ulm university universität ulm

English Version

Risk Management and Insurance

Analysis – Assessment – Decision

Actuarial Sciences – the basis for the main focus of research

Foreword by Prof. Karl Joachim Ebeling, President of Ulm University

Ulm University is regarded as a pioneer in the establishment of Quantitative Economics. In 1977, it was Ulm that first introduced Mathematics and Management as a course of studies, which to this day still enjoys a great demand, and which has led to the establishment of similar study programs in other locations. This study course forms the basis for the successful research area of risk management and insurances established at the Ulm University.

The quantitative focus of economic sciences in Ulm deals with the measurable foundations for economic decisions; this enables Ulm University to distinguish itself significantly from the traditional study programs in the field of economic sciences. Graduates from Ulm are highly sought after on the job market and are extremely attractive for industry, and services sectors.

The internal objectives of the Faculty of Mathematics and Economics also reflect its quantitative focus, which includes financial services and their mathematical methods, whose scientific analysis supports the university's priority research programs. Sustainability research, well established within Ulm University with professorships for sustainable knowledge, sustainable education and sustainable markets and institutions, is becoming increasingly important for the consolidation of this area of focus. A newly established Master program which includes these important issues for society, as well as for future professional life, will be of great benefit for students.

The research focus on risk management and insurances is embedded in an extensive network of partners from business and industry both within the Science City Ulm and beyond. In particular the Institute for Financial and Actuarial Science (ifa) works closely with stakeholders in Ulm University, and makes an important contribution to the strength of this main focus of research recognised throughout Germany.

Risk Modelling

The key issue lies in the modelling, quantification and control of risks. The areas of financial mathematics and stochastics, as well as those of finance and the insurance industry, are particularly involved in addressing these issues. The exclusive characteristics of Ulm are supported by the unique subject combination of mathematics and economic sciences within a single faculty. Both these subjects, relevant to the focus of research, are closely interlinked and generate important synergistic effects, as well as a range of possibilities for interdisciplinary research and teaching projects.

One area of focus of the Masters program is that of actuarial sciences. The professional profile of an actuary offers many diverse career prospects in the fields of banking and insurance, specialising in the evaluation and management of financial risks. One important advantage for Masters students in Ulm in this context is that parts of the basic examinations to become an actuary are integrated into the study program and can be assessed during their studies.

In the case of capital investments in particular, risk management represents an area of great sensitivity, which has suffered considerably from the financial market crisis, and which has suffered a resulting loss of reputation through the application of unfair investment strategies. It is therefore of particular concern to us that aspects of business ethics be taken into proper account, that people are put first, and that the application orientation of the business content is coordinated in the services of citizens for the safety and organisation of life. We want to do our part in strengthening this attractive and important subject area in the interests of the public. With its diversity and its presence in key social sectors, this focal point offers many opportunities to develop scientifically reliable and tailor-made solutions. ■

Prof. Karl Joachim Ebeling, President of Ulm University

Research in the Faculty of Mathematics and Economics

Prof. Dieter Rautenbach, Dean of the Faculty

The Faculty's central research topic lies exactly on the interface between mathematics and economic sciences. We study important issues in areas of economics, with the help of mathematical modelling, analysis and simulation.

The central themes are insurances, financial risks, environmental and supply risks, as well as risks in health, services and industry. For a long time, the core of this research topic has been the Graduate College of the German Research Foundation: "Modelling, Analysis and Simulation in Economathematics."

Most of the economic problems stem from finance and insurance management, where both our scientists and students benefit from the close links between economics and mathematics. The high quality of the research is reflected in the research ranking of the German Economic Review, which puts the Faculty in second place for finance among all the universities in the German speaking area. Moreover, in the last five years, the Faculty has won 16 prizes for research on insurance.

Our research on quantitative economic sciences focuses on the quantitative foundation for economic decisions in profit and non-profit organisations, particularly research on risk management and the related theme of sustainability

Prof. Dieter Rautenbach

research. In cooperation with Medicine and Psychology, we also examine behavioural issues related to economics and management.

Risk research is one of our faculty's central areas of expertise. Our scientific work mostly begins with statistical analyses. How probable is the occurrence of an event and how high will the damage be? A price that is appropriate to the risk can then be determined. The reliability of the results is checked.

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>
> *Prof. Dieter Rautenbach, Dean of the Faculty for Mathematics and Economics*

Dealing with risks

The behaviour of individuals and institutions must now be analysed. This is because dealing with risks is influenced by how individuals perceive risks and by the communication within the company. We employ the methods of psychology, information economics and organisational economics. Finally, the costs of the risk must be distributed by source and adequate control structures and possible safeguards must be developed.

However, it is not only natural catastrophes that are of enormous relevance to society as a whole. The same is true for another area of our research — "Management Rules" — and their consequences for company risk. At the latest, this becomes clear when the methods developed are applied to company pension funds. In large companies, this might represent billions on the balance sheet. ■

Mathematics, management and economics as a unified whole

The Ulm idea: a tailored study course developed from needs assessment

It has been possible to study mathematics at Ulm University since 1972. "In those years, we had the chance of planning a study program, like on a drawing board—a study program that is unique in the German speaking area", explains Prof. Ulrich Stadtmüller, the mathematician who has helped to develop the faculty over decades.

"Some of our staff had observed in the USA how mathematicians found jobs in industry and in financial services and how statistics and computer science were becoming increasingly important as work with computers started. These experiences were included when we started thinking about new concepts in educating mathematicians. You could suddenly calculate things that had previously been impossible." Furthermore insurance companies were facing relaxation of the regulation system in Germany, which demanded new skills from their staff. Now, the plan was to develop an interdisciplinary program based on strong mathematical foundations but with emphasis on applied topics and oriented towards the needs of business and industry. Partners from industry and the ministries were involved in the discussions. The result was the program which is now called Mathematics and Management. "Companies such as Allianz Insurance and the Deutsche Bank were very positive, as they were looking for academic staff with sound theoretical knowledge, but who knew how to read a balance sheet and who were familiar with the work of an auditor as well."

The following courses deal with the complex of issues related to risk management:

- **Mathematics and Management** (Mathematical Finance, Mathematical Insurance)
- **Management and Economics** (Sustainability, Behavioural Economics)
- **Finance** (Financial Mathematics, Financial Economics, Actuarial Sciences)

Our success shows that we were right

According to Stadtmüller, half of the graduates have an employment contract in their pockets before they have their master degree. Four weeks after completing the course, 90% have fixed employment. They are successful in the insurance industry, the financial industry or in the financial management departments of large companies but also in other branches like the software industry. Since the range of the program is so wide, students in Ulm do not only understand about insurances or banks, but about risks—as risk may be packed in many different ways and furthermore, they have broad knowledge of applied mathematics. Whether we are talking about insurance risk or company pension schemes, or about a derivative bought by a company to protect themselves against any changes in the capital markets, risk management always demands the same abilities.

