Siebe, Wilfried; Milde, Hellmuth; Broll, Udo; Bieta, Volker

Working Paper

The New Basel Accord and the Nature of Risk: A Game Theoretic Perspective

Dresden discussion paper in economics, No. 07/07

Provided in cooperation with:
Technische Universität Dresden

Suggested citation: Siebe, Wilfried; Milde, Hellmuth; Broll, Udo; Bieta, Volker (2007) : The New Basel Accord and the Nature of Risk: A Game Theoretic Perspective, Dresden discussion paper in economics, No. 07/07, http://hdl.handle.net/10419/22748

TECHNISCHE UNIVERSITÄT DRESDEN

Dresden University of Technology
Faculty of Business Management and Economics

Dresden Discussion Paper Series in Economics

The New Basel Accord and the Nature of Risk: A Game Theoretic Perspective

VOLKER BIETA

UDO BROLL

HELLMUTH MILDE

WILFRIED SIEBE

Dresden Discussion Paper in Economics No. 07/07

ISSN 0945-4829

Address of the author(s):

Volker Bieta
University of Trier
Money, Credit und Finance
54286 Trier

e-mail : bieta@uni-trier.de

Udo Broll
Dresden University of Technology
Faculty of Business Management and Economics
01062 Dresden

e-mail : Udo.Broll@tu-dresden.de

Hellmuth Milde
University of Trier
Department IV - Money, Credit and Finance
54286 Trier
Germany

e-mail : milde@uni-trier.de

Wilfried Siebe
University of Rostock
Faculty of Business, Economic and Soicial Sciences
18051 Rostock

e-mail : wilfried.siebe@uni-rostock.de

Editors:

Faculty of Business Management and Economics, Department of Economics

Internet:

An electronic version of the paper may be downloaded from the homepage:
http://rcswww.urz.tu-dresden.