Integrated Risk Management with Cash-Flow-at-Risk/Earnings-at-Risk methods

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1. Lifeboats are built in good weather and not during storms

Taking risks has always been an essential part of entrepreneural activity. The term risk comes from the Italian word "riscare", which is translated by "shipping around the cliffs or more generally to dare something (F1). Risk does not mean to be left alone with one's destiny. It mainly means an active decision for or against risk. As an example in the last few years one could observe major restructuring in companies like DaimlerChrysler, the Deutsche Bank and Preussag (now TUI). Enterprises have on purpose accepted new risks to take advantage of the accompanying chances.

A more recent example is the conscious acceptance of risk with the buying of UMTS-licenses. The expected profit for the telecoms was very appealing, although the accompanying risk of investments was enourmous. To be able to judge objectively whether the risks that accompany a chance are justified, an integrated observation of risks and profits is required. Financial risks and chance can be compared with statistical models.

In the early 90s statistical methods entered the Risk Management department of banks. Trading departments were leading the way, and developed early methods to estimate the potential loss of different financial portfolios. For banks it was relatively easy to develop risk models, as from financial instruments like bonds it is easy to work out a definite Cash-Flow.

The market value of financial portfolios can be measured every day without too much effort. Volatiliy and therefore the risk of market prices like interest-, currency exchange rates and raw materials is measureable. It is equally easy to cover open financial positions (and can be done quickly) with the help of derivatives. Therefore banks generally use a short-term horizon (1-10 days) to navigate and estimate their potential loss for relatively short time spans (1-10 days). The short forecast horizon simplifies modelling.

In the non-financial industry the overall image is slightly different, which does not allow the direct copying of the model used in banks (F2). Contrarily to banks, not financial portfolios but the operational business is the main risk factor (operational risk). Also the required time period is much bigger than in banks. Like a big moving supertanker, companies cannot start to navigate only once the iceberg is directly ahead. One has to take into account the long braking distance. This requires risk analysis looking far into the future. Risks that are relevant for the company like the loss of market share cannot be covered with derivatives and operational actions need some time after the deployment before the consequences start kicking in.

Therefore lifeboats must be ready before a crisis starts. This requires concepts that allow to detect risks as early as possible and to consequently enable early action. For this task classic Value-at-Risk-models from banks can only be applied within limits (F3).

2. Models and the belief in models

Companies require flexible risk models, which take the operative business into account and where the uncertainty of future Cash-Flow forms its own risk factor. Additionally one has to model the dependance of market price changes and the profits, respectively earnings from future sales. A change in currency exchange rates could lead to a significant decrease on the export markets of a business.

Taking into account the various enterprise specific requirements for risk measurement we can derive the following minimal requirements for risk models.

Instead of assuming certain and constant Cash-Flows, uncertain Cash-Flows have to be modeled, which might be due to random changes in sales volume.

One should try to achieve an integrated risk measurement, which for example includes that changes in the market price caused by unfortunate developments of the currency exchange rate have consequenes for the sales volume.

To satisfy these requirements, a few modifications are necessary to the classic Value-at-Risk approach. If future Cash-Flows are uncertain, no certain present value can be determined. Therefore risk measurement must be based on the Cash-Flows. But if instead of only the present value the entire Cash-Flow is examined, the distribution of the risk factor at the end of the forecasting horizon is no longer enough. Instead one has to simulate the entire path of the risk factor all the way through the forecasting time span. We use Random Walks for this.

A Random Walk is a random process (F4). The choice of a random process is based on the idea that risk factors like market prices only change when the market participants obtain new information. If and when new information is available depends on chance. The same applies to the change of other risk factors like interest rates, currency exchange rates or the prices of raw material, which also depend on chance.

Random Walks can best be compared with the walk of a drunk man (F5). When he starts walking back home at the end of the evening, every single step is difficult to predict, but generally one can assume that he will aim towards his home. It remains uncertain exactly which way he will choose. This example clearly shows, that Random Walks (stochastic processes) can be combined with a trend (deterministc component).

Using stochastic processes, one can simulate the development over time (paths) of interest rates, currency exchange rates and raw materials as well as the development of the sales volume. One has to distinguish two different points of view. First, income and expenses of the company can be regarded. This is the base of Cash-Flow-at-Risk models. Second, the development of orders and expenses can be simulated (Earnings-at-Risk) on balance sheets. The difference between Cash-Flows and Earnings arise from national accounting standards and disclosure requirements.

For example buying raw materials leads to immediate costs, but not necessarily to immediate expenses. The raw material only gets added to expenses when they enter the production process. Therefore not every cost leads at once to postable expenses. The same is true for buying assets like new planes for an airline company. Buying leads to an immediate outgo, expenses only enter when it comes to periodic amortization. Therefore a time difference between outgo and expenses can exist. The difference between models for Cash-Flow at Risk and for Earnings-at-Risk lies in the different input factors. The mathematical modeling is the same in both approaches.

Independent of whether one looks at Earnings-at-Risk or at Cash-Flow-at Risk, with the help of stochastic processes one can simulate as many scenarios for the developments of the risk factors up to the planning horizon as wanted. With roughly 10,000 simulated paths one can construct a two-sided confidence interval. The size of the confidence interval is dependent on the desired propability of the prognosis. Figure I is a confidence interval for the currency exchange Euro/US-Dollar with a probability of 90% and a planning horizon of 12 months. A probability of 90% means that in 90% (9.000 out of 10.000) of the simulated paths the currency exchange rate Euro/US-Dollars falls in that intervall (F6).

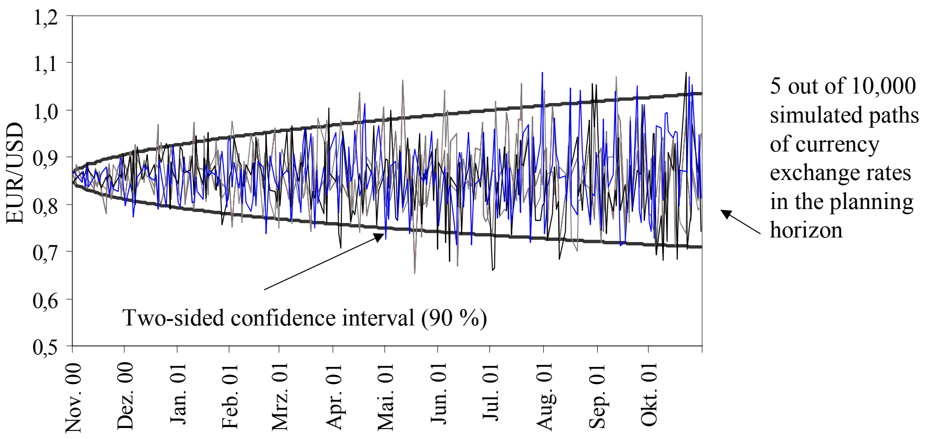


Fig. 1: Two sided confidence interval; 5 of 10.00 simulated paths are visualised to show the change of the currency exchange rate in the planning horizon. The enveloping lines show a 90 % confidence-interval.

Depending on whether an increasing or decreasing exchange rate is a risk for the company, 95% of the simulated paths lie above or below the boundary path, which reflects the worst case with 95% probabilty. For an exporter from the eurozone the risk lies in rising Euro/US-Dollar exchange rates. Therefore the company will be interested in the worst currency exchange rate for the next 12 months. Conversely, the risk for an importer lies in falling Euro/US-Dollar currency exchange rates. Every company needs therefore to decide individually which development of the risk factors lead to a positive or negative effect.

People often criticize that the complexity of sophisticated statistical models lead their users to a blind belief in the models. Based on a wrong diagnosis indeed wrong actions can be taken, if users no longer scrutinise the results. In 'Jorion' (F7), a critic of statistical models says, that a pilot who only uses the altimeter and no longer looks out of the window will crash as soon as the altimeter fails. Of course a pilot should not fly by altimeter only, as it is only intended as a supporting tool for the pilot. One has to understand the statistical models as decision aid, but not replacing the Risk Manager and releaving him/her from taking decisions.

This anecdote shows that one has to clearly understand the assumptions and limits of the used models. All models abstract from reality, otherwise they could not work, due to the complexity of reality. Only once the user knows the assumptions and limits of the models, he will be able to use them appropriately. A detailed analysis of the assumptions of Value-at-Risk can be found in 'HAGER' (F8).