Ulm tackles new challenges

The insurance industry has been subjected to enormous changes and new challenges. Until the 1990s, the German insurance industry was almost cut off from the rest of the world. Because of the strict regulation of the market, there were only a few products in life insurance. When you built a house, there was no choice between different insurance companies, as there was only one insurer for each federal state. However, the market was opened by the EU in 1995, and German insurers were suddenly exposed to competition with British and American products. There was a great need for new methods and models, as well as other ideas and procedures. Thus, people with proper training were required.

It has turned out that the combination of subjects in our program provided the ideal foundation for these challenges. Using modern information sciences, economic questions and economic results are linked with mathematical models and their calculation; this is the promising approach towards treating the problem of risk holistically. To achieve this, students have to tackle other areas: insurance economics and actuarial science, mathematical finance and finance.

With this knowledge, they are like people on a theatre stage. They can train the spotlight from different angles on the risk event, so that they can then develop a model and analyse the problem with it. ■

Systemic risks in occupational pension schemes

There are risks even if the contributions to occupational pensions are treated responsibly

"What do car manufacturers and electricity suppliers have in common? They are both insurance companies that incidentally also sell cars or current." This is how Prof. Hans-Joachim Zwiesler sees the crux of the problem that will become a major headache in future—particularly to large companies. A portion of employees' wages is not paid in cash but in pension or survivors' benefits. For the moment, the payment is tax free. The tax authorities only demand their share after payment.

Occupational pension schemes have been established in Germany since the 1970s. However, this item now makes up most of the liability side of the balance sheet. Bayer AG has pension reserves of 9 billion Euros. For Volkswagen AG, the figure is as high as 24 billion Euros. According to Zwiesler: "The advantage is that the money remains within the company and can be invested or used for internal funding. The companies are not subject to the same investment restrictions as insurers. However, the company must be certain that the money will be available when it is to be paid out to the pensioner. This gives rise to the following problems, which are increasingly being studied by analysts. If the value of the pension reserves changes, this can lead to significant losses by the company."

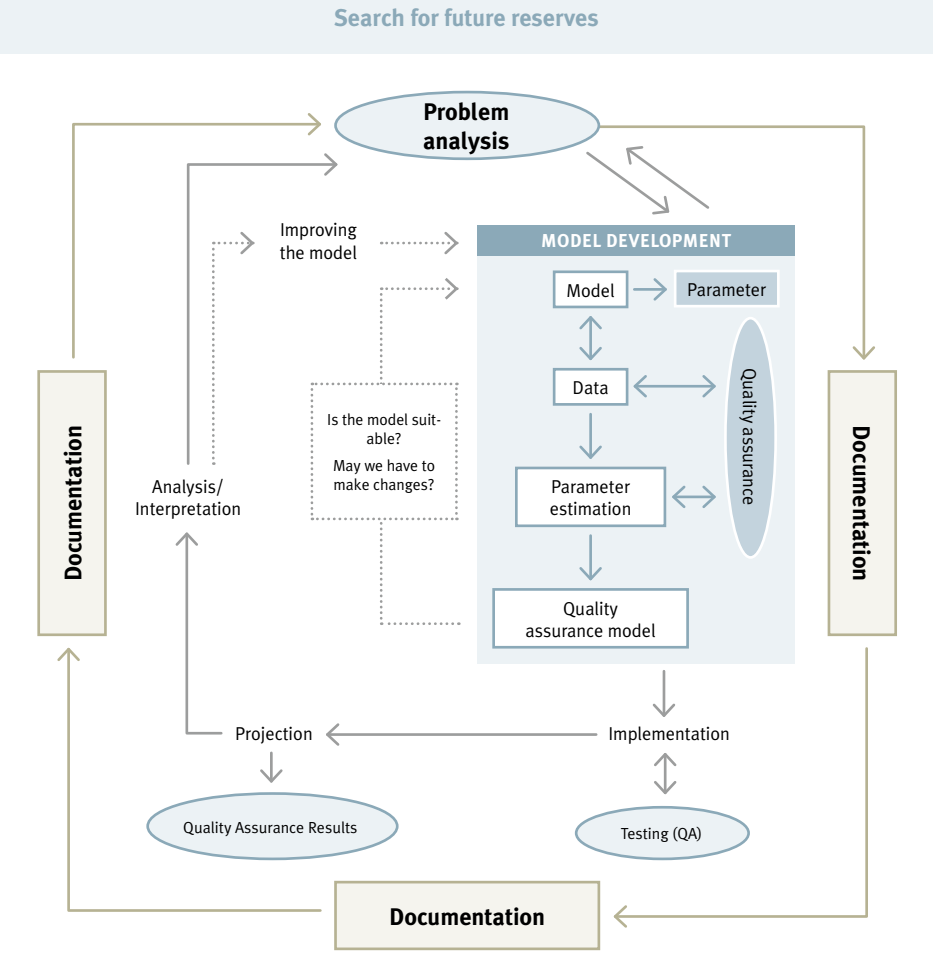
There must also be safeguards against inflation. The company is therefore obliged to adjust for inflation every three years. Alternatively, an automatic 1 % increase per year can be included in the pension payments. As Zwiesler summarises: "There is great potential for risk here, which means a lot of work for the actuary. What happens when the baby boomers retire is quite critical. This is admittedly not as explosive as an inter-generational contract as in social security. But nevertheless, in this case too, part of the money must be earned by the next generation." But what happens when there is not enough money or the company is bankrupt? If there is not enough money for pensions, the German pension guarantee fund assurance—a sort of reinsurance—must step into action. This is financed by contributions from all German companies.

Risky investment strategies

Prof. An Chen, Director of the Institute of Insurance Science, is studying the investment behaviour of market participants. Her studies show that the more funds an investor has available, the easier he finds it to make riskier investments. But there is also another phenomenon. When the financial situation is poorer, the investments become riskier. Gambling behaviour becomes evident. These investors are driven by the hope of still saving themselves with high profits from a risky investment. They might win a ticket with their last penny for the profit of millions that they passionately desire. But investors may also be seduced by the irresponsible investment behaviour of a so-called "moral hazard". If there are safeguards against any risk (for example, with a pension guarantee fund), the investor can make risky investments without worry—as the risks are born by others.

> ***"What do car manufacturers and electricity suppliers have in common? They are both insurance companies that incidentally also sell cars or current."***
>
> ***Prof. Hans-Joachim Zwiesler, Institute for Insurance Science***

THE CONTROL CYCLE – INSTRUMENT FOR AN OPTIMAL INVESTMENT STRATEGY



The figure shows how the Ulm scientists measure various risk factors and calculate alternatives for provision for old age.

