A systemic approach for risk analysis (in insurance)

by Werner Furrer

Preliminary remark

The author has developed the present concept about risk assessment, particularly in insurance, as a contribution for a working group of the insurance supervisory services of the member states of the European Union, when he was himself responsible for actuarial matters in a national supervisory authority and a regular member in working groups on insurance matters of the EU-commission.

The report of the working group was published in 2002. The publication of the present paper has been authorized by the chairman of the group.

1 Summary

There is nothing more practical than a good theory

Einstein

Internal and external supervisory activity of an insurance company has sometimes been too much concentrated on single isolated aspects of the various risks, which may threaten the financial stability of an insurance company. We suggest the *systems method,* to bring the various elements into a more coherent picture, briefly showing the concept here. The systems method is not aimed at substituting well established scientific procedures and those of good bureaucratic practice, but to integrate them.

The systems method allows, to coin precise concepts and to classify risks, as shown in a first step. The definitions should be valid in any context, where risk is a topic, the first two chapters deal with the term risk in general. In the last chapter we demonstrate the systems method as a tool to analyze an *insurance company* within its environment. The author has developed this paper for a working group of the EU-commission.

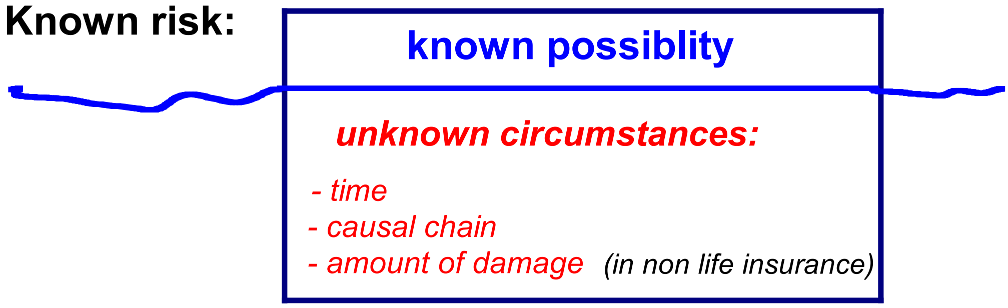
2 Definitions

2.1 Risk of an event: Known and unknown information

We define to be a ***known risk*** the *possibility of an event or a class* of events, which turn out to have a different result from the „normal, expected, calculated“ flow of events and which would have a notable damaging effect (financial and/or other) on the person(s) exposed to the risk.

Unknown of the risk may be, whether *it will happen at all*, to what sum of money it would *amount*, such as the damage to a car. Or uncertain may be the *time*, when it will occur, like the inevitable death of a person. Only known risks can be treated by insurance. We know of the *possibility what could happen*, but not the exact circumstances under which it would happen.

Metaphorically we can compare this relation between known and unknown information with the often quoted iceberg, of which the part under the waterline signifies the unknown information, as illustrated by the following graph:



Even if we don't know the exact time and the fatal mechanism of the causal chain, we may determine a relevant time horizon, possible types of mechanisms and a geographical area, where a specific risk is located or enhanced.

It may be a useful and rewarding task to bring some of the unknown data to light, to analyze a type of risk and thus perhaps reduce its potential. This work will usually be done by analyzing past events of the same type or thanks to some realistic imagination and may be with the help of simulation. Owing to a special attention towards a specific event, it may perhaps be diverted if recognised in time and fought with appropriate means. This task lies beyond the scope of the present article, except for the type of risks that are a threat to the functioning of an insurance company. Nevertheless the general single event risk can be tackled by the system's methodology as well. Sometimes we have to distinguish the psychological attitude of *risk awareness* from plain knowledge, which can exist in theory but isn't present in our mind. A step further in the field of psychology is the *risk attitude* of the responsible person, which can vary from the adventurous individual who enjoys a risk by itself from an over cautious attitude which in its extreme can end up as a risk in its own right.

Our definition is valid for the *quantitative version* of a stochastic risk ex post, which is the ***difference*** between the *expectation value* of a theoretical probability distribution, considered to be valid for a *series of comparable events* and the *effective resulting average*. This latter definition is obviously only valid for someone, for whom such a series of events has any meaning, such as an insurance company, but untypically for an individual.

The ***loss amount*** is equal to the difference between the expectation and the effective result. It could be of positive value and various types of „positive risks“ may be treated the same way as the risk of damage, but not in every context. An insurance company e.g. has no claim to the profit of a policy holder, but it has to cover his losses as agreed in the contract.

2.2 Risk evolving processes and the risk bearing environment

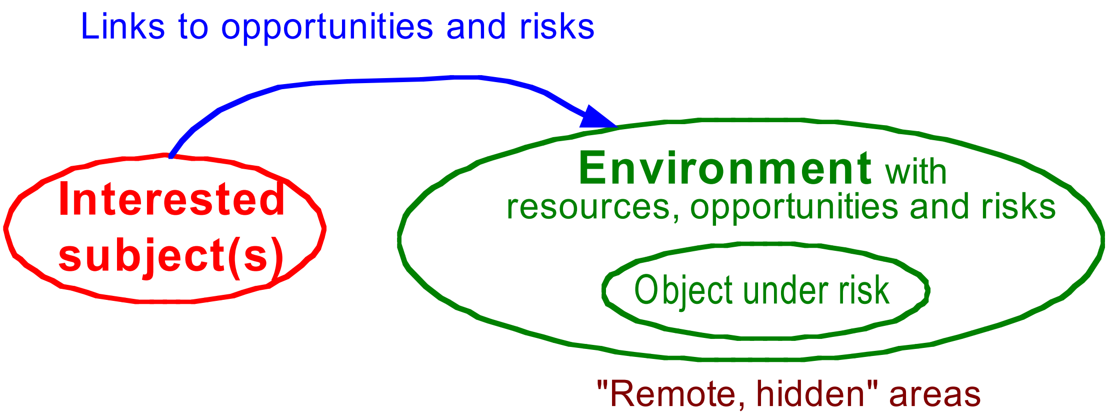
Our world is the result of processes causing chains of other processes, slightly over exaggerated it "consists" of processes. To understand or even better to control a process is all about causality, but we hardly ever understand a process completely, leaving always part of it to chance - chance bearing risks. Science tries to uncover the laws of causality in nature and in our social environment. They may be applied, if we try to describe a model of a specific process.