3. Cash-Flow-at-Risk in an export based company

3.1 Entrepeneural risk inventory

In a risk inventory one has to work out which risks exist in and for the enterprise and what major impacts they have on the overall success of the enterprise (F9). We extended the schema in Nader (F10) and structure the inventory as follows:

1) Discover all existing risks and classify different risk types
2) Measure/estimate the size of all existing risks
3) Take a decision for each existing risks or combined risks.

   Either

   - Accept the risk, as the expected return is adequate.
   - Manage the risk in one of the following ways:
     i. Accept the risk completely and add the price of the risk to the price paid by the customers.
     ii. Reduce the risk by hedging or diversification and add these costs as well as the remaining risk to the prices.
     iii. To pass on the risk, e.g. to (re)-insurance. These insurance fees are added to the price of the products.

   Or reject the risk due to one of the following reasons

   - The return is in no relation to the risk.
   - The market situation does not allow the price increase for the product/service.
   - There is no market or only unsatisfying mechanisms to secure against the risk or covering the risk is just too expensive.

In the area of financial risks, the focus lies on interest rates, currency exchange rate and the price of raw material. Generally one can distinguish for all these market price categories between value- and Cash-Flow-exposures. Value-exposures reflect assets like portfolios with fixed interest rates, foreign currencies or stock of raw materials. We use Value-at-Risk (F11) models to measure value-exposures.

Cash flow-exposures include not only fixed payments, but also positions for which the Cash-Flow is uncertain and which therefore can't be aggregated to the present value directly. Examples are income form future sales or expenses for raw materials, as long as one cannot securely forecast the necessary quantities. The dependence between market price risk and the expenses of a company can be modeled relatively easily, but mapping the interdependencies between the market price and sales is more challenging. Here one can apply the in marketing known models of price elasticity or econometric models (F12).

The following example shows the methodology and process of Cash-Flow-at-Risk models with a case study (F13). A German manufacturer of housewares produces gold and silver cutlery and exports them to the USA. For one cutlery set 10 troy ounces (oz) of gold and 10 troy ounces (oz) silver are needed. On the world-wide market, both raw materials are traded in US-Dollars. The selling price for every canteen (cutlery set) is 6.000 US-Dollar for the American wholesaler. Due to cut-throat competition, any change in raw materials or bad currency exchange can't be passed on to the customers by a price increase.

Since American customers have started brewing their own beer, the company also exports copper kettles to the USA. The kettle is coated with an aluminium casing. By marketing a second product, the enterprise hopes to diversify its risk. 25kg of copper and 10kg of aluminium are needed to manufacture the copper kettle. These two raw materials are also traded in US-dollars on the world markets. The kettle is sold for 250 US-Dollar to the American whole saler.

First for the operational area one has to plan the Cash-Flow for the next 12 months. On 28.11.2000 the sales department plans for monthly sales of 250 canteens and 1.000 copper kettles for the next 12 months, based on a market study. Additionally they assume that the sales will fluctuate about 10% around the expected value. Therefore the monthly sales of canteens will be in the between 225 to 275 pieces and a standard deviation of 25 is assumed. Monthly sales of copper kettles will also be assumed to be normally distributed between 900 and 1.100 pieces.

Now one also has to look at the competition, Yama Hatschi, the Japanese manufacturer of cutlery and copper kettles, which contrarily to the German manufacturer, does not offer its products on fixed US-Dollar price, but in YEN to eliminate the currency exchange risk. Yama Hatschi's cutlery costs 720.000 YEN per unit and the copper kettles costs 30.000 YEN per kettle. The market in America is very competitive and customer loyality to a specific manufacturer is low. At the time of the risk prognosis (28.11.2000) currency exchange between US-Dollar/Yen is 110,14. Therefore for the American whole saler it does not pay off to buy from Yama Hatschi. A canteen would there cost 6.537 US-Dollar (=720.000 YEN / 110,14 US-Dollar/YEN) instead of only 6.000 US-Dollar from the German manufacturer. The price for a copper kettle would correspondingly be 250 instead of 272 US-Dollar.

But as soon as the US-Dollar gains value against the Yen and reaches a level of 120 US-Dollar/YEN, the products from Yama Hatschi are cheaper for the American whole saler than from the Germany producer. With an exchange level of say, 121 US-Dollar/YEN the canteens from Yama Hatschi would cost only 5.950 US-Dollar and the price of the copper kettle only 248 US-Dollar. The Risik model therefore assumes, that the sales of the German manufacturer drop at once for both products by 30% as soon as the exchange rate rises above 120 US-Dollar/YEN.

After an initial prognosis for the next 12 months, the enterprise expects a Cash-Flow of 8 Mio. Euros in total due to export income minus the costs for raw materials. The finance departement is asked to work out estimates for the Cash-Flow-at Risk based on market price changes for raw materials and the currency exchange rates. To summarise, this risk inventory identified six relevant risk factors: the raw material prices for aluminium, gold, copper and silver as well as the two currency exchange rates of EUR/US-Dollar and US-Dollar/YEN.

3.2 Measuring Cash-Flow-at-Risk

The basis for risk measurement is an exposure-map, where all dependencies between sales volume and market prices are systematically identified. The exposure-map describes how income and expenses of the company change with varying market prices. No standard exists for the creation of exposure maps. Every enterprise has to construct its own exposure map, based on knowledge from the risk inventory.

The exposure-map for the enterprise of our case study contains four equations. The first equation calculates the cost of raw materials for the canteens. At the start of each month raw material is bought according to the "just in time" principle. To simplify we assume that no stock is required and only the quantitites for the whole saler are produced. This allows to achieve an especially low sale price. According to the same methods, the material costs for copper kettle is calculated.

The monthly sales volume in US-Dollar is calculated by multiplying the sales quantity with the sales price (in US-Dollar) of each product. The monthy sales volume in EUR is calculated by the sales volume of the previous month in US-Dollars and the current currency exchange rate. Let's look at January 2001: on December 1, 2000 the raw materials for December are bought. The finished products are shipped in December. At the end of the month the whole salers pay their bills to the manufacturers. Money arrives at the manufacturer the 2nd of January 2001. At the date of arrival, the received US-Dollar sum is translated into EUR. Due to the necessary transport time, the paytime frame for the whole salers and the duration of the cash transfer in the banking system, there is always a time lag between the buying of the raw materials and the sale of the finished products, so that the payments have to be exchanged with different currency exchanges.

Equation 1: Material costs per set $= \dfrac{\text{10 oz gold} \cdot \text{gold price in USD} + \text{10 oz silver} \cdot \text{silver price in USD}}{\text{currency exchange rate EUR/USD at the start of month n}}$

Equation 2: Material costs per copper kettle $= \dfrac{\text{25 kg copper} \cdot \text{copper price in USD} + \text{10 kg Alu} \cdot \text{price of Alu. in USD}}{\text{currency exchange rate EUR/USD at the start of month n}}$

Equation 3: Sales volume per month in USD = Nr. of exported canteens · 6.000 USD + Nr. of exported kettle · 250 USD

Equation 4: Sales Volume per month in EUR $= \dfrac{\text{Sales volume in USD for month n}}{\text{currency exchange rate EUR/USD at the start of month n+1}}$

All shown dependencies between raw material prices, currency exchange rate and the quantities are linked together in a spreadsheet to be able to simulate the Cash-Flows for the next 12 months. To be able to cope with unexpected increases in raw material expenses, the Cash-Flow is calculated after subtracting the raw material expenses. For examples from the sales obtained during the month January, the expenses for the therefore needed raw materials are subtracted. The simulated sales quantities include if-then conditions, wich simulate the drastic decrease if the currency exchange rate rises above 120 US-Dollar/Yen.

For each of the six relevant risk factors (market prices for aluminium, gold, copper and silver, currency exchange rates for EUR/US-Dollar and US-Dollar/YEN) we simulate 10,000 price paths for the next 12 months till the end of the planning horizon. We get 10.000 scenarios for which we also model the results of the changes in all six risk factors with the help of exposure maps. We therefore simulate 10.000 possible Cash-Flows (cf. Fig. II) for each month in the prognosis horizon. For improved clarity we accumulate the simulated Cash-Flows for each scenario into a yearly Cash-Flow, from which we can estimate the distribution of the Cash-Flow for the entire year.