How do the company financial managers want to safeguard the reserves for the future? Ulm scientists are searching for an optimal investment strategy. They are also working through the possibility that several companies go bankrupt, which causes a systemic risk. Chen explains that one possibility might be a risk-adjusted premium. It would then be possible to reward investment behaviour or higher rates of owner equity.

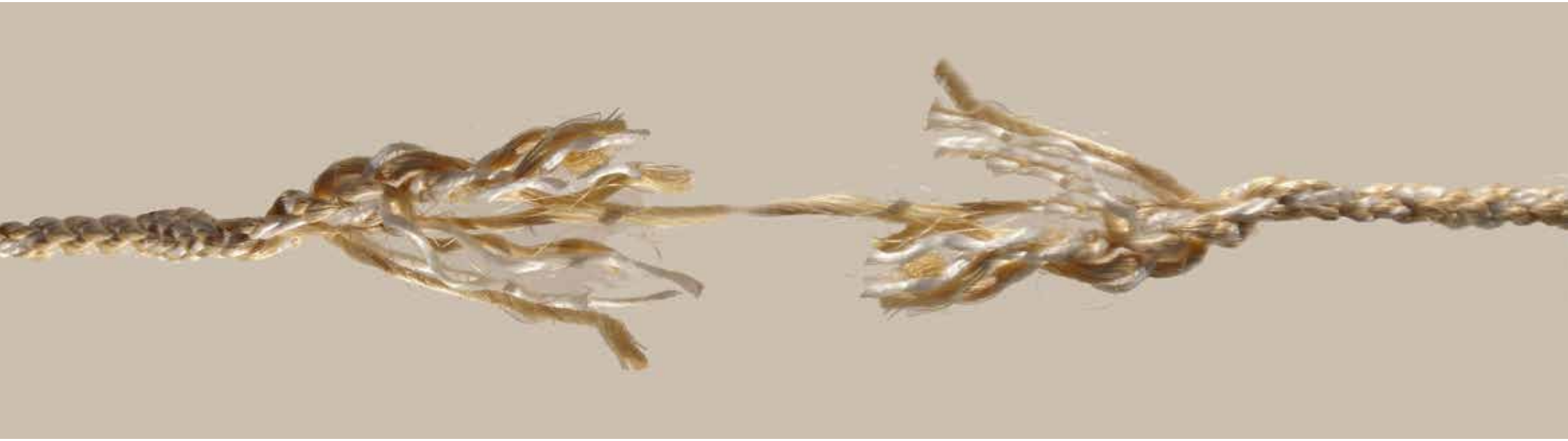
However the Ulm scientists are not only studying the various risk factors, but are also calculating the consequences of alternatives methods of calculating retirement pensions. Insurance companies offer pension funds in which the employer gives the money to the pension funds, from which the pensions are subsequently paid. It is then an interesting question as to how such a fund should be provided with risk capital. In separate steps, they describe the safety mechanisms between the participants—a complex matter with four participants. The scientists must then specify which mechanisms must be considered as a risk. Zwiesler gives the following example: "Usually when the pension fund of a certain company is underfunded, the sponsoring company of the pension fund and the pension guarantee fund will step in first to support the pension fund. The future premiums that the sponsoring company needs to provide to the pension guarantee fund will be increased according to the magnitude of the underfunding level of the pension fund. Surely the other companies will suffer a lot if many pension funds default simultaneously." On the basis of these assumptions, models are developed for the probability of such scenarios. It is then calculated how much risk capital would be necessary. Another solution is that other investors step in to save the system.

Other countries – other systems

According to Chen, these studies have not only excited interest in other countries with similar systems, such as the USA, but also in EU partners who provide for old age in other ways. "It is really fascinating to find out how these different systems may be reasonably compared—as they all have the same objective." An Chen then explains the strategy in China, her home country. "With the one child family, the Chinese will have just as severe problems as the Germans with the population pyramid. Only they have had less experience with officially managed pension schemes. Women in China often retire in their mid 50s. As they are mostly already grandmothers, they take the responsibility for bringing up their grandchildren, while their children work. In return, the children make sure that their parents can survive financially." This family safeguard is now at risk, which is why the Chinese are very carefully studying pension schemes in the rest of the world. We are discussing possible cooperative studies with a delegation from the elite University of Fudan in Shanghai. ■

Modelling risk

Stochastics is only useful when randomness comes into play



“Mathematics is an art, which is often (though not always) helpful to other sciences”. Prof. Evgeny Spodarev, Director of the Institute of Stochastics, is certain that scientists need to carry our fundamental research (and not only applied) research, in order to develop new theories. “We develop theories that may be derived from practice. Nevertheless, they possess their own independent justification and beauty.” This is why they say that mathematicians are years ahead of practice in some areas of knowledge.

The level of mathematical literacy in the everyday world is often quite low. Spodarev observes that even significant industry players continue to work with bad mathematical models. Notable offenders are banks and insurance companies, which often have problems calculating the risks of their own products. “They should have good actuaries, who are capable of calculating an adequate model of the risk. In the real world, they often employ staff with only rudimentary mathematical knowledge. They use the wrong models and are amazed when these models fail to reflect the real world.” How can Ulm mathematicians help in such a case? “One of our industry partners had made serious errors in risk modelling. In response, we developed a model of storm losses that produced three-dimensional maps of annual losses. Using the insights from this model, we were able to develop software that allowed pur partner to calculate their insurance premiums correctly.” This helped the insurer’s actuary department.” Spodarev emphasizes that it is

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>
> *Prof. Evgeny Spodarev, Director of the Institute of Stochastics*

important to make sure that customers understand the limits of stochastic modelling, which is only applicable to random events. "Some of the things that happen in financial markets have nothing to do with the laws of chance. Investors have become aware of a specific opinion or political situation and take fright, leading them to dispense with a certain investment. This is not a random event." Spodarev stresses that stochastic modelling approaches only work when the market is relatively stable. Extreme events or crashes—where the normal market mechanisms no longer work—lead to false assumptions and make stochastic forecasting impossible."

Stochastic geometry in 4-D

What is the chance that a burglary or other crime will occur at a specific location? The Bavarian State Criminal Office commissioned the Ulm stochastics experts to develop a suitable model of crime risk. Using the results of this model, high crime risk areas could be identified and police patrols in those areas could be increased. Spodarev explains that their calculations had to determine risks that depended on the day of the week and season, as well as on spatial location. Thus, their model had both temporal and spatial dimensions. In stochastic geometry, complex 4D structures can be described using just a few model parameters. Stochastics can calculate a probability—how likely it is that something happens. However, it cannot predict the times and locations of specific crimes. So, of course, criminals will not be caught red-handed just by calculating a probability. ■

BUSINESS SUPPORTS SCIENCE

Since 2010, the Signal Iduna Group has donated half the funds for a Junior Professorship in actuarial science. The company not only provides financial support. Through his close contact with their actuaries, Junior Professor Marcus Christiansen learns about the current risks in this type of work.