Whenever we talk of risks (actually whenever we talk of anything!) it has to be made clear, ***who*** is/are the involved parties, who is exposed to which risk(s) and how can/should he deal with it.

We perceive the completion of a process, its effect as an *event* - an *accident* or *damaging event* on the *object under risk* in case of a risk fulfilling process, damaging some or all of the objects properties, as described below.

The type of event, possibly the processes leading to them offers a convenient basis to classify risks. Sometimes we want to identify subclasses as well by distinguishing an additional quality of the risk evolving process or the event leading to it. Thus we may have to distinguish death by accident from natural causes as a criterion for an insurance contract.

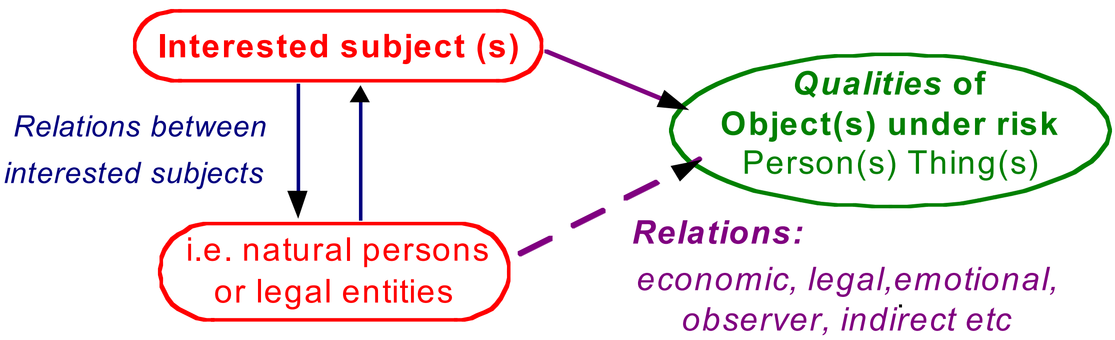
By definition we call the area where risk processes evolve, the *environment* of the object under risk.



The interested subject may detach himself from certain types of risks – from the risk bearing environment - at least partially. But the resources and opportunities, e.g. the use of fire, lie exactly there as well.

2.3 Whose risk? The interested parties and qualities of objects under risk

For some type of risk the "object under risk" is the subject himself, but often there are other subjects involved as well. We distinguish the abstract ***subject*** from the ***object*** directly under risk, an object, which is related to the subject, e.g. by ownership like a car or by other *types of* ***relation***. We want to visualize this principle with the graph below:



For an insured risk there are always at least two interested „subjects" or „parties" [1], the insurance company and the policy holder. With the usual

[1] „Interested, involved party" may be a more familiar term in insurance, „subject" is the technical term of the systems methodology.

reinsurer we have already a third party and often the policy holder is not identical with the beneficiary - may be more than one, all of them interested subjects too.

The „quality of an object under risk“ can be a person's life or health, assets of a firm or an individual, or a *useful process*, e.g. of production etc. The "supreme quality" of an object is its very existence as the life of a person.

An economic relation will usually imply at the same time a legal one and possibly an emotional one too. Relations between a subject and an object as well as the ones between interested subjects can be qualified as „economic, legal, emotional“ etc.

Between a subject and an object the typical relation is „ownership“, at the same time an economic and legal term. Several interested subjects may be bound by a contract, e.g. a policy holder and an insurance company with the consequence of various benefits and obligations for all the involved parties.

2.2.1 Friendly, useful and antagonistic subjects

At worst, in an antagonistic situation another interested subject is our enemy, a threat for us, for our object, because the enemy expects our loss to be his profit! There are more subtle antagonisms than the one between an owner of some property and the thief of it. The policy holder and the insurance company normally share the goal to reduce a risk. But if damage has struck, they may disagree about the obligation, whether the company has to pay!

The "interest" of a subject is to avoid a loss or to win a benefit. In an analysis of the *subject's role* we have also to make clear, what his competences, capacities and responsibilities are, how an involved person can and should act towards a recognized risk. Periodically interested subjects may control – themselves and or each other – to which extent they have fulfilled their obligations.

The role of whomsoever – whatsoever subject – involved with the object, e.g. with an insurance company, can be judged at any given event or transaction as *useful or somewhat detrimental* by either his negligence or incompetence, by a deliberate, but legally correct antagonism or by fraud. Usually the importance of an actor, the prominent villain, changes from scene to scene, which requires us to redirect our attention every so often.

For special purposes we can examine the (social) „system“ of several interested subjects, where each of them is an „element“ or a „component“ and is connected to other subjects by legal, economic and/ or social relations, some cooperative, others perhaps antagonistic. With the term "subject" we can also refer to an organised social body of cooperating individuals like a company or a department of it, the board of directors and so on.

The typical relations – interaction - between the members of such a social group are the *exchange of information*, including opinions and directives.

A supervisor may be quite neutral about many details of the whole process, but to understand it better it may be useful, that he tries to identify his thoughts with the position of other more directly involved subjects, look at things from a different perspective and thus change his observer-relation.

2.2.2 Classes of objects defined by properties[2]

An object is defined and recognised by its ***properties***. The *damage* in consequence of a risk would be *produced by a process*, which changes an important property or on the contrary distorts an expected beneficial change, may be one, which has been deliberately organised.

Classes of objects, defined by its characteristic properties as "homogenous" and subclasses, each with at least one more defining property are the basis on which we perform statistics. Statistics is a paramount technique to describe risk behaviour on whole classes.

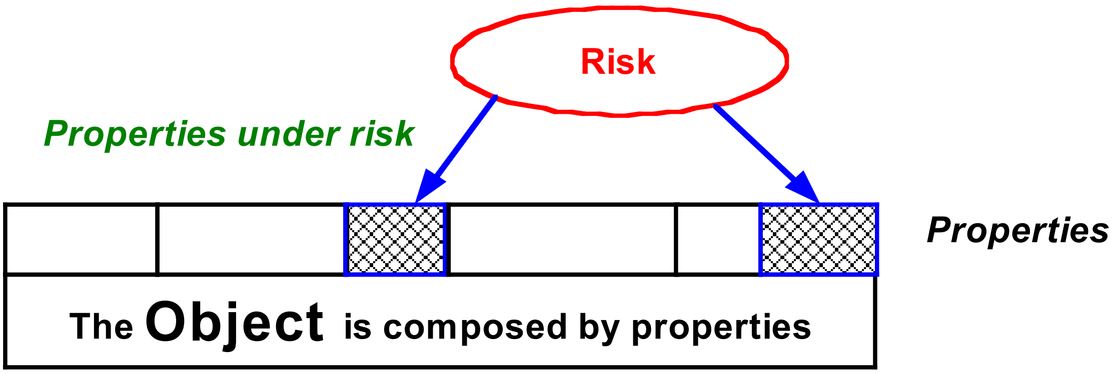
[2] This chapter may be skipped for the reader, who isn't up for too much theory.