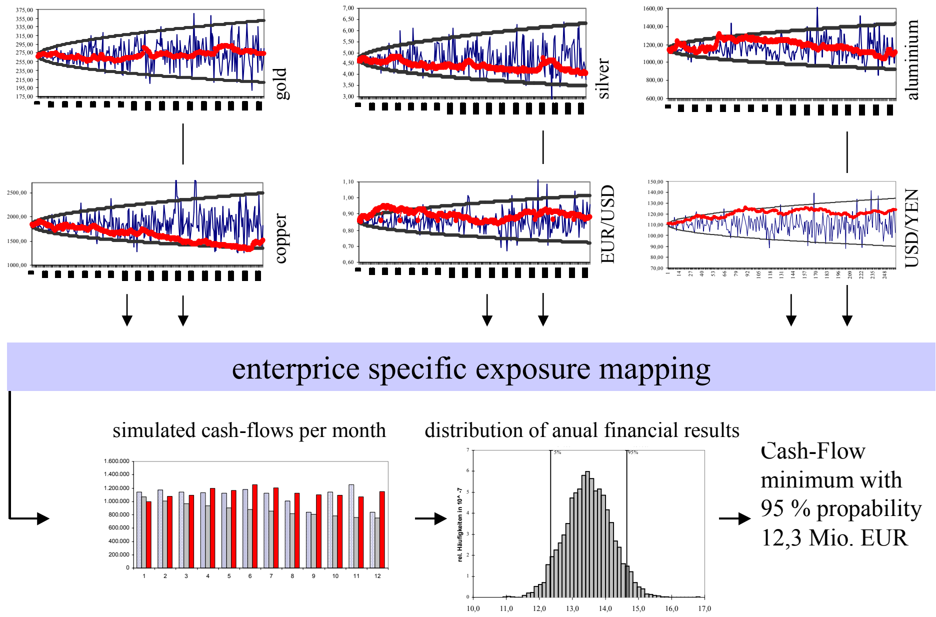


Fig. II: Cash-Flow-at-Risk calculation

Using the frequency distribution one can estimate a yearly Cash-Flow, below which one will not fall below with a given probability. The Cash-Flow-at-Risk is defined as the unexpected deviation of the expected value, which can either be the average of the distribution of the yearly Cash-Flow or a desired yearly Cash-Flow. In our case study the enterprise aims at gaining a yearly Cash-Flow of 14 Mio Euro, after the reduction of material costs. The simulation of minimum (95 % probability) Cash-Flow leads to a value of 12.3 Mio Euro. The maximal unexpected deviation (95% probability) for the planned yearly Cash-Flow of 14 Mio Euro is 1.7 Mio Euro (=14 Mio. EUR – 12.3 Mio EUR) and represents the Cash-Flow-at-Risk (cf. Fig. III).

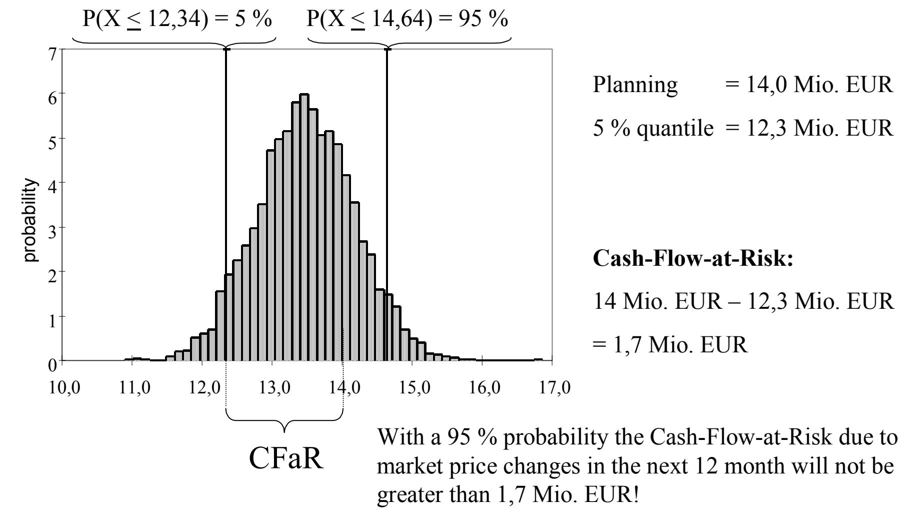


Fig. III: Cash-Flow-at-Risk distribution

Once the Cash-Flow-at-Risk calculations are done, one has to decide if the enterprise can bear the risk. For this all other additional expenses have to be planned and put into the minimum-Cash-Flow. The enterprise expects the following expenses in the next 12 months.

(1) fixed human resources	7,5 Mio. EUR
(2) fixed operating expenses	3,5 Mio. EUR
(3) necessary reinvestments	2,3 Mio. EUR
(4) debt capital interest rates	1,0 Mio. EUR

From the frequency distribution of the yearly Cash-Flow one can work out the probability distribution function. This allows to tell with what probability the various expenses can be covered by the yearly Cash-Flow. Once the material costs are taken off the minimum Cash-Flow will be enough to cover the expense positions 1-3 (cf. Fig. IV) with 60% probability. The cover of all positions is guaranteed with only 12% probability. The probability to reach a Cash-Flow of at least the planning value of 14 Mio. Euro is 22%.

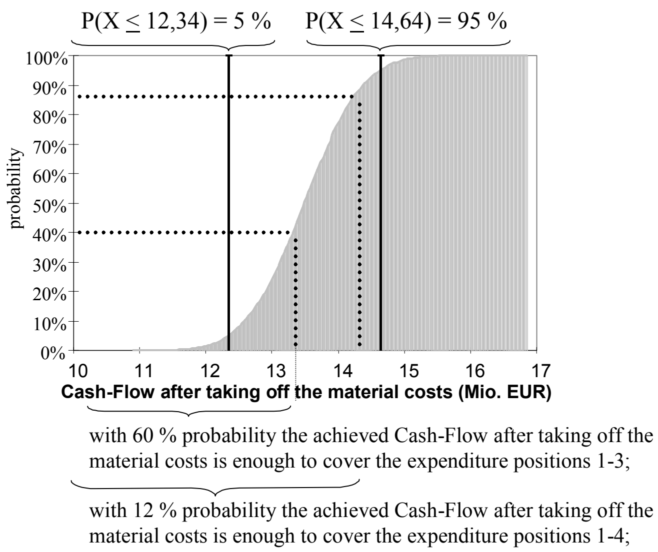


Fig. IV: Distribution function of the expected income and expenses

The Cash-Flow-at-Risk Model gives early control impulses. It indicates with what probability liquidity problems will occur due to unfortunate market developments in the next business year. In its budget the company had already taken care of bad a market situation and despite of expected income of 14,3 Mio EUR only planned with a sum of 14 Mio. Euro, but the real liquidity problem could become much worse. As with 95% probability the minimum cash flow is 12,3 Mio EUR, with the same probabilty a liquidity problems will not be more than 2 Mio. EUR. If the company can not accept this, at the start of the planning horizon it still has a chance to minimze the impact by starting control reactions.

3.3 Derivation of controlling methods

Once the enterprise has calculated its risk potential, it can systematically manage the risks. Currency risks and raw material risks can be controlled with derivatives and forward contracts. This reduces the market price risks and leads to less Cash-Flow-Volatility (cf. Fig. V) F14. Especially in countries with a progressively increasing tax income the use of result volatility can lead to tax savings. Additionally the enterprise could try to increase customer loyality by operational and strategic measures, so that in times of bad currency exchange rate developments fewer whole salers buy from the Japanese competition.