They tell him about problems which they cannot deal with during their daily work as thoroughly as would be necessary for an analysis with a long-term perspective. Christiansen then attempts this with realistic data from the company. He develops statistical techniques with other procedures and risk management techniques. As he says: "I do not do their work for them and this work is not commissioned. I would like to solve basic problems that are then published in scientific journals and which would then benefit both the whole field and society."

For example, Christiansen is studying how policy holders change their insurance company. The legislator wishes to encourage competition by making it possible to change insurance. But what happens when predominantly healthy people change into one tariff and sick people into another? "This anti-selection effect is linked to many risks for the insurance company. For the tariff with disproportionately many sick people, the premiums would greatly increase. It would then be almost impossible to recruit new policy holders. On the other hand, it would be difficult to leave a tariff like this, as it would mean losing part of the actuarial reserve." ■

"I would like to solve basic problems that are then published in scientific journals and which would then benefit both the whole field and society."

Jun. Prof. Marcus Christiansen, Institute for Insurance Science

Study programs – Research – Prizes– Collaborations

Mathematics, Management and Economics

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STUDY PROGRAMS AT THE FACULTY

Ulm University Faculty of Mathematics and Economics is one of the few faculties in Germany that combines courses in mathematics and economics in the same building. About 400 students per year complete their degree here.

All our graduates have excellent professional opportunities. In 1977, we were the first faculty in Germany to offer a course on business mathematics and thus laid the foundation for the close link between mathematics and economics.

The degree programs:

- Management and Economics (B.Sc./M.Sc.)
- Mathematics and Management (B.Sc./M.Sc.)
- Mathematics (B.Sc./M.Sc.)
- Mathematics (teaching)
- Mathematical Biometry (B.Sc./M.Sc.)
- Computational Science and Engineering (CSE), (B.Sc./M.Sc.)
- Finance (M.Sc.)

ACTUARIES OF THE FOURTH GENERATION

The analysis of the financial crisis led to the emergence of two problems. Products were developed with risks that had either not been properly calculated or with calculations that had been wrongly interpreted. Moreover, communication between the market participants was inadequate.

Ulm University therefore asked itself how the study area of actuarial science could be placed on a broader basis. In order to analyse complex situations, the financial world must be described in mathematical models. This will also be true in future.

In response to the complexity of the problems, the models themselves have become more complex in recent years. Nevertheless, the analyst should not forget that they do not cover all features of the real world.

Commercial decisions must still be made by human beings. They decide whether they implement the mathematical results one to one, or use their ”common sense”, which may possibly also include consequences beyond the company.

It would be good if as many managers as possible understood both the significance and the limits of the mathematics. The mathematician must therefore be capable of presenting his results and the limitations of their models in such a way that non-mathematicians can understand and interpret them as well.

In addition, the mathematician must develop an understanding of process management, how his models can be integrated into commercial processes and decisions are reached.

Ulm University has responded to this challenge with the training concept for “Actuaries of the Fourth Generation”. The teaching program includes not only all essential mathematical and economic knowledge and abilities, but also lectures on process management and organisation.

There are also lectures on communication for actuaries. These explain to the actuary how he can present his models, with their results and limitations, in a comprehensible manner to managers, supervisors or analysts. Thus Ulm University is trend-setting in the holistic training of actuaries.

1967 *Foundation of Ulm University*

1970 *Mathematics started as subject*

1973 *Black-Scholes Model*

1977 *Mathematics and Management*

1992 *Actuaries*

EXCHANGE PROGRAMS AND CO-OPERATIONS

For 30 years, the Faculty of Mathematics and Economics has been coordinating an exchange program with American universities.

The partners are: Syracuse University, University of Wisconsin at Milwaukee, Binghamton University, San Diego State University, Illinois State University, Missouri University of Science and Technology and Florida Institute of Technology.

Other international co-operations are restricted to specific themes. These are: University of West Florida in Pensacola (Statistics), Edith Cowan University Perth, Western Australia (Economic Sciences), Lomonosov Moscow State University (Mathematics), University of Waterloo and Fudan University Shanghai (Insurance Sciences).

In addition, the Faculty cooperates with numerous universities in the following countries ...

... in mathematics with: Brazil, Estonia, France, Great Britain, Ireland, Italy, the Netherlands, Austria, Poland, Sweden, Spain, the Czech Republic and Turkey

... in economic sciences with: Croatia, Switzerland, Cyprus, Greece, Poland, Portugal, Rumania, Slovenia, Hungary

... in general university exchange programs with: Egypt, Australia, Brazil, Chile, Canada, Mexico, Russia, Singapore, Taiwan and USA

PRIZES AND HONOURS

About 40 professors research and teach at the faculty, including numerous winners of national and international research prizes.

Research on the insurance industry, managerial finance and mathematical finance is regularly awarded important prizes, including the Merckle Research Prize, the Spencer L. Kimball Award, the Kessler Prize, the Gillardon Advancement Award, the Best Paper Award of the German Association for Managerial Finance, the Best Paper Award of the Global Association of Risk Professionals, the Reuters Award, the Swisscanto Best Paper Award and the Tor Vergata Young Economist Prize.

Approximately 400 students each year are awarded a degree. These regularly include the winners of prizes for outstanding final papers or doctoral theses.

Here is a selection of the prizes for insurance economics, managerial finance and mathematical finance: SCOR Prize for Actuarial Sciences, Gauss Prize for Young Scientists from the German Association for Mathematical Insurance and Finance, together with the German Society of Actuaries, MINT Award, Berlin Prize for Insurance Sciences, Südwestmetall Advancement Award, Prize of the Centre des Professions Financières (FR); Gillardon Advancement Award, DZ Bank Career Price, Reuters Award, Acatis Value Prize, Mileva Einstein-Maric Prize.

NETWORK

The Ulm network is closely linked. The Faculty maintains very good and intensive contacts with industry and commerce, both within the Ulm/Neu-Ulm region and far beyond. The five **endowed chair professors** show our close links to special cooperation partners particularly clearly: the Ludwig Erhard Chair on Economic Policy, the Werner Kress Chair on Strategic Management and Finance, the endowed Chair on Sustainable Knowledge, Sustainable Education and Sustainable Economics, the Péter Horváth Chair for Business Management and the Junior Professorship for Insurance Mathematics of the Signal Iduna Group.

The **Scientific Computing Center Ulm** is an interdisciplinary research centre set up by Ulm University, as well as being an established partner of industry. Since 2005, **Landesbank Baden Württemberg (LBBW)** has supported a Trading Room, which gives students direct access to financial markets and data. The **Institute of Financial and Actuarial Sciences (ifa)** is an independent advisory company for actuarial questions related to life insurance. **The Ulm Forum for Economic Sciences (UFW) e. V.** provides support to science, university education and practice. The **Economics Advisory Council** is an informal committee with managers from industry and economics, most of whom studied business mathematics at Ulm University.