Each relevant property or a combination of such - out of whatever collection of objects - performs in the normal situation a *useful function*, which is destroyed by the damage.

Properties of a certain type are grouped into a ***variable*** and according to the type of variable results a definition, as of what is „normal“ or „disturbed“. There are binary variables with the values yes or no (true or false), dead or alive pregnant or not etc. To specify the values of qualitative variables, like „colour“, „shape“, „material“ we have words. Further there are scale quantitative variables, discrete quantitative variables to specify an amount and continuous variables, like „length“ or „money“. We define the normal state either by naming the accepted properties or with an interval of tolerance, outside of which an object is damaged.

What the actual, relevant values are has to be *ascertained* by an appropriate measurement or by the judgement of some competent subject - an „interested“ subject? - yes if it professes the neutral interest to find the truth. Besides it is legitimate that each party assesses its own version of „truth“.

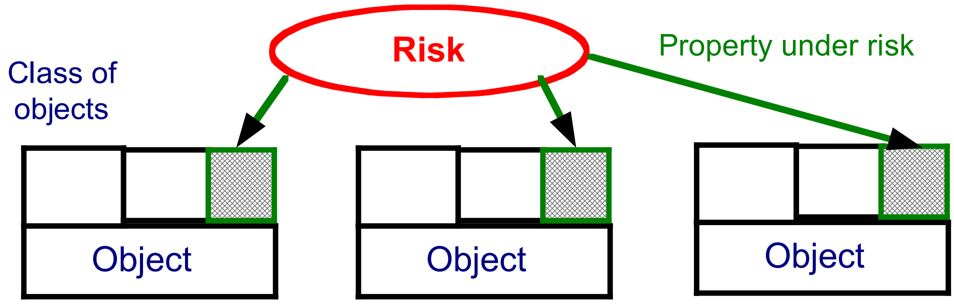
The following graph may emphasize the connection between an object and its properties under risk:



The risk of a car accident is a threat to the physical integrity of the car, i.e. to the wealth of its owner and more so by a possible third party liability and worse yet to the physical integrity of the drivers body and to that of the passengers or of other concerned persons - „properties“ of the involved objects - as we may formalize. It is a matter of how we construct our system (of thoughts!), whether to name the owner to be „object", or his economic existence or rather his car.[3]

We may distinguish the risk of a single adverse event from a collection of such events, which are *generated through a stochastic process*, the ones which make up the business of insurance companies.

A ***type of risk*** refers to a *type of object.* A set of its properties - may be just one - define a ***class of objects*** on which we can perform statistics, if possible for each property separately, e.g. the damage to a car separate from third party liability.



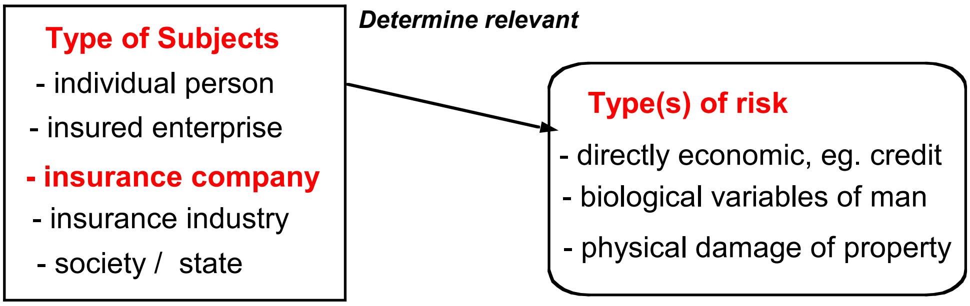
A class of objects of the same type of risk are thereby grouped together and since the comparable events, which produce them - the „risk process" - can be analyzed and calculated with the powerful tool of mathematical statistics, they become a topic of insurance, which allow that an interested subject may transform its individual risk of a great financial loss into a sure, but comparably modest expense.

The business of an insurance company is to bear the financial side of other peoples risks, if at all possible, without risking its own existence, but rather to make a profit out of this business. The industry has developed appropriate techniques to fulfil this purpose. It nevertheless runs the risk to miscalculate the stochastic process on which it takes premiums and covers losses or to miscalculate one of the many other factors of its business.

[3] Our construction implies a direct relationship between the interested subject(s) and the risk, which is a special case of the general systems concept „subject(s) related to a ***problem***".

One could almost say, that anything, which is considered to be a risk for an individual, for a company or for society as a whole, is a potential topic for the insurance industry.

Each subject, be it a legal entity or an individual, will be related to *various types of objects under risk*, for an insurance company systematically so. We may however want to distinguish various classes of risks, each of it related to an appropriate class of objects, as indicated by the next graph:



Our list of relevant subjects and the one of types of risks are by no means complete or in any way authoritative. They just have to illustrate the methodology. The central type of interested subject we study here are *insurance companies*, or preciser one single company under our supervision after the other. Relevant for a specific company are the risks it offers to clients according to the classification determined by the EU-directives. This official classification won't prevent an insurer to establish his own concept for tarification, marketing and administrative purposes.

3 Risk Management: Recognise risks and optimize them

If something can go wrong it will, if nothing can go wrong, something will go wrong

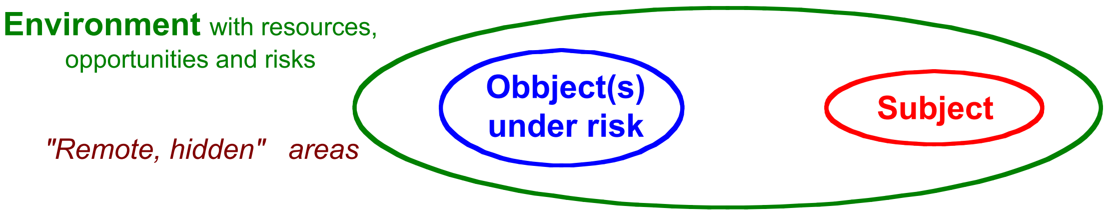
Murphy's law

3.1 To recognize risks

To become a known risk it has to be recognised by the interested subjects, in particular cases by someone acting on behalf of the centrally involved person, like the guardian or parent of a child, to a certain extent the insurance company for their clients and the state by way of social security etc.