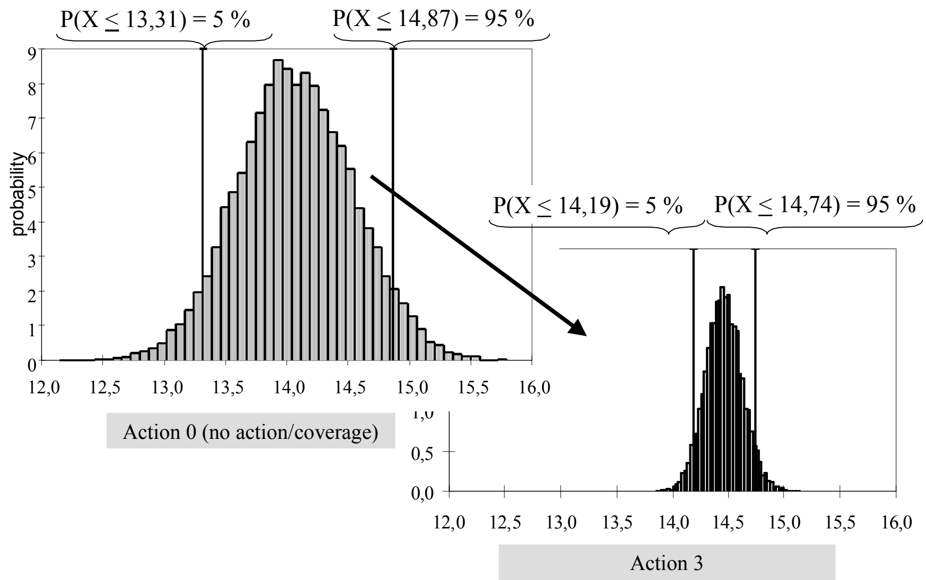
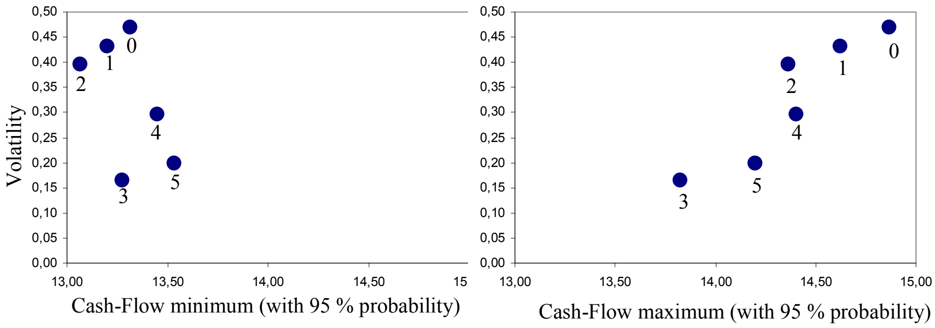


Fig. V: Comparison of the results with and without coverage

When using risk coverage, one has to consider that by using symmetric derivatives, the risk reduction is always accompagnied by a reduction of the chances. Symmetric derivatives contain all instruments where buyer and seller have the same win and loss chances (e.g. Swaps, forward contract) F15. Symmetric coverage instruments cause therefore only low costs at time of the contract sale.

On the other hand, when buying asymmetric derivatives like options, the customer has to pay a premium. Asymmetric derivatives are characterised by the fact that the seller gets a limited winning chance the size of the premium and an unlimited risk of loss. Contrarily the risk of loss for the buyer is limited to the paid premium, but his winning chance is theoretically unlimited. Based on the chosen base price, the premium that must be paid can be very high. Therefore the buyer gets the advantage of limiting risk, while keeping chances open at the same time.



Action	CF before action	action costs	CF after action	CF volatility
0	14.865.860	0	14.865.860	470.876
1	14.913.510	294.065	14.619.445	433.254
2	15.273.800	911.088	14.362.712	396.099
3	14.735.990	911.088	13.824.902	165.942
4	14.403.760	0	14.403.760	295.999
5	14.534.740	338.772	14.195.968	199.651

Fig. VI: Chance-Risk comparison for different hedging strategies

Figure VI shows the different actions and their impact on the yearly Cash-Flow and its volatility. Action 0 means no coverage. Here the volatility is the highest. The minimum Cash-Flow with 95% probability is 13.31 Mio EUR, the maximum cash-flow 14.87 Mio EUR. Of all possible actions, doing nothing leads to the biggest spreads of the yearly Cash-Flow.

In actions 1 and 2 options on all four raw materials are included. The two actions differ only in the size of the chosen strike price for the option. In action 2 the covered prices are relatively low, so that executing the option is rather likely and the premius are correspondingly high for action 2 compared to action 1.

The premium payment for the extensive coverage in action 2 shrink the minimum Cash-Flow and the maximal Cash-Flow disproportinately, so that both values are worse than action 1. Action 1 as well as action 2 lead to worse yearly Cash-Flows than taking no action (action 0), but both actions reduce the volatility for the yearly Cash-Flow.

Action 3 extends action 2 and contains an additional coverage against currency exchange risks with the help of forward exchange dealings. Forward contracts are symmetric and therefore limit especially Cash-Flow-volatility. Action 3 leads to the smallest of all volatilities in the yearly Cash-Flow. With symmetric coverage instruments one at the same time limits chances, so that action 3 gives the smallest with 95% probability reachable maximal-Cash-Flow.

Action 4 only consists of forward exchange dealings to secure the currency exchange risk EUR/US-Dollar and therefore does not cause expenses at the time of the contract conclusion. The yearly Cash-Flow is not charged with expenses for coverage, so that action 4 leads to a higher minimal Cash-Flow than action 1 to 3. As obtaining raw materials as well as the exchange of the gained sales face currency exchange risk, this method leads to a significant reduction in Cash-Flow volatility.

Despite the fact that compared to action 0 in action 4 the volatility decreases by nearly 40% (=295.999/470.876), at the given probability the reachable maximal Cash-Flow decreases only by 3% (=14.403.760/14.865.860). The decrease of the maximal Cash-Flows is due to the symmetric effect of forward contracts. At the same time, at the given probability level, the minimal Cash-Flow increases by about 1% (=13.449.930/ 13.311.200).

In action 5 a combination of the coverage of the currency exchange risk with the help of future contracts and the coverage of the price of raw materials for the most expensive raw material gold with the help of options. The selective choice of single risk factors for the coverage leads to smaller premium payements than actions 1 to 3.

The volatility of the yearly Cash-Flows is strongly reduced by action 5 and reaches the second best value (with ascending sorting). At the same time action 5 leads to the highest minimum Cash-Flow. Both criteria together make this action to an interesting packet for conservative risk management, but one has to cut back the with 95% maximal reachable yearly Cash-Flow. Here action 5 performs worse than packets 0, 1, 2 and 4.

Based on the simulation of Cash-Flow-at-Risk taking coverage intstruments and the associated costs into account, an enterprise can decide how much risk it wants to reduce and on what chances it therefore has to give up. Generally one will see here, that not all control mechanisms are efficient (F16).

4. Modern mathematical/statistical models and methods

We briefly mention selected models and methods, which can be relevant for the modelling of CFaR. The main interest of the Risk Manager lies in the interpretation of the results. Even a well-founded analysis is of little use if a Risk Manager does not know what the result means and what uncertainities are attached to it. Sometimes the rough size and the development tendency is more important for Risk Managers than exact numbers. A validation of what effects potential actions on the risk would have can also be helpful.

The challenge lies in comprehensive and coherent modelling of all financial and operational risks and their consequences: a complex and always enterprise specific task.

4.1 Models

4.1.1 General models

Models are often built on historic data or from local expertise on the fundamental processes. To make the conclusions of these models worth anything, it is essential that the (often implicit) assumptions of the model are satisfied in reality. One example is the different cornering ability of a car on dry and slippery (icy) roads. The "summer driving" style should definitely not be used in winter. With mathematical models, sometimes a transformation of the data can increase the possible applicable data range: While it's very difficult to predict share prices, one can model the log-Return value much easier, which is derived from the share price. By gaining this simplicity it becomes possible to continuously control the data in automatic running tests and to immediately pass on important deviations to the Risk Manager.

The already mentioned Random Walks are very simple models, but even these require the estimation of deterministic components. One might use various resampling methods like the bootstrap (F17).

Random Walks as well as Brownian motions are memory-less. The change in the simulation from one timestep to the next is not dependent on the last value. The well-known Black-Scholes model uses an exponential model (geometric Brownian motion) to model the price change. More realistic models are obtained using Markov-Chain Monte Carlo (MCMC) (F18) methods, as here the simulation steps depend on the actual state. MCMC is booming in the last 10 years, as powerful computers can simulate in rather short time stochastic processes, as e.g. used extensively for the modelling of currency exchange risks and associated hedging strategies.