1993 *Foundation of ifa*

1999 *Management and Economics*

2003 *Finance*

2005 *Graduate College, LBBW Trading Room*

2010 *Mathematical Biometry*

2011 *Computational Science and Engineering (CSE)*

2020

Not sawing off the branch we are sitting on

Sustainable economics is more than just public relations

“My job is to identify the social and ecological risks and to sensitise us to them. I then have to develop instruments, either to reduce the risks or to exploit them to generate opportunities.” Martin Müller is Endowed Chair Professor for Sustainable Knowledge, Sustainable Education, and Sustainable Economics at Ulm University. The chair was donated by the City and Region on the occasion of the 40th anniversary of Ulm University. Although he is not responsible for a focus research area, more and more, his work is becoming part of his colleagues’ research projects. This is particularly the case in work linked to industrial risks.

Industry needs raw materials, but the prices of these may fluctuate violently. Companies therefore protect themselves against these risks or hedge the risk. This is a proven procedure, but combats the symptoms, not the cause. Müller’s job is to search for other solutions, for example substitute materials or potential savings. He may investigate whether old mines can be revived. “Think about the rare earth elements. They are not really so rare, but are found in very low concentrations in the earth. For example, mines in the USA that produced rare earths as secondary products were closed at a time when there was no demand for these. China currently enjoys an essential monopoly in rare earths, as it dominates the market with 97% of world production. We should then ask ourselves how we can reduce the price risk associated with this situation.” It takes years before an old mine is reactivated. Other deposits, such as those in Greenland, would lead to almost insuperable environmental problems, because of their high uranium content.”

When is a product “clean”?

On the one hand solutions must be found that work over a long period; on the other hand, environmental compatibility is of increasing importance. Consumers are now interested whether the production of a product is ecologically and ethically “clean”. This is a Herculean task for some large producers, as the variety of materials is increasing and more and more is purchased internationally. As Müller explains: “Some tantalum comes from the Congo, where it finances a civil war. In Peru, children work in mines and the term “blood diamonds” speaks for itself. For example, VW has 48,000 direct suppliers. This needs work on the identification, analysis and avoidance of problems.” The first step is to specify standard rules to which suppliers must comply. Do they comply with specific standards? Then information on suppliers is collected with a questionnaire. “Information about specific countries—such as corruption—can be obtained through Transparency International. Substance databases provide information about risks linked to substances. Depending on what you mark with a cross, points are awarded. Finally there is a score that is a measure of the risk associated with a supplier.”

Questions are asked, but controls are carried out, too. Müller describes the course of the project as follows: “If there are breaches, you should try to develop improvement plans, so-called “corrective action plans”. You must then make a fundamental decision about the importance of the price, quality and sustainability”.

Müller has also analysed sustainability and the connected risks for companies in the region. One bank wanted to offer an investment fund

for sustainable products with regional character. "The assumption was as follows. The inhabitants of the region would like to know who is involved and are glad if they already know the company. The risk in developing this product is that there will be problems if a single rotten egg is included." Sustainability has become an important issue in the financial sector. You can see this in the foundation of new "ethical" banks, which commit to ecological or social objectives. According to Müller: "Many people have changed their views after the financial crisis. This is a good thing. In the long-term, we don't want to saw off the branch on which we are sitting."

Masters in sustainable company management

From the winter semester 2015/2016 on there will be a study program on Sustainable Management, partially financed by the State Program for Sustainable Science. The students will learn how to make commercial decisions that consider secondary ecological and social effects. As the themes and research projects are highly complex, the program will be interdisciplinary. Besides from economic knowledge, the program will deal with the relevant principles of philosophy, psychology, biology and information science. As the next step, Ulm University will concentrate the research and project work in a Centre for Sustainability. ■

"Many people have changed their views after the financial crisis."

Prof. Martin Müller, Foundation Professor for Sustainable Knowledge, Sustainable Education and Sustainable Economics

Analysing environmental and supply risks

The electricity market has its own special risks

The current unhindered emission of greenhouse gases throughout the world is linked to massive risks to the world climate and therefore a danger for future generations. An essential factor in reducing these risks would be to decrease the elimination of CO_2 in electricity production. However, switching energy supply from fossil fuels and atomic energy to renewable energy sources is a complex challenge and a variety of risks must be considered. Here is one example: If a large proportion of current is produced by the wind and sun, how can we be sure that the light will not go out when the wind does not blow for long periods and the sky is cloudy? And what happens with the new participants in the market?

The economist Prof. Sebastian Kranz deals with questions on the suitable design and regulation of markets and institutions. The main aim of his research on the energy sector is to understand the incentives of the different market participants and then to design the general framework of the market in such a way that the desired goals for energy policy can be achieved in a sustainable and economically favourable manner. "If we want to guarantee secure supplies, companies must have adequate incentives to invest in reliably available reserve power stations or in storage technologies—which are currently very expensive. However, a major factor in the decisions on investment is whether the investment costs will in fact be recovered. This must

be incorporated in a suitable market design." Sebastian Kranz also studies the susceptibility of different market mechanisms to the risk of the exploitation of market power.

The networks play a key role in the energy turnaround. If network development does not keep pace with the development of renewable energies, the following situation may become increasingly frequent. Windmills in the north of Germany can actually turn fast, but sometimes have to be switched off, as cheap wind current cannot reach South Germany on demand.

As Kranz explains: "The current regulation of network operators and the organisation of our electricity markets—where in practice power stations receive the same electricity price everywhere in Germany—provides hardly any incentive to network operators and electricity suppliers to coordinate the development of networks and regional structures of investment in power stations in a cost-effective manner for consumers." Many different factors can be considered. For example, direct current cables can reduce energy losses over long distances, but need expensive transformers. Perhaps there are cheaper power station sites in North Germany than in South Germany. However, in South Germany, there may be new costs for new network investments. With colleagues from Cologne and Munich, Sebastian Kranz is investigating a suitable combination of incentive regulation for network operators and intelligent market-based payment of electricity suppliers, so that managers have incentives to consider the costs for society as a whole.

Game theoretical models explain managers' strategic behaviour and its consequences under various market mechanisms. Mathematical models from statistics and risk theory help in the analysis of the decisions of market participants and their consequences.

Collaborations

In general, the energy market is a highly complex theme. As Kranz explains: "In this case, a single large study cannot solve the whole problem. Many different aspects must be studied over years, often in cooperation with other institutes, such as the Cologne Institute of Energy Economics. In the future, we may cooperate with the Centre of Solar Energy and Hydrogen Research or the Helmholtz Institute Ulm for Electrochemical Energy Storage".