Risks are a threat to a subject's „resources", may be to a useful process or an „instrument", means of production etc.

I.e. the risks for a subject lie beneath his opportunities. They are found in his „***environment***", in the physically close zone, among the often used objects and those prepared for later need, like a fund to finance a person's old age. This idea may be illustrated with the following graphic:



Similar attention as to the obvious risks a subject may have to pay to the more „remote" elements in his environment, remote in space, time, frequency, less obvious, more hidden for his perception. For a less probable risk the chance is equally smaller, that we will be aware of it. Everybody realizes the danger of a sunburn in the Sahara desert, but it is much less known that in certain years more people die there from being drowned by an occasional flood in the Wadi gorges, than by thirst! According to some statistics a holiday maker at a tropical beach runs a higher risk to be struck dead by a falling coconut than by the attacks of sharks!

Beyond such anecdotal illustrations we remember, that a risk with little probability, but a high potential of damage has the same expectation value as cases of higher probability and a lower potential of damage and thus these cases are more or less equivalent for the calculation of premiums.

To find out about our risks or about that of other subjects we first analyze the *normal functioning* of the world around us, as we use it and partially have created it for our convenience. Every single mechanism in our environment or at ourselves, on which we depend, presents the risk of a serious failure. If we know these mechanisms, we know where to search for risks.

The technique to construct models as presented in the last chapter should serve as a tool to analyze and understand reality.

3.2 Optimizing Risks: Recognize, analyze and take action

With risk management a subject assesses regularly his actual pending and possible future risks, a task that every decent individual will have to perform from time to time.

At first thought it might be obvious, to „optimize“ risks means to „minimize“ them, to reduce them as much as possible, and certainly in many cases a great potential of reducing risks is thoughtlessly wasted. Nevertheless there may be decent or at least morally and rationally acceptable reasons, not to reduce risks at any price – e.g. reasons of costs.

For a person it may sometimes be a challenge of life to run willingly certain risks, hoping for an economic benefit out of such venture or perhaps to avoid an even worse risk, not to speak of the various possible emotional fulfilments some individual expect in reward.

Strictly avoiding considerations of feelings an armada of specialists analyze the risks of their clientele. As already mentioned, an insurance company runs a deliberate and calculated risk as a form of business.

A systemic and systematic procedure of risk management will include the following steps:

- *Recognize* single risks and may be *complexes of related risks*, recognize particularly how they *change* perhaps *increase*, come up again or may have disappeared.
- *Analyze* each risk in its own right and analyze the complexes, „systems“ of related risks, particularly, whether some of them could have in their combination a more than additive, but accentuated effect, whereas others may offer themselves for a trade off, i.e. a free choice, whether we prefer one risk rather than the other. Surgery, like almost any type of medical

treatment, always implies a certain risk but will hopefully end an otherwise long enduring agony.

Analyzing a recognized risk means to search for *possible causal mechanisms*, which can trigger an accident. There is combustible material on stock. How much heat will spark off a fire?

- Develop and apply *principles of action*. First we need a method to monitor the total of relevant risks and then we have to *allocate the means*, „whatever is reasonably necessary“ or perhaps a maximum available for security in concurrence with other purposes. Sometimes we can select the acute time and other circumstances under which we are exposed to a risk, such as to have done surgery.
- The decision maker who can choose between alternatives will prefer the one with the least damage or with the highest benefit – for himself interested subject of course - provided he can calculate these values, particularly if some of them are non monetary.

Again this decision maker is perhaps a group, a system of individuals, where each one will struggle and compete, to achieve for himself the most out of conflicting interests. Or may be they achieve a common solution, a compromise to integrate an optimum of the conflicting interests. There is a broad field of theory and of practical experience for any of these attitudes, competing, conflicting or rather cooperative, and we even find, seemingly contradicting, quite often some ambivalent combination of all of them.

3.2.1 Risk classification by the interested subject

For a first simple taxonomy we distinguish as main characterizing properties “objective”, external risks from “subjective” ones, the former those beyond the person’s control, the latter expressing some deficiency of a responsible person or social body. An interested individual may secretly or subconsciously sympathize with a risk, respectively with being a victim of it due to some benefit like an annuity for some otherwise bearable damage, e.g. invalidity.

Risks can be further distinguished by the type of relevant environment - nature, economy, technology - as later explained in more detail. A taxonomy on a scientific or practical basis will predominantly deal with the objective "external risks".

For most distinctions there are overlapping possibilities, even for the subjective and the external risk beyond an individual's control. If he acts properly he may perhaps avoid them or reduce its potential damage, provided he receives the necessary information in time.

We suggest the following **criteria to classify** risks:

a) By the type of ***risk evolving process***. The risk evolving process happens as a fatal interaction between the object under risk and its environment. In the classic sense of life insurance this is mainly the evolution of mortality and other biological processes. The risk of the company in this respect is to deal inappropriately with the stochastic basis of these processes.

b) By the ***organisational unit*** within a company, whose inappropriate work could *cause* a risk evolving process and the ones, responsible to *recognize* such a process and initiate action.

Ideally type a) and b) overlap, if each type of risk is handled by its assigned organisational unit. Like in all type of business it may be valid to distinguish at some point *strategic* and *operational risks*.

As main categories of a subjective risk we propose:

-insufficient information

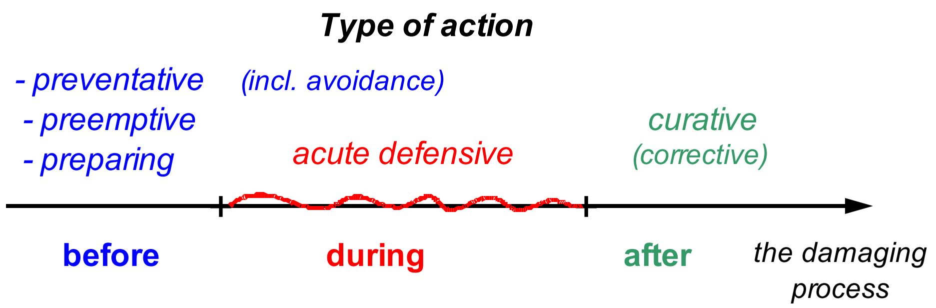
- inappropriate judgment

- inappropriate action by the responsible decision maker himself or by some executive institution.