Many other models are well suited (with limits) to model financial time series. Most popular are GARCH (F19) (generalized autoregressive conditionally heteroscedastic), SV (F20) (stochastic volatility) etc. They reflect the standard model of log-returns, but can't explain "heavy tails" too well: Financial data is often not normally distributed and shows more very small and very large values as predicted by the standard model and asks for an analysis using Extreme Value Theory (EVT). Based on the problem at hand, data and the goal of the diagnosis one has to take a pragmatic choice amongst these models.

4.1.2 Special models

The bond market tells us, what today's money will be worth in the future. Here stochastic processes are used for the risk analysis, too, but compared to share prices, one does not assume exponential movement of interest rates, but assumes the short rate to fluctuate in a defined interval. The standard models are Ho-Lee, Vasicek and Cox-Ingersoll-Ross.

Term structure models: For the stochastic modelling of fixed interest rate bonds we use CIR (F21) models, as they fit the local market best. If we enter a deflation, Vasicek models would be more suitable, as negative interest rates could arise. At the moment we prefer the CIR-2 model for the German bond market as it is more realistic than CIR-1 and at the same time numerically more stable than CIR-3 and popular with indudstrial doers.

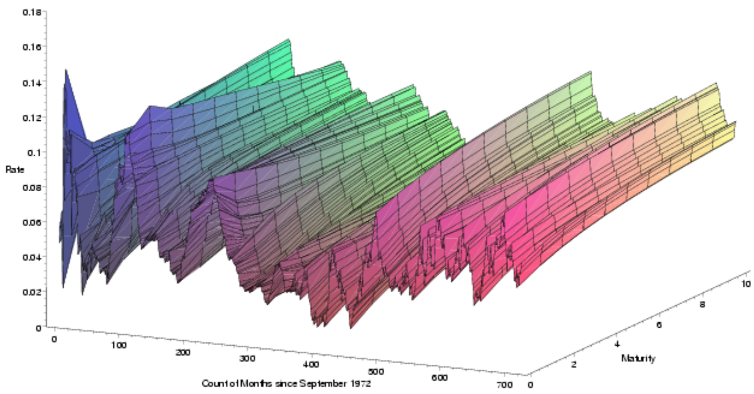


Fig. VII: Sophisticated CIR-2 (F22) model to simulate realistic interest rate structures for the German bond market. If Germany (as already happened in Japan) falls into *deflation, or one wants to take that possibility into account, one should use "Vasicek models". The first 362 values are historical data followed by simulated values. One clearly sees the peaks generated during the oil crises (1972/73) at the left side of the graphic.*

Market models: For the famous Black-Scholes (F23) model, which works out the price of options, the Nobel price was given in 1997. The seller of a European type option does not wait passively till maturity, but instead invests a certain amount of money in the same share and in a riskless asset (e.g. bond) using a dynamic strategy, so that the value of the portfolio at maturity equals the value of the option at maturity: either zero, if the share price is below the "strike price" (fixed price, at which one can buy or sell an asset), or the positive difference between the share and the "strike price". If an option is sold at a different price than the Black-Scholes price, a rational trader can make profit without risk ("arbitrage").

Based on our experience, for a model to be successful it must be widely acceepted, which is certainly true for Black-Scholes, though from time to time there are shocks on the stock market (e.g. through political results, recessions, etc.), which show the limits of these models: We think for example of the black Monday of October 1987 or the Baring Crash. The problems around Long Term Capital (LTCM) Management, a Hedge-Fund, where Scholes and Merton were amongst the founders caused in a one week the dollar to fall against the Yen by 13.7% (F24). We can cover these extreme cases using Extreme Value Theory (EVT).

Risk Managers should know the assumptions, weaknesses and strengths of their models (cf. model check Fig. 3). If possible models for the entire enterprise and dependencies of the various factors should be take into account.

4.1.3 Estimation

Nearly all models require calibration by estimating parameters. Generally speaking the variables are chosen so that the model fits the data well. Based on the requirements this can be a simple optimization of the maximum likelihood (F25), or a more complex method like Kalman-filtering (F26) (e.g. with CIR models), or requiring resampling techniques like the bootstrap.

Estimation is generally connected with optimization. If easier gradient-based methods which follow the slope of the search surface fail, genetic or swarm particle algorithms (F27) are often a solution. Genetic algorithms imitate the natural selection principle "survival of the fittest" by starting with a random population of possible solutions and then continue to combine the best (interbreed; reproduction) or slight modification (mutation) and after millions of iterations (generations) use the results. Swarm particles follow a similar nature imitating approach, which is like human learning a combination of group and single learning. Genetic algorithms and swarm particle algorithms may require a lot of computing power, but are very robust and versatile.

4.2 Simulations

Simulations enable deeper insight in the behaviour of complex systems. As soon as one starts combining several factors, the simulation can become very compute intensive, but can be executed transparently in parallel on several computers simultaneously (F28). What is the "best" method to minimize the risk of an entire company? A simulation shows the consequences of possible decisions. Algorithms from the area of artificial intelligence and financial mathematics allow the targeted search for better strategies.

One main topic are so-called nonparametric methods like non parametric density estimations or approaches like non parametric regression. Non parametric approaches are much more flexible than their parametric pendants and are used nowaydays mainly for explorative data analysis. A second important issue is the use of high quality random number generators, especially for modern Markov Chain Monte Carlo (MCMC) methods. MCMC approaches draw random numbers from highly dimensional distributions and are used often in Bayesian settings.

4.3 Random number generators

High quality simulations require the optimal interplay of many small details like the use of high quality random number generators (F30), so that not the entire simulation is weakened or even made useless. It is crucial that complex simulation that due to time constraints are executed on several computers simultaneously use independent random number streams, as otherwise all computers work out similar scenarios, so that no advantage compared to one compuer is obtained.

4.4 Risk and performance measures

The risk and the performance of a portfolio or a company is objectively measureable and can therefore be optimized. Therefore the Risk Manager develops strategies to produce out of the used capital at a fixed risk level as much profit as possible. To limit the risk in the finance area the Basel-Committee (1992) and the EU (EEC 93/6) have introduced the directive that banks and investment companies have to put money aside to cover market risks. This security coverage strategy should be applied in all companies. Value at Risk (VaR) is the best known risk measure in the finance world. For enterprises on should look at the Cash-Flow-at-Risk (CFaR), as already mentionned.

Both have weaknesses, as for example subaddivity, that is diversification is not fulfilled. The risk that two events X and Y happen at the same time should be less or equal to the risk that the event X and event Y happen individually. At the moment leading experts prefer Expected Shortfall as risk measure. While VaR is a threshhold, which only in α% of the cases is surpassed, the Expected Shortfall is an expectation (average) of all losses, provided that one has already fallen below the threshold. We recommend the modelling of "Expected Cash-Flow Shortfall".

Additional Risk measures are RAROC (F31) and RORAC (F32), the „Return on Risk Adjusted Capital". The income of an enterprise is adapted to the individual risk and put in relation to the amount of capital used. This allows to improve the allocation of capital and the aggreation of risks.

The choice of risk measures, so what is measured and how the results are combined later should be done carefully as the consequences can be far reaching. The wrong combination of dependent risk measures can in the easiest case be useless and in the worst case lead to wrong decisions. The common modelling of different risks might require the use of Copulas.

4.5 Extreme Value Theory (EVT) and Copulas

John Meriwether, one of the key persons behind LTCM (F33) told the Wall Street Journal in an interview (21.8.2000) about his new company JWM: "With globalisation increasing, you'll see more crises. Our whole focus is on the extremes now – what's the worst that can happen to you in any situation – because we never want to go through this again" (F34).

EVT describes und understands quantifiable events that rarely happen. It is especially well suited to describe the „heavy tail" in win- and loss distributions. EVT fits well to financial time series like logarithmetic returns that are not normally distributed.

Not only the modelling, but also the question how one should handle these extremes from an economic point of view is important (F35). Leading experts like Paul Embrechts and Valerie Chavez propose the integration of EVT in Risk Management systems.

One potential area of application is the risk estimation in the export market in an enterprise. What size can a drop in sales be and how likely is it? (F36). EVT looks at such rare events, which may have dramatic impacts.