Within the faculty, there are synergies—both in teaching and in research—between Martin Müller's business management perspective and the general theme of environmental protection and sustainability. ■

BASIC RESEARCH MEETS PRACTICAL WORK

Risk can also be described as the presence of uncertainty. Either involved parameters are not precisely known, or the processes are so complex, that both our current knowledge and computer calculations are not enough to consider all parameters. Numerical analysis is applied to these problems in a wide variety of areas, such as the financial world or engineering. The underlying mathematics has many similarities.

One reason for the financial crisis was the mutual dependence of different market participants. Mathematical modeling of this complex financial structure is very difficult, as many dependencies cannot be measured or are even unknown. If the numerical analyst wishes to quantify these uncertainties, he must identify the dependencies and their influence on the overall behaviour of the financial system. According to Prof. Karsten Urban of the Institute of Numerical Analysis: "If I wanted to consider everything, I would have differential equations in more than 300,000 dimensions. As the complexity of the calculations rises exponentially with the number of dimensions, it would be impossible to calculate this, even in 100 years. We call this the curse of dimensionality."

Numerical analysts like Urban can use mathematical methods to analyse past financial crises and to calibrate their models correspondingly, but they cannot look into the future. "If firm A seals a contract with firm B, it is very rare that you can read about this in the newspaper on the following day. And even if you could, I don't know what effect this would have on the stock market. However, we can identify the risk factors and quantify their influences." ■

Extreme values worry scientists, too

Multivariate models take several risks into account

Weather phenomena always attract a great deal of attention, especially when they are extreme. Those affected suffer under the consequences and often cannot understand why they were not warned in good time or why the necessary precautions were not taken. Events are also referred to as extreme because they are rare. This rareness is good in itself, but causes trouble when trying to estimate the associated risks.

In many applications, simple models such as the normal distribution (as shown in the Gaussian bell curve) do not adequately account for the possible occurrence of extreme values and therefore enormously underestimate the risks.

Multivariate models can help

Models need to reliably reflect the relevant properties of the risks. This is true for the effects of weather events as well as for events in the financial markets.

Prof. Robert Stelzer, Director of the Institute of Mathematical Finance, explains the possible challenges: "In many situations, several risks play a role at the same time. These must therefore be represented in appropriate multivariate models. The obvious question is then what are the mutual dependencies of the different risks. With two risks, various approaches can be used to model the dependency structure effectively. However, as the number of important risks increases, the situation gradually becomes more difficult and most methods become increasingly inadequate."

Reality is too complex

Robert Stelzer's students investigate how financial markets can be described mathematically in an appropriate way. They select a model that reflects the market structure well and then they employ mathematical methods to draw conclusions from it.

"If I have a result, I have to ask myself a series of questions. For example, is this plausible and is it compatible with economic theories? If not, I have to consider whether I have selected the correct mathematical model or mathematical approach, or whether the mathematical results demonstrate defects in the economic assumptions I have made." Thus Stelzer plays the ball back to economics. "There is not only pure mathematics, which is inherently correct, but in the application there is an underlying system that you want to describe. In the end, all models are wrong, as reality is always more complex. Yet, as reality is too complex for us to understand, we need models that effectively reflect the most important aspects for the specific application."

But there are also extreme events. Admittedly, methods have been developed in extreme value theory and statistics to determine the frequency of extents of damage that have not yet been observed. However, it is important not to make an exact prediction—which is impossible—, but to make as accurate as possible an estimate of the probabilities of the different extents of damage of future events. "What happens can always be worse than anything that has ever happened before—whether we are talking about floods or a financial crash. Then it does not help if I refine the model again and again by incorporating more and more assumptions. This may give a result that appears to be precise, but also increases the risk that my assumptions are false and that my results are therefore unreliable. The result may never be presented as a single apparently precise figure; the precision of the prediction must always be included. In other words, a measure must always be given of how much the actual values will deviate from the point estimate." ■

Be aware of the risks and act accordingly

Research on financial risk management is important – as maxims like this are difficult to implement in practice

Higher profits are generally only achieved when the risk is high. This applies both to private investments and to commercial activities. Financial risk management is helpful in balancing chances and risks and in avoiding unnecessary risks.

Risk management starts with risk assessment. By how much may property prices decrease in the coming three years? How high is the risk that a country becomes bankrupt?

Examples such as these illustrate the difficulties that risk managers have to deal with. Many events that may be of decisive importance for success or failure are of very low probability.

Gunter Löffler, Professor of Finance at Ulm University exemplifies the problems of assessing risks from historical data as follows: "The debts of the Greek government were restructured in 2012. The most recent comparable case in an industrial western country was Germany in 1953."

However, only measuring risks is not enough, even though this is still the principle task of risk managers in banks and elsewhere. Risk specialists should play an essential role when chances and risks are being compared. This is because many players have an incentive to give more weight to chances. The hope of being paid a larger bonus, of being bailed out by the government or of keeping up with successful competitors makes it easy to overlook risks. Some psychological behaviour patterns have the same effect.

Research on financial risk management is therefore multifaceted. Measurement problems are one research area at Ulm. The finance researchers are investigating how high the risk is that banks or states infect each other and how this can be measured. This is a really important research question, as the risk of chain reactions is often given as the main argument for official rescues.

Another current research project investigates whether investors in US bond funds have benefitted from the funds' use of credit derivatives. On average, these derivatives were used by fund managers to take more credit risk, and not to reduce existing risks. Many funds were then taken by surprise when risk premia increased during the financial crisis of 2008. They had betted on a reduction in risk premiums.

According to André Güttler of the Institute of Strategic Management and Finance at Ulm University: "The situation is reminiscent of the failure of the hedge fund LTCM, whose managers also made fundamental errors and who had to be saved in 1998 by the US Central Bank and a group of large banks."

Research and practice

Gunter Löffler reports: "We recently assessed the risk for a medium-sized company that long-term contracts would not be fulfilled due to the bankruptcy of the contractual partner. We are currently discussing with a bank how to generate scenarios for developments in property prices." Co-operations of this sort often lead to interesting themes for master theses. ■

Integrating psychological aspects

People tend to be overconfident

In the ideal economic world, man is homo oeconomicus. He does what promises to bring him the greatest advantage, particularly in financial matters. Such rational behaviour can be easily integrated into the sober world of numbers when modelling risks.

The only problem is that human beings cannot turn off psychological processes. We are guided by emotions and our assessments are flawed. Thus, the individual himself can become an element of uncertainty when assessing risks. This is why behavioural aspects are being increasingly integrated into economic analyses.

According to Gerlinde Fellner-Röhling, Professor of Behavioural Economics at Ulm University: "One important factor in financial markets is that people tend to be overconfident."