To analyze the damage with the clear information of hindsight can be useful for future action and is sometimes used for too easy moralizing.

3.2.2 Preventative measures and risk reduction

If we call the damaging process the „enemy“, even if in case of blind nature „she“ doesn’t know of her role, the measures to fight a risk can be classified *according to the time and moment* they are put into action - before, during or after the damaging event:



To have sufficient assets is a measure of prevention, whereas investments after the event to cover losses, would be curative.

With “prevention” in its strict sense versus “avoidance” of a risk the subject actively creates his risk free or risk poor environment, he prevents a destructive, damaging process even to start, whereas by avoidance he steers clear of risky situations and environments. Again a sound behaviour typically combines both attitudes. In systemic terms we try to shield off the object under risk from the threat, or more metaphorically move it to a less risky zone in the environment.

That prevention should always be preferable over every other strategy is sometimes too common wisdom. In business as in life we often don’t have an easy choice between a cautious preventative and a risky behaviour, instead we have to walk a tightrope.

Preventative measures are ideal, if they are *available at reasonable costs* and if we have sufficient knowledge about the risk and enough power to follow our concept. We use non inflammable material and don’t enter the sea so as not to get drowned or bitten by a shark, which shows also the possible problems connected with this type of strategy: We forsake the pleasure of swimming, generally speaking, in terms of economics, a benefit. Prevention has its price and sometimes bears specific risks by its own, like e.g. vaccination, which for a minority is the very cause for their fatal end. If an insurance company sets high prices, it may seem to be a prevention against losses, except that it could run out of business due to competition.

With a pre-emptive strike – a form of prevention - we actively destroy or at least disturb the threatening component in the environment, before it harms, we kill the sharks, even before they have the chance to become a threat, clearly not very healthy for ecology. With an equally dubious morale a state will rage war against another one to be first.

The big realistic issue, which can be considered a more general concept than its subclass - strict prevention - is often not to prevent a risk totally, but to *reduce* it, its probability, its amount or both, in one word its *expectation value*.

If we can argue on strictly economic terms we have to *minimize the sum of the expectation value of damage and the cost for risk reduction* (possibly prevention), of course a very theoretical concept. If we don't trust the validity of our calculated expectation values or for ethical reasons, we may rate the risk with a higher weight ω, than the effort to reduce costs, so that we come up with the following goal formula:

MINIMIZE(costs_for_risk_reduction + ω*Expectation_value(risk)), $\omega \geq 1$

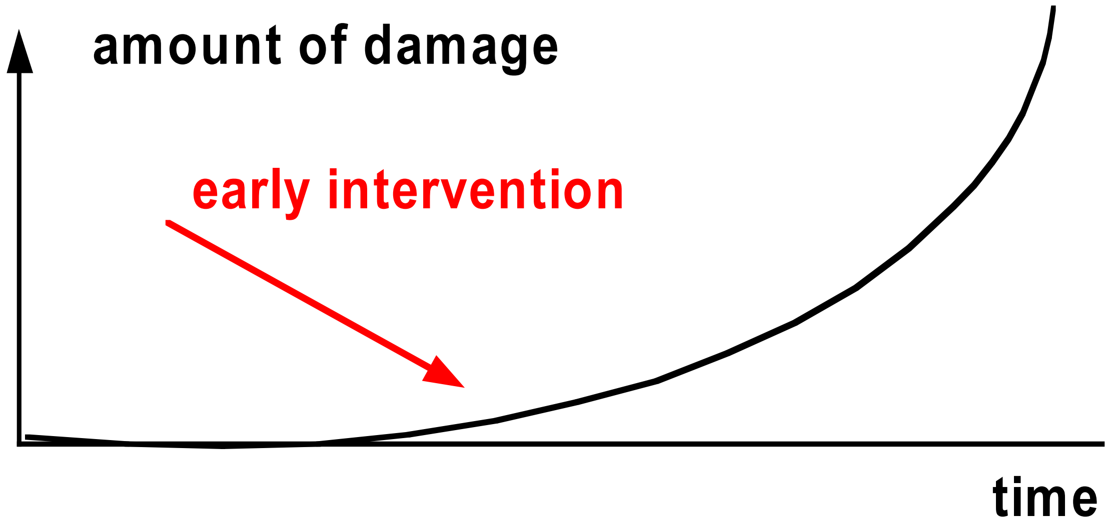
The greater ω, the more importance it gets in our calculation.

Adequate motorways reduce the probability of an accident, seat belts and air bags the possible amount of damage. Of the same type of preventive measure - reducing the potential risk - is the „risk transfer" through insurance, available for an insurance company too by means of reinsurance.

On almost every issue an insurer and its clients share a common interest for risk reduction (the longevity risk in annuity contracts being one of the few exceptions) and therefore will be inclined to cooperate.

Acute defensive is the work of the fire brigade, of the emergency medical service the airbag in a car and may be of the army. They will only work efficiently if set up in time and maintained properly like the supervisory authority for that matter. The need to be prepared in time is also valid for the various types of curative repair services, again a preventative strategy to reduce a risk, like the long term medical services or a garage for repairing a car to buy a new one so as to replace the destroyed resource.

One aspect of preparation is to *develop strategies* how to fight a damaging process after its outbreak. A first act in such a scenario will be to recognize new developments, may be thanks to an *early warning system* set up to observe permanently or in sufficiently frequent intervals a delicate environment, diagnose the hidden manifestations of a disease after its outbreak. Some type of medical disease and equally fire or sometimes war, have an escalating course, which may be slow enough, that an *early intervention* – second best to prevention – can squeeze the destructive process with limited effort and save the object from major damage, as illustrated by the following graph:



Unlike in medicine to make recover an insurance company, there is just one universal *curative drug* – money (though you may argue, that in medicine too, this is exactly the same underlying magic potion of whatever treatment, the universal form of “energy” to carry out whatever economic activity!). Having the necessary funds available, we have decide about an appropriate therapy. Who is responsible to spend how much on what operation for recovery to repair which component of the defective system?

At worst, if the company isn’t able to provide the necessary funds for an appropriate cure, where there are no willing and capable shareholders around and no substitute institution neither – like a reinsurer or in particular cases perhaps the state – the beneficiaries of the insurance contracts themselves will have to pay the price for an incurable situation.

