are steadily increasing with the techonological and social development, with the increasing frequency of economic fluctuations and decreasing duration of macro-economic static phases, release of capacity of insurance companies may be used to meet the requirements of the public for increasing amounts of risk cover and for the cover of new risks which were unknown in the past and on which no experience exists.

The more cover capacity an insurance company can release and the more it can expand its " area of insurability " due to a reasonable risk acceptance and reinsurance policy [4], the better it can meet the cover requirements of the public and the better is can fulfil its tasks.

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