It has been found that stockbrokers think that they can predict the future more accurately than the facts allow: "This can lead to increased trading volume and sometimes to excessively high market prices." After the dotcom bubble and the financial crash of 2008, laymen readily accept the image of the overconfident financial juggler.

However, this hypothesis can only be tested in a scientific economic experiment. For this reason, Fellner-Röhling has let her students trade in an artificial stock market. In order to create realistic conditions, they received financial rewards depending on their success.

First, they were given public information about the probability distribution of the asset value. Subsequently, they received private information. The correct estimation of the asset value should be based on a combination of both.

"A typical pattern is that the precision of the private information is overestimated. In the extreme case, the broker considers that his private information is absolutely correct and then accepts more risk than is justified when trading", according to Fellner-Röhling.

In experiments, Prof. Fellner-Röhling always attempts to disentangle cognitive and emotional factors. The difficulties of such an approach are illustrated by yet another phenomenon. She explains: "People feel much more pain due to a loss than pleasure due to a gain. If assets gain and lose in rapid alternation, people shy away from the investment risk. We call this myopic loss aversion." The time horizons that investors consider are often too short. The high volatility of the market is then obvious, but the long-term chances of returns less so.

Researchers have observed this type of myopia in students and professionals alike. Fellner-Röhling showed that this behaviour can be attenuated by two interventions. The participants in an investment experiment either received aggregated information—that combined short term gains and losses—or their investment horizon was extended.

"Investors were compelled to leave their portfolio unchanged for a certain period of time and not to sell it immediately when prices fluctuated. This constraint restricted their freedom of action, but increased their final returns."

Thus, it becomes clear that research does not stop at analysing irrational behaviour, but instead strives for solutions in order to protect both the individual and society from negative consequences. ■

> *"People feel much more pain due to a loss than pleasure due to a gain."*
>
> *Prof. Gerlinde Fellner-Röhling, Institute of Economics*

Calculating risks in the life sciences

Infection in hospitals is a burning question

The concept of risk is often used in medicine. How high is the risk of developing cancer? How risky is this operation? What are the risks of a specific drug treatment? Clinical studies must provide the answers. Biostatisticians are responsible for planning and evaluation. These experts must master the necessary mathematical and statistical methods, as well as having adequate basic knowledge of medicine and biology.

Prof. Jan Beyersmann, Professor of Biostatistics, explains the special features of this subject: "The biostatistician does not conduct research alone in his room, but collaborates with users. It is often a question of survival time analyses and these have a similar mathematical structure to insurance mathematics. However, the available data are different, so other techniques are used, too."

Ethics sets the limits

Before he starts calculating, the biostatistician must describe the term "risk". As Beyersmann explains, the problem is that this is not a clear case of right or wrong. He gives three examples of the difficulty of the design of a study and the definition of risk. In randomised studies, patients are assigned to treatment groups on a random basis. These are the gold standard for demonstrating the efficacy of drugs or treatments. However, a study of this sort would be unethical, if for example the mechanisms of action were to be compared of treatment with the patient's blood and with donor blood (for example in a study on cancer patients with transplanted blood stem cells). Experience clearly shows that the patient's own blood is better if possible.

For many patients, there is always the risk that the patient may be infected with other pathogens during treatment. The risk of infection is normally quantified as the number of infections per 1,000 patient days. In our example of patients with transplanted stem cells, the donor blood treatment suddenly leads to a lower risk of blood infection. However, if the risk is quantified as the number of blood infections per 1,000 patients, treatment with the patient's own blood decreases the risk (as expected).

This contradiction may be resolved by considering the mathematics and the medical situation. As Beyersmann explains: "Patients with donor transplants need longer to recover, and this leads to more patient days. At the same time, it is necessary to give them prophylactic treatment. This leads to a reduction in the risk of infection per 1,000 patient days. There are ultimately more infections than with the patient's own blood, although these are delayed."

"The new Act on Infection Protection shows what a hot potato this is. In general, there are too many infections in hospital and it is thought that this might be linked to the excessive use of antibiotics."

Prof. Jan Beyersmann, Institute for Statistics

The study described by Beyersmann provides new insights into the antibiotic prophylaxis of cancer patients. In general, the use of antibiotics may be problematical. "The new Act on Infection Protection shows what a hot potato this is. In general, there are too many infections in hospital and it is thought that this might be linked to the excessive use of antibiotics."

The search for relevant data

Another area of research is health care research as a component of health system research. This deals with the care, nursing, diagnosis, treatment and follow-up of the patient. "We evaluate the observation and settlement data of the health insurance funds, in order to investigate the risks during the course of the patient's treatment. For example, we may ask whether administration of beta-blockers has a favourable effect on life expectancy." Beyersmann chose this example to illustrate the procedure's potential for error. "If you compare patients who have regularly taken beta-blockers with those who have not taken them regularly, you come to the conclusion that beta-blockers prolong life. However, this is a mistaken conclusion. This is because only persons who have already lived long enough can belong to the group who regularly take beta-blockers. This is a faulty classification."

Back to the issue of infection. Residence time data are used to analyse infection risks and prophylaxis. The latter can also be thought of as the positive risk of avoiding an infection: Infections should be avoided. Then for transmittable diseases you can put the patient in an isolation room. However, this is expensive, particularly for intensive care patients. A cost-benefit analysis is then performed to balance the costs caused by an infection against the costs arising from infection prophylaxis. Thus, once again various risks are compared. But how do you quantify the costs of an infection?

"You compare the mean number of days for which an infected patient was in hospital with the number of days spent by an uninfected patient. You also have a specific cost rate for one such day in hospital. Here the mistake would be that an infection only affects costs when it has already occurred. A long term patient who was expensive may have lain for a long time because his infection developed early. Or it can be a patient with a late infection, who lay for a long time and had a relatively complicated clinical course. Sometime after two weeks he still developed an infection. However, this prior stay has nothing to do with the infection."

Jan Beyersmann considers that the chair in Biostatistics and the study program Mathematical Biometry provide considerable added benefit for risk research at Ulm. "The subject "mathematical biometry" is almost unique in Germany. There are study programs in the area of biostatistics, but only Ulm has the close relationship to mathematics." ■

A look at theory, analysis and everyday work in the private sector

Dr. Thomas Wiesemann, Member of the Management Boards of Allianz Lebensversicherungs-AG and Allianz Private Krankenversicherungs-AG

Ulm University (UUlm): Dr. Wiesemann, you studied Mathematics and Management yourself in Ulm. What was your experience?

Thomas Wiesemann: In 1986 when I started, there were several different universities where you could study these subjects in combination. However, the other universities offered more of a patchwork concept, where you had to gather up everything yourself. In contrast, Ulm offered a really integrated program, with the subjects mathematics, management, economics and computer science. There were already graduates when I started. Ulm had already left the experimental phase. Nevertheless, you could still feel the real passion from the beginning, both in student counselling and in the courses. I think the reason was that these were the people who had developed the integrated program of "Mathematics and Management" themselves in Germany and who fully supported it. We students were on good terms with the professors and the staff-student ratio was excellent. Fortunately it's still like this.