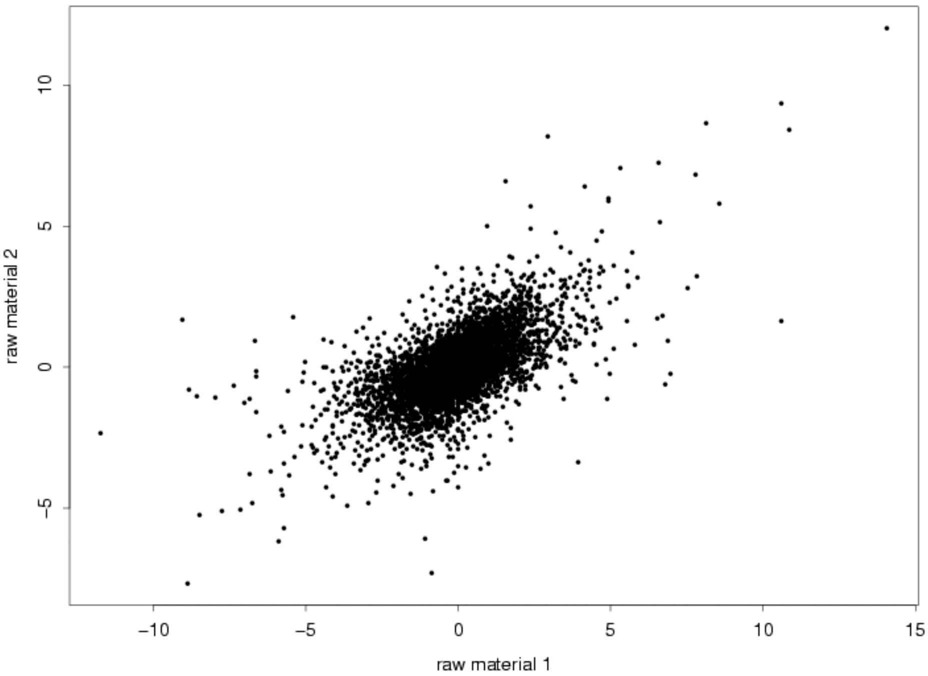


Fig. VIII: The plot of the negative log-return of two raw materials shows their dependance and requires more sophisticated modelling, e.g with Copulas.

Copulas:

Copulas (F38) help with the modelling of complex dependencies, which happen frequently in real life. In our above export example modelling is additionally made more difficult as the exchange rates are not independent. The exact correlation is often unknown and generally non-trivial.

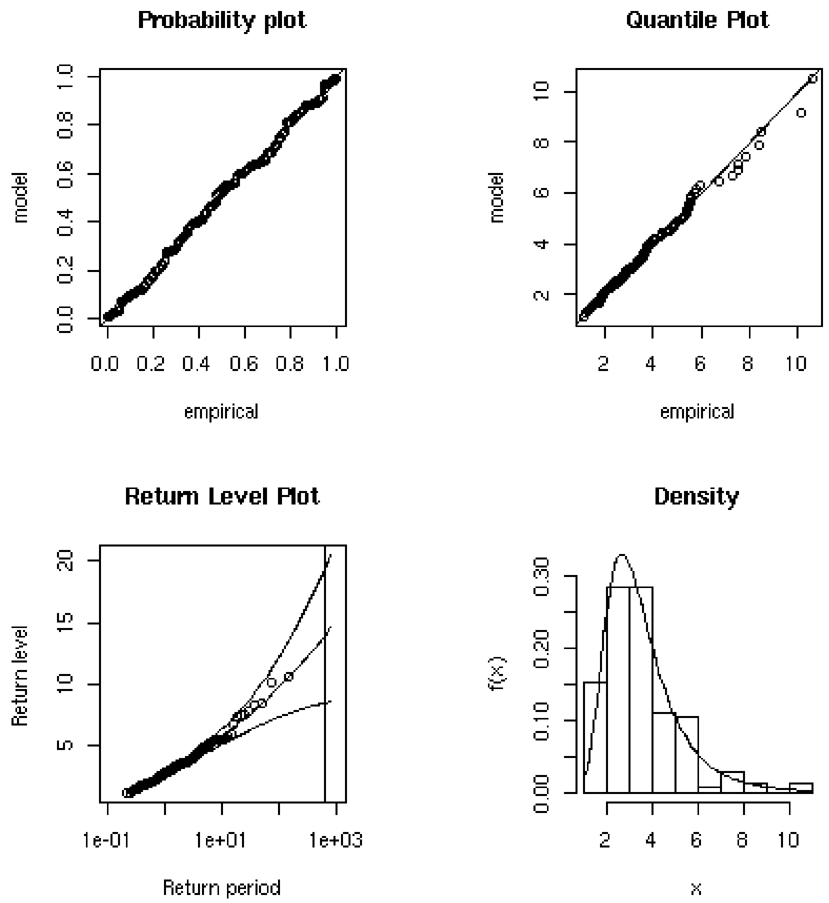


Fig. VIIII: Model Check (upper half) a two-sided confidence interval (based on Extreme Value Theory EVT) as well as a density plot. EVT is very suitable to model data, where few data points are given and one gets to the limits of known models or does not yet have a more exact model and searches the largest outliers or robust and reliable thresholds.

4.6 Software

Our goal is to offer the client a comfortable system, which always allows risk diagnosis with the current data or also with selected scenarios. (“what if the oil price rises to 40 USD a barrel?”) If possiblie this software should be automatised and integrated in existing environments. More in the next chapter.

4.7 Data analysis

Data analysis prepares the existing data, so that one gets a feeling for the problem. We have years of experience with many different languages and tools (S-Plus, R, different databases, Execel, ..) which can be very useful for different types of questions.

General datamining techniques often show patterns and relations in the data, so that key factors for the enterprise risk can be spotted. The following screenshots show the datamining technique “Projection Pursuit” (F39), which from a cloud of points identifies three groups with similar properties.