A term related to „loss“ or „damage“ in consequence of a risk, a term with lower profile but happening more frequently, is the *„disturbance“*, which usually will be remedied with a *„corrective action“*, often the earlier recognized and applied, the smaller the necessary effort. „Cybernetic management“, or whatever expression we use for this technique, describes some instruments of action and how to analyze situations. This school of thought may inspire some concepts of risk management if adapted with wise restriction. According to the central idea taken over from control engineering disturbances or “deviations from the normal track” are regularly corrected through “feed back” signals and occasionally anticipated through (preventive) “feed forward” information.

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3.2.3 Internal control and the supervisory authority

Apart from possibly insufficient funds internal control is all about the *human factor*. The responsible subject has to check and correct whatever could be done wrong or has already performed badly, an inappropriate organisation, schemes of working flow, insufficient skills, motivation and training of people and you even have to preclude bad will and possible attempts of fraud. Success depends on the top of the organization, the management, the CEO, the subject with full responsibility and power to act. Who controls them?

If it exists at all as an institution and is set up with enough independence the internal control can work for the same goals as the supervisory authority, detect and bring to light pending problems, serious failures, the hidden risks among the chances.

Normally a body of internal control will have deeper knowledge about its owns firm and it can work with a more pragmatic approach, the authority is bound to its strict legal framework, but hopefully vested at any time with independence also under critical circumstances.

The instruments of supervision are mainly preventative, above all the rules of solvency. The most effective action of the authority is probably just their checking, testing and verifying of a company's activity combined with occasional recommendations, on a whole often more effective than straightforward intervention, which is righteously restricted by law and may be challenged by the affected company.

The idea is valid for internal control as for risks, to get an idea about them, we have to understand the sequence of the normal correct operations, which we study along the flows of information and funds.

4 Models for insurance companies to integrate flows of information

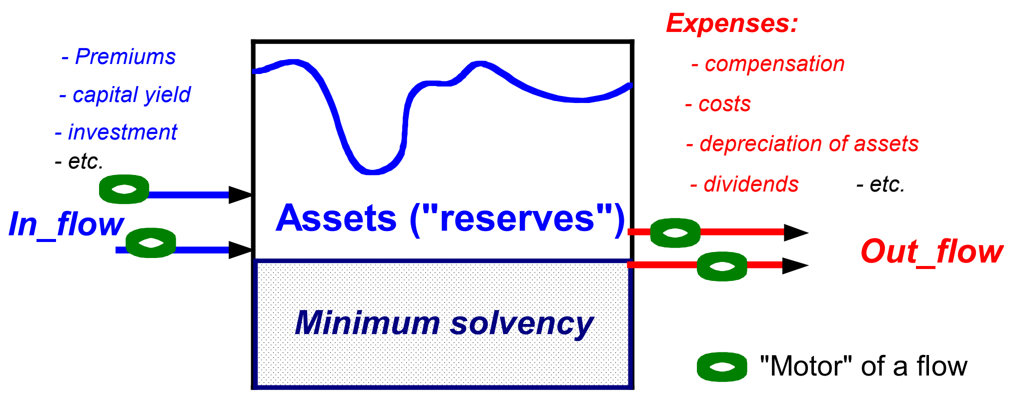
A model is a mapping of some part of reality onto a system of thoughts or of information. The maps as drawn by an architect - about some reality yet to come - illustrates the concept and in particular, that we may need more than one model to describe and conceive a particular selection of reality. For our main topic, the insurance company, as for many other types of objects, the most important distinction refers to its inside area versus the outside and the interaction of both. „Inside" are the processes controlled to a high degree by the management of the company, whereas on the „outside" the company may have a certain influence or can at least adapt itself in an advantageous, hopefully profitable way.

4.1 First model: The company as an input/output-system

One type of interaction and a powerful tool in systemic modelling is to treat any company as an input/output-system with various flows. [4]

In the case of an insurance company the main flows are those of *money*, as shown in the graph below:

[4] Actually the input/output-concept is not only valid for modelling a company. It equally describes important aspects of the human body, of any organ of a living being, of any machine. Any computer or program, and any complex of causes and effects can be modelled in this way.



The flows are financial variables, the „in_flow" is composed of (regular) returns and (occasional) investments, the „out_flow" by expenses and various other types of payments, particularly to clients.

Too little in_flow in a given period of time or too high an out_flow are risks for the company. They have to be balanced by sufficient assets. The moment, when the assets are at zero, the game is over, the company is bankrupt (and may be so even some time before it is unable to fulfil its immediate financial obligations).

The rules of solvency imposed by the supervisory regulation establish a minimum amount of assets a company has to guarantee to prevent a sudden drain either by surprise or as a consequence of too audacious management.

The main **sources** of **in_flow** are *premiums* and *interest revenues*, those of **out_flow** are *payments* and *costs*, but also occasional losses of the value of assets, a somewhat „virtual" flow, depending partially on the accounting rules and not on direct interaction of the company with the world outside.

Usually we don't have to invent the relevant variables of financial flows, but can take the ones used in accounting. The classification and aggregation of single flows done by this discipline is a first type of model. More sophisticated models will try to understand the stochastic events with the methods of statistics.

The irregularly undulating line on top of the assets has to visualize the fact that the flows of money are not continuous. That it pours in and above all out in irregular intervals instead, that some of the flows are caused by stochastic processes and we remember that it is the very task of the insurance company to pave out such waves on the side of the consumers - firms or private individuals - to a certain extent. The insurance company achieves this goal with the help of the law of the great number.

The „driving force“, a system of causal factors that provide - typically regular flows of payment - may be called a „motor“, e.g. a sales agency and on the output side e.g. the periodic dividends paid to shareholders. But for some analysis we have to remember, that each „flow“ is composed of single events, some of which can perhaps be described by a probability distribution. The motors or the accumulation of single events, their produced quantum“, are the cause of a company’s prosperity or weakness. Their analysis should reveal the prevailing situation, about chances and threats.