UUlm: You are not the only graduate who has remained in close contact with the university.

Wiesemann: From the very start, Ulm University has made every effort to keep in contact with graduates. In addition, in 1987 students and graduates of the Faculty founded the Verein Studium und Praxis e.V. [Society for Study and Practice]. This is about collaboration between companies and students and graduates of Ulm University. Seminars are held, with a large annual congress.

UUlm: What are the consequences for Ulm of the enormous changes in the financial services branch?

Wiesemann: In the context of the demographic transition and high public debt, there is an ever increasing demand for private pension schemes. But at the same time the volatility of the capital markets has greatly increased. It is therefore necessary to develop stable financial products that deliver sustainable results. Thus the theme of risk management has become more and more important. How can I incorporate resilient risk management into financial products which can fulfil this aim? There is no need for Ulm to change its concept. As a result of wise foresight, the combination of economic sciences and mathematics provides the correct mixture for this task. On the one hand, we need the mathematical abilities to develop the right models. On the other hand, it is just as important that these models function and fulfil their demands when they are used in reality by "real" people.

Dr. Thomas Wiesemann

> *"We students were on good terms with the professors and the staff-student ratio was excellent. Fortunately it's still like this."*
>
> *Dr. Thomas Wiesemann*

UUlm: How important is the relationship to practice?

Wiesemann: The Faculty greatly extended economic sciences for very good reasons. Attached institutes have been founded that work in close cooperation with the Faculty. They offer industry a variety of advisory and analytical services. This proximity to practice results in a spill-over effect and this again influences research themes.

UUlm: Your company also takes Ulm graduates.

Wiesemann: Each one brings his individual abilities with him. Generally, Ulm graduates usually master themes very quickly and can help to produce concrete results. This is because they have had a very good logical and analytical education. Thanks to the economic sciences, they also have a good understanding of the demands and challenges of real-world situations. ■

Ulm was the right decision

Students award an AAA for the combination of subjects

Lukas Hahn
Actuarial sciences

The great advantage of Ulm is that you don’t study mathematics in one place and management in another, but the study program Mathematics and Management, which is concentrated and clearly structured in a single site. I first learned the necessary basics. Then I could specifically design my study plan with the focus on actuarial science and statistics.

Ulm University has the reputation of being number one in insurance sciences; this is fully deserved. I was able to take all the certificates for actuary training during my degree course. Besides Erasmus, the university-specific partner programs have helped me to find university places abroad in Ireland and Canada. Most importantly, however, I would like to emphasise the reason why I think Ulm University is so successful. Whether you face a crucial decision or have simply got stuck in your work, it is very helpful that you have direct contact to the professors. Their doors are always open. ■

Ximena Navarro
Finance

I had already studied actuarial sciences in Mexico and worked in different financial institutions. Most students are male there too, but I have always found mathematics easy and fun. While searching for an English-language course abroad, I chanced on Ulm. Comparing Ulm with Mexico City you can say. The weather is poorer than in Mexico City, but the study program is very good. The professors are really interested in what the students are doing. The teaching in mathematics is a demanding mixture of theory and applied subjects, such as insurance mathematics. I have learned, for example, why the financial world does not necessarily need more and more new models. What is more important is to scrutinise and to understand the existent ones, their foundations and their assumptions. After finishing my Master’s Thesis on credit risk, I will attempt to gain more experience in a German company. ■

Karin Schiefele
Statistics

When I was at school, I enjoyed doing calculations. I now find it exciting to develop mathematical models, with which physicians can evaluate their research data. Besides Ulm, there are only few comparable institutes that combine methodological research with practical applications.

I started working on oncological studies for my diploma thesis. Here at the Institute of Statistics, I am continuing to work on issues related to cancer research. Physicians do everything in their power to prolong the lives of cancer patients. The challenge is that the drugs often cause intense side effects. Therefore, during the initial phase of development, you cannot use the usual procedure with healthy participants. The physicians work with severely ill patients. The number of participants is small and it is not easy to select the correct model. This research demands a great deal of responsibility and is mathematically very challenging. ■

Ulm University – strong overall profile

Dieter Kaufmann, Chancellor

As a member of the university board of Ulm University, I see the developments in risk management and insurance very positively. As described in the structural and development plan, we have set ourselves the goal of orientating research towards fundamental and applied questions in areas relevant to society. Ulm University integrates the political goal of sustainable development into a central idea overriding all subjects. The concept of sustainability then encompasses the orientation towards values related to the prosperity of future generations. These include elements such as economics, ecology and social issues. The themes of risk management and insurance precisely fit within this orientation of the University. The analysis is not only restricted to insurance scenarios, financial risks, or environmental or supply risks, but also examines behavioural-oriented aspects in economics and management. The former considerations are often supported by computer sciences; the latter investigations are carried out in close cooperation with medicine and psychology.

As a university dedicated to medicine, engineering and natural and economic sciences it is possible to consider the issues holistically, as the problems of today can only be considered in collaboration with, and beyond the limits of the individual sciences. This is also evident in the unique constellation and the good cooperation between the two disciplines—mathematics and economic sciences. The mutual enrichment through a lively exchange and efficient cooperation with the natural and life sciences and engineering is contributing towards strengthening the profile of our university.

Contacts and exchange with industry are important for Ulm University and include externally funded projects, advisory work, analyses and mediation of practical work for students. In this way, we ensure that our scientific work addresses the challenges of today.

Ulm University has developed a unique profile, with a focus on sustainability. Ulm University is searching for solutions in economics and health services research. In addition, the University contributes to sustainability in numerous joint projects, e.g.:

- Green electronics to reduce the power consumed by electrical instruments,
- New battery technologies for electro-mobility and stationary stores,
- Accident-free driving and new mobility concepts,
- Research and treatment of infectious diseases,
- Healthy nutrition and aging,
- Biodiversity.

My task and the task of our administration is to support our scientific facilities through suitable structures in the pursuance of their own responsibilities and to concentrate our strengths. We live in a highly dynamic and innovative environment. It is not clear today what might change the world of tomorrow. I understand the duty of administration as providing support that allows scientists to produce excellent results in research and teaching.

As Chancellor, I have to consider not only “How?”, but also “Where?” Together we have to find the right themes to create a strong position for ourselves in competition with other universities. We must identify future-oriented thematic issues related to sustainability or similar topics. In doing this, we must create synergies between the individual disciplines and thus strengthen our profile.

As a university, we fulfil our social responsibility by making substantial contributions to scientific problems of social relevance in research and offering our students training at the very highest level that considers the needs of society and industry. ■

Dieter Kaufmann, Chancellor

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