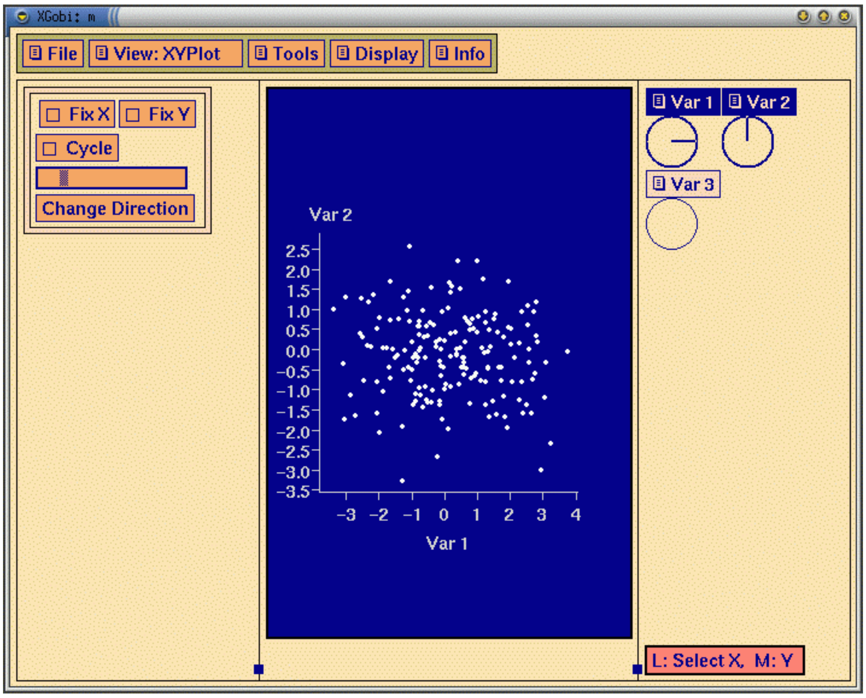


Fig. X: original mess

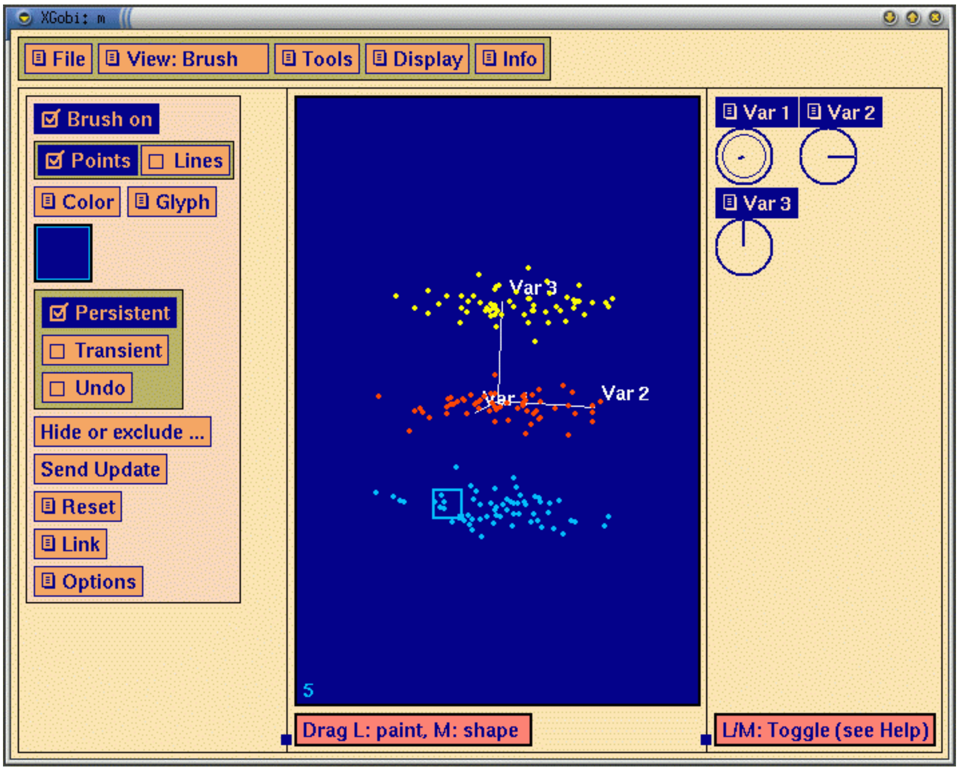


Fig. XI: Three representative groups werde identified and marked wth colors. This gives starting points for further risk analysis.

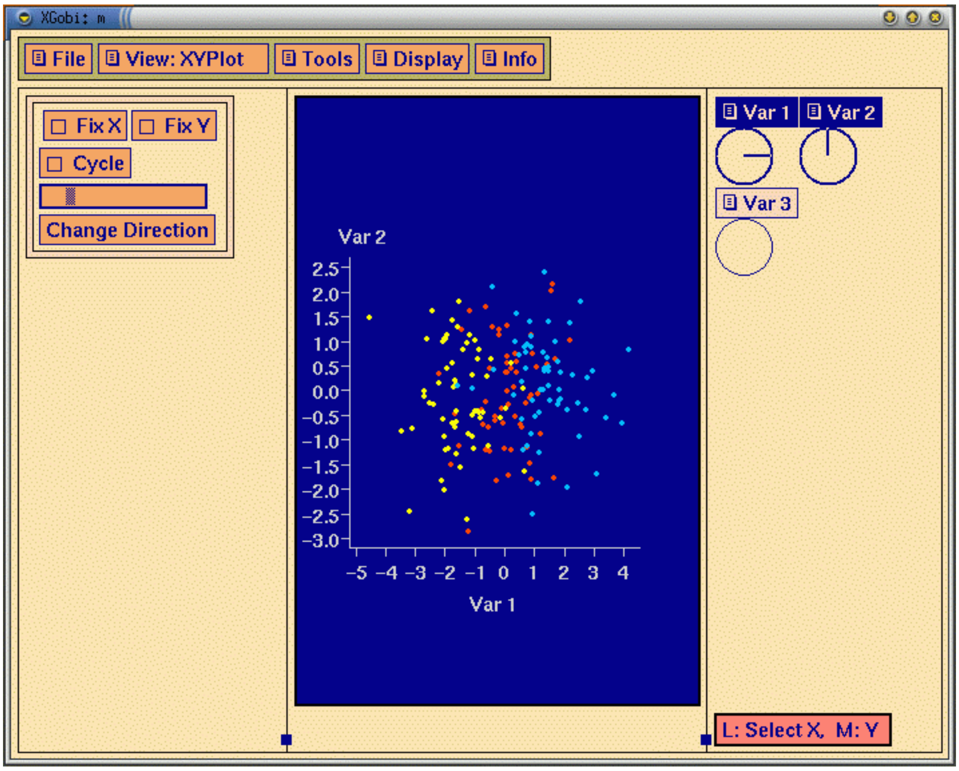


Fig. XII: The original data view. Now we marked graphically to which group the points belong, which at least in the middle section is non-evident.

4.8 General comments

After the LTCM collapse Myron Scholes analysed that the concrete planning for crises is at least as important as VaR. One should extend the models with additional stress tests and via EVT techniques try to get a feeling for the size of potential catastrophes and to prepare counter measures.

The same way, one would consult a second doctor in critical cases, it is advisable to use several competing models simultaneously and to use the worst case results conservatively and always pick the one worst for the enterprise to be able to cope in all cases. Anyhow, when looking at entire global companies one will find different models in the various departments, e.g. for the valuation of currency exchange risk or the export developments or the behaviour of the competition, which for the overall image has to be combined with different priorities. Also operational risk like the failing of machines, fluctuations in quality and the delay in shipment, etc. should in the long-term be integrated in the enterprise risk model, as they might have complex consequences on the Cash-Flow.

By applying Bayesian-theory, the intuition of the Risk Managers is not ignored. It is put in the prior (the result, that the Manager expects) and then one sees whether the data confirms the hypothesis.

Risk Management is relevant as long as the company exists. But even the use of the most advanced models and Bayesian theorey will never be able to replace the intuition of the Risk Manager, but they can help to objective judge feelings.

5. Risk Management is a process and not a product: project ZUP

„Risk Management is one of the most important innovations of the 20th. century" (F40) (Steinherr)

Risk Management and fire protection have many things in common. In both cases one tries by careful planning ahead to minimse the risk and the consequences of catastrophes. Planning the "emergency exit ways" and other similar security techniques should become as common in companies as it is in the design of buildings.

Our software (F41) can be put on top of „existing systems" and allows the ongoing analysis of the actual data, so that deviations (similar like a smoke detector) cause an alarm. The so developed risk transparency increases the strategic planning of the enterprise and leads to profitable, as stable and efficient companies, as potential dangers can be detected and avoided early.

The system itself is conceptualised as an objective decision aid for competent Risk Managers, but the common sense of the users must never be ignored. All models simplify some parts of reality and ignore other aspects to get a deterministic system. But still, estimation using Extreme Value Theory even with little data is still better than pure guesswork and gives at least an indication in which way one should investigate further.

We recommend the combination of all operational and functional risks as described in the project ZUP (F42). Based on existing ERP systems (Enterprise resource planning) and via ethernet connected production machines state- and production data can be collected in real time. Apart from optimizing the production systems ("lean production") also the permanent verification of the risks is possible, so that strategic targets can be compared with the current and the expected Cash-Flow.

Traditional ERP systems help companies to spend money and to organize the production, but they do not help to proactively save money. The reason is that they do not work wth real-time data and their analysis is not based on Cash-Flow, which is a critical indicator for the health of an entire enterprise.

Instead of using the simple measureable Cash-Flow, investors and owners judge the state of the enterprise based on the business plan and on strategic tragets, that are often only partly related with Cash-Flow, but to manage a company efficiently, the management needs uptodate and exact data about the state of the company, at least on a daily basis, which is a critical indicator for the health of an entire enterprise.

If a company can use its income and outcome to plan with a short time horizon and to estimate the risks, hedge them and use the Cash-Flow for short-term investments, to generate additional income. Today's ERP systems do not support this idea.

The ZUP component

With the now available, cheap and well networkable monitoring hardware, one can build cost-effective MES-Systems. Their data is put in real-time in the intranet (or crypted) via the internet to be assembled in a central component ZUP, which we are developing. The abbreviation ZUP stands for the russian equivalent of NASA's Mission Control Center (MCC): the MCC in StarCity, the once forbidden city.

This central software component creates reliable results with new algorithms on the latest development stage in statistics, operations research and computer science. The big goal is to understand the processes happening in a company and is based on objective measurements using correct modeling and give forecasts with which the available resources can be used optimally.

What does ZUP do?

The easiest task of ZUP is the collecting and organizing of data in real-time with which ZUP diagnoses the state of the enterprise and offers solid help of the daily task management. This help is not only help for decisions, but also the possibility to take management decisions via remote control from distance and to pass them to the relevant people.

As an adaptive and self-learning system ZUP is able to optimize processes in the company as well as forecast business developments, which are relevant for the enterprise. The stability of the enterprise is increased by offering a solid base for Risk Management. The time lag between operative and financial cycel becomes shortened. Additionally a high-resolution control mechanisms makes sure that (as far as possible) a just-in-time production is used and less parts and raw material need storage than in a classical company.

Based on our Know-How we work with the management of the company to identify and solve the main problems and surveil the sensible regions, so that the problems do not reoccur. Very often it is the small changes that bring the big gains in efficiency in a company. To find them is a mixture of expert knowledge and sound common sense, which ZUP supports. An example is that a deliverer for a print-shop is linked up to the sensor that alarms before the the print-shop will run out of ink.

By using the Internet one can use cost-effective interactions among and between different organisations among thousands of kilometers. Data can be crypted to ensure secure communiations, so that business secrets remain secrets. Via the same communication ways management can remote control various aspects of the company. Via redundant communication ways and sensors this functionality stays intact even under extreme conditions.

For ZUP due to various reasons we decided to use open source components: If necessary at all, license costs are much cheaper and code inspected by many people guarantees assured quality. Developers can customize the components down to the source code level at place directly, which can’t always be done with proprietary software.

Manage information space

The system as a whole is an open architecture for continual further development. It will scale with growing company and better hardware. Existing standard components can be integrated and it will contain extensive data exchange possibilities so that the training costs for the user will be very little. Saving of the data will be confirm to the various ISO standards as well as with German and international book keeping standards.

ZUP stays ontop of the information overkill through extensive filtering on various levels. If something goes wrong in production, the engineer in charge will get informed automatically. If the problem persits, the manager on the next level gets informed, while business management first only gets informed that ther is a problem with unit XYZ, which makes the company lose so much money per hour. Top management can therefore based on the actual situation adapt their hedging or short-term investment strategies, so that the income of the current money gets optimised. Finally, ZUP will not only help to avoid losees, but to make wins.

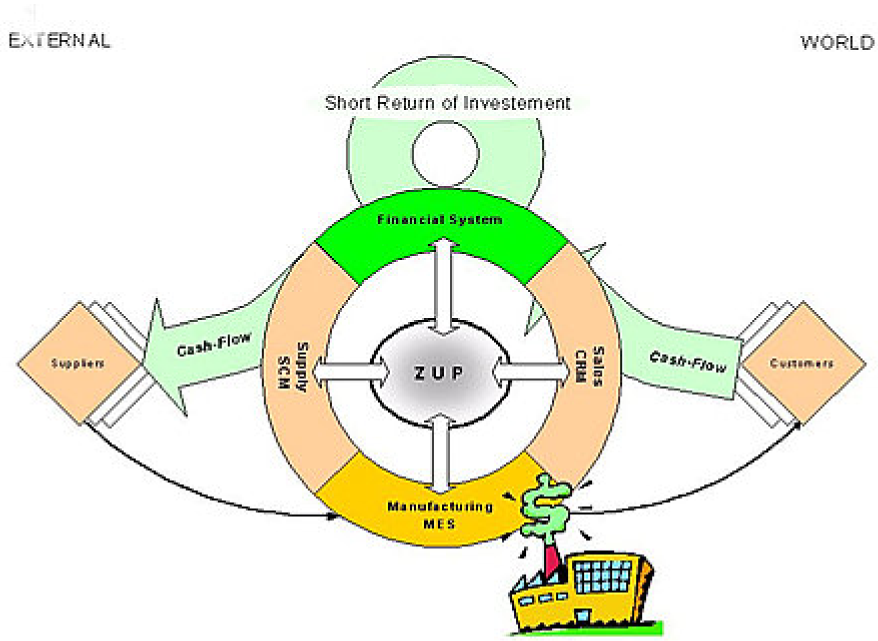


Fig. XIII: ???

6. Outlook

With Cash-Flow-at-Risk models we offer a risk modelling approach that is fine-tuned for enterprise needs. The model allows for different prognosis methods. Random Walks can be combined with historic trend, or with forward prices. Also other random processes can be integrated, like Brownian Bridges (F. 43)

The Cash-Flow-at-Risk approach also conforms with the requirement for most a long planning horizon. Due to the high flexibility of the model, many risk factors from different segments can be simulated in its effect on the yearly Cash-Flow in an enterprise. Next to the operative Cash-Flow also realoptions can be taken into account (F44). The possibility to watch both market price risks and their effects on the operative business is a special strength of the Cash-Flow-at Risk approach. Here the presented case study shows an interesting risk position. The German manufacturer does not buy any equipment or raw materials in Japan, nor does he export to Japan and the German enterprise does not hold any assets in Yen, but despite of all this there is a high risk exposure to the currency Yen.

A wrong control impulse arises especially, when one only looks at the expenses for the raw materials. This would lead to the conclusion that the risk lies in a sinking EUR/US-Dollar currency exchange rate. The lower the rate, the more expensive the buying of the raw material becomes. But then one would ignore that at the same time the enterprise exports to the USA and therefore gets US-Dollars. Unter the assumptions that the export income is higher than the buying of the raw material required. Then the main risk is not the increasing US-Dollar, but contrarily in a sinking Euro against the US-Dollar. The masurements to cover against a rising US-Dollar would not lead to a reduction, but in fact to a risk increase (cf. Fig. XIIII). An incomplete capturing of the cash-flows from the operative business can therefore lead to a completely wrong judgement of the actually available risks with undesirable effects.

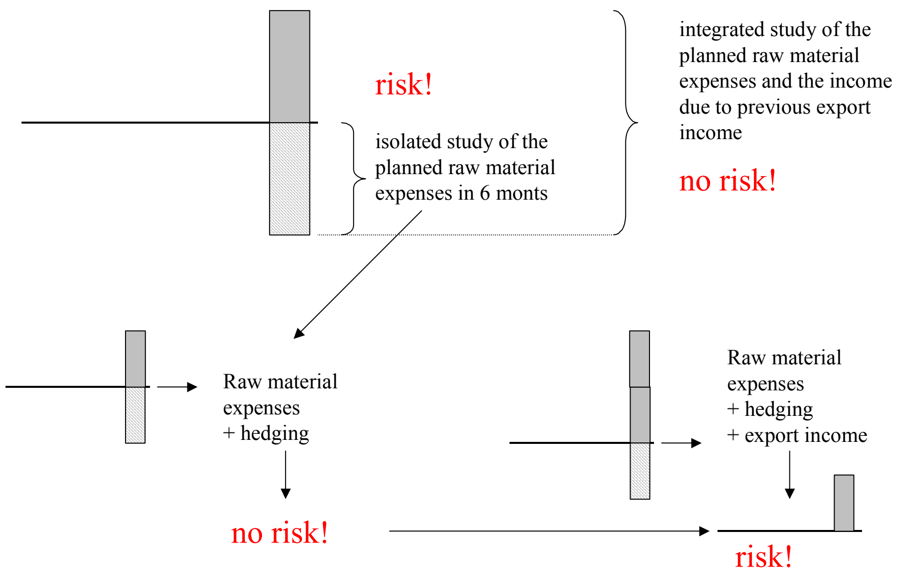


Fig. XIIII: wrong control mechanism due to an isolated study of the risks

To conclude, one can say that Cash-Flow-at-Risk models are an economically sensible integrated view of the financial and operative risks in a medium-term horizon. Contrarily to the still often used analysis based on single, subjective market scenarios, Cash-Flow-at Risk models simulate many possible scenarios and align with the statistical properties of the regarded risk factors. The used parameters can be observed on the market and followed objectively. Due to the flexibility of the Cash-Flow-at-Risk models one can verify the efficiency of limits and derivatives to limit the risk.

Cash-Flow-at-Risk models are therefore a helpful instrument to help the decision finding process in enterpreneural finance management. They help to make complex relations and situations objective and transparent. By steadily increasing professional finance management the distribution of such models will likely increase.

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