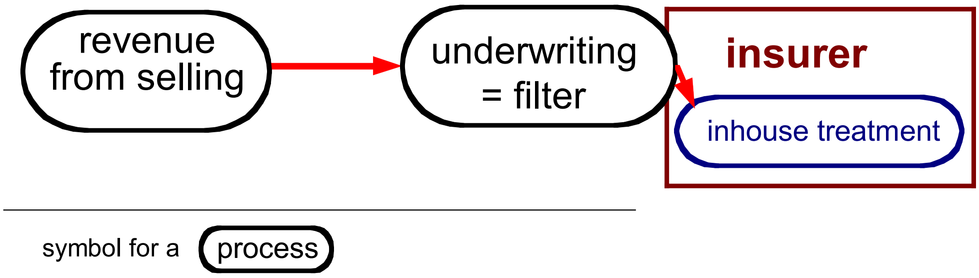
With the idea that we always deal with flows of payments we can address the various issues (tasks, problems) as they are dealt with by some traditional discipline, the most important ones registered in the following list:

Task	***Discipline to solve the task***
register flows	*accounting, informatics*
“stock” flows	*investments, asset management*
measure or estimate flows	*assessment of damage, clerical statistics*
forecast flows	*budget planning, mathematical statistics*
generate input	*sales activity, asset management*
prevent avoidable outflow	*underwriting, risk management*
calculate required input (premiums)	*actuarial disciplines*
keep liquidity	*cash management*

The typical discipline to analyze “internal” (actually virtual) flows would be cost accounting.

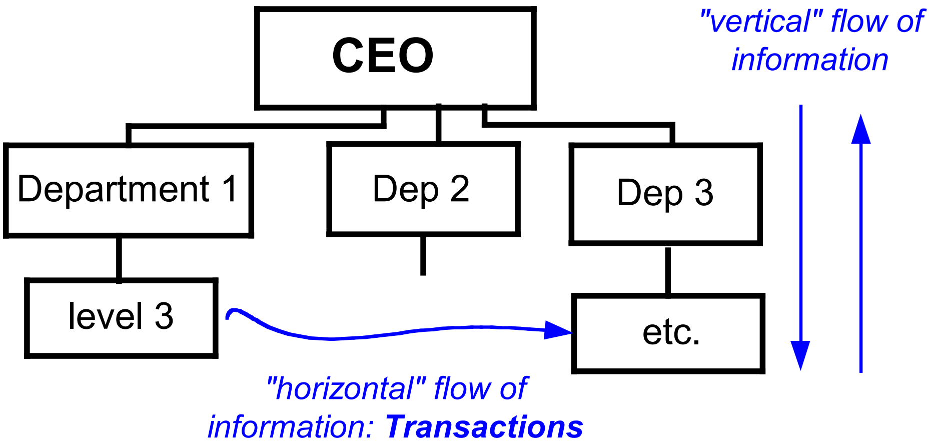
4.2 Second model: Workflow of transactions and flow of information

One single payment may be considered to be an *event*, whereas the repeated flow of payments onto or from the same account may be called a ***process***. These payments are *effects*. They must be *caused by other processes* as illustrated at the lifeline of any company, its sales, the most important source of revenue:



The data, which has been produced through the sales agents, will have to be processed next by the underwriting department, which has to control, accept or possibly refuse the provisional contract or apply another type of tariff, before the data is processed by the in-house services.

Opening the „black box“ of the input/output-system a little bit for a short look inside of the insurance company, we can consider it as a socio-technical system, a synthesis of collaborating persons and machines - computers in our context. The organization from the top CEO via departments and subdepartments down to the individual employee will inevitably be of a hierarchical structure.



We analyze such a system by establishing the structure and the various flows of information. On the channels from top down flow the „orders", „instructions" of *management* or whatever more modern forms of communication; on the way bottom up flows the *reporting*. Less obvious are perhaps the „horizontal" flows of information, from one department or individual and information machine to other such units, „operations" or „transactions".

Classical and modern types of media are used to carry forward or store information, sheets of paper, oral communication as well as electronic devices. One of the problems is to integrate them along their workflow in an efficient way, e.g. at the steps from man to machine, but also between various computers etc.

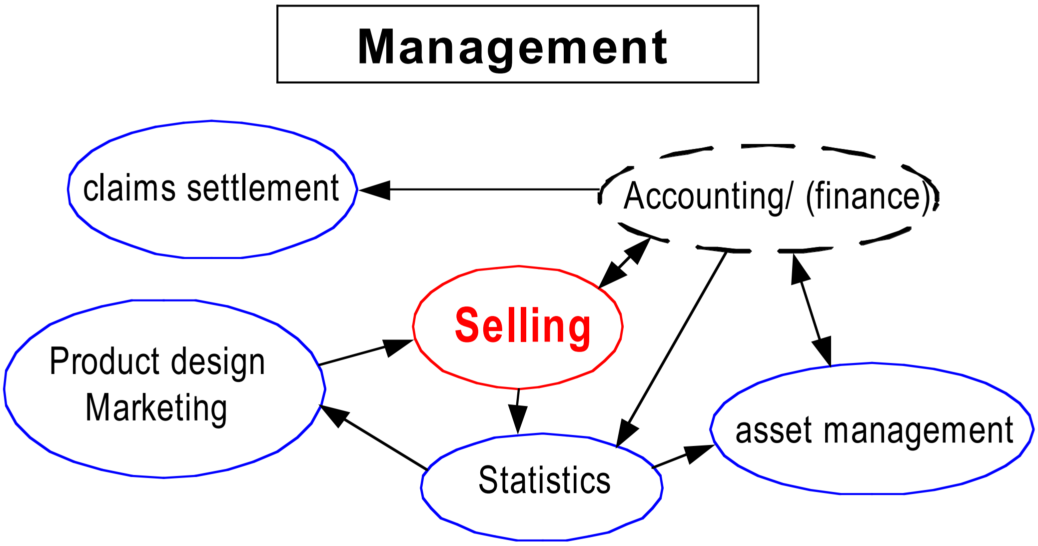
Each component in this system - department, individual or computer - performs again as an input/output-system of information by receiving such from others, processing it and handing it on to various next stations.

In a complete analysis we get chains or nets of connected processes, each running on some path through the hierarchical structure of the organisation. Every process may be the cause of payments or of other processes. Each transaction is under the risk of failure, the information may get distorted, perhaps particularly so at the very source of each flow. Each single damaged mechanism could be the cause that the whole „system" (the company) performs badly and may be at risk.

Following the flow of such chains of information, we should discover the flaws and malfunctioning in certain elements of the chain and in links between them. We work with the same method as if to find out about the cause, why the engine of a car has broken down.

4.3 Interaction of functions within a company

The well known representation of a company's organization with a hierarchical structure applies the systemic principle of structuring any system in its parts – "components" - and to set up and analyze the relations between them. The whole set of relations represents a *structure*. Before we divide the company in organizational units, we should analyze its "natural functions", as e.g. in the following chart, again to illustrate the methodology rather than an accurate complete picture:



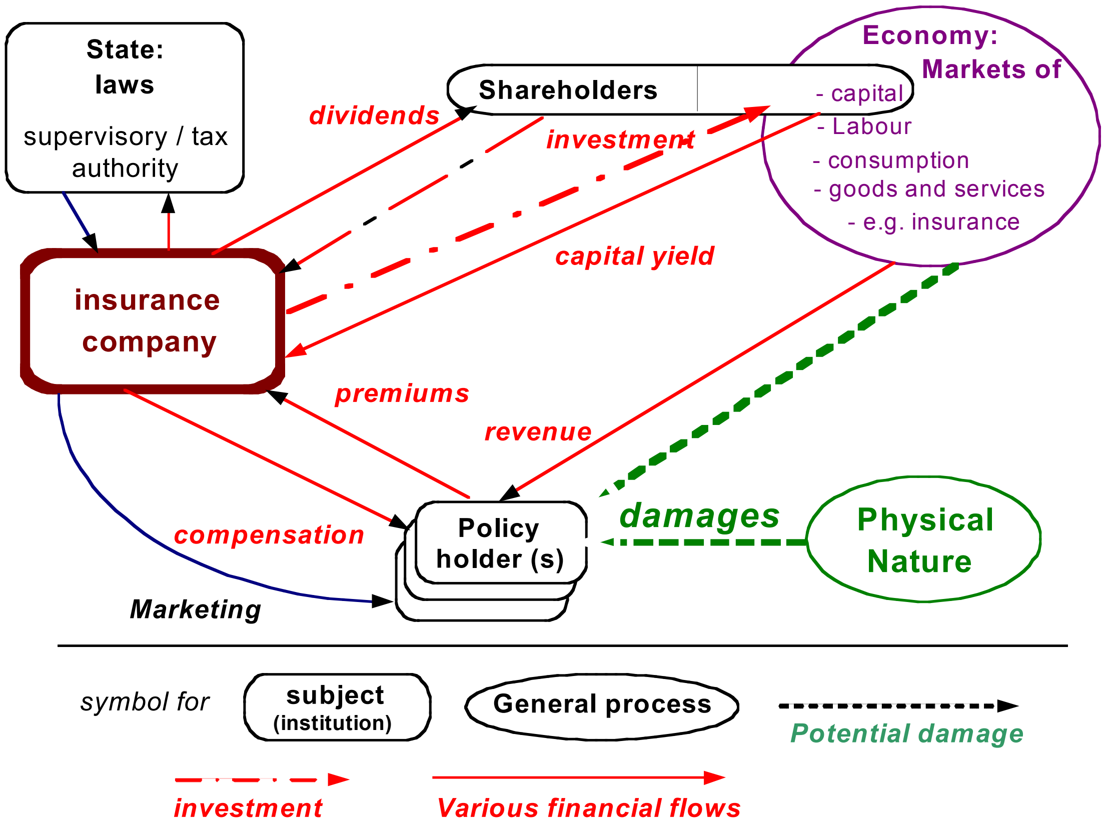
For the operation this picture will have to be "mapped" on the hierarchical structure of the organization.

As important as it is to be done properly from an analysis about "critical issues" we might drop the function "accounting" all together, since it is a purely "technical" discipline, whereas the other functions showed here contain a somewhat "artistic", intuitive element. A person with the right sense of responsibility and even know how can do rather wrong, if he lacks the intuitive skill, necessary for his task.

Each relation, represented by an arrow has the meaning of "information input" or "causal influence".

4.4 Third model: The Company interacting with its environment

In the input/output-model we didn't study, where the various flows come from or are going to nor by what laws they are caused. In order to analyze those laws we have to analyze the company's interaction with its environment. The latter can be divided into some main components, as illustrated with the graph below:



As complex as this chart may look like at first glance, it is of course only a trivial simplification of reality. E.g. in our drawing in order not to strain clarity excessively we haven't even given a hint to information flows, which would be of great importance in any realistic representation of a system, all this again with the purpose to *demonstrate a methodology*, rather than to provide an accurate description of the real world.

The methodology means to establish the relevant components in the environment of the insurance company and to analyze the relations between them. Such a graphic may be a starting point for further analysis of a concrete situation.

Each relation - graphically a line – which represents a flow of information can mean by that a variety of transactions, computer programs and applications of them, statistics, mathematical calculations, advertising, written correspondence, perhaps conversations, but also a financial transaction.

All together they are represented by a net, and for each section or net of sections the specialists may set up their specific model.

We easily see from such an overview, where to integrate the findings of various scientific and organisational disciplines into the overall model, e.g. statistics, which measures the possible amount of damages caused by nature or by some economic risk like credit and the compensations that have to be paid in consequence, a basis to calculate the premiums, that have to be requested.

Specialists of macroeconomic theories can provide data about the market of insurance and e.g. the particularly important values of interest rates made up in a complex process between the capital market and the decisions of the central bank.

4.5 Analyze scenarios with simulations

Anything we perceive, is either a process or involved into processes being transformed by them and perhaps contributing itself to changes. One way to model processes are simulations, scenarios of what may or should happen if certain causes materialize. We apply the presumable laws, governing the analyzed situation – economic, social, statistic/stochastic ones etc. Stochastic simulations is a widely studied technique

Along each line of the graphical structure we may simulate what/if-changes - what may typically happen, if the general economic situation is growing or decreasing, if interest rates are falling or decreasing, if losses amount to the extreme side of their expected statistical distribution etc.

4.6 Applying models to the real world: Select and structure

There is no such thing as a general abstract insurance company as we have used for demonstration purposes. But our modelling technique can also be applied to a specific single company or to a specific type of insurance business.

To apply models to the real world one usually has to *select* part of it, and *structure* this focused area *into further details*. We have for instance aggregated all the premiums into one flow, whereas the sales department is of course interested to have separate data for each product, may be per area or even per sales representative.

If we structure a company more in detail we see the various departments, each itself an input/output-system for the flows of information.

Finally to get a more precise picture, we have to *quantify* as much as possible the various flows and amounts of stock and describe the events of a certain type with an appropriate mathematical distribution function.

5 About the author

Werner Furrer, born in 1944 has a diploma degree in mathematics from Basle university. He has been working as an actuary and as an operations research analyst in various companies.

Among his main publications is a book on decision making (Basle 1988) and the recently revised 3rd edition on systems thinking, Zurich, 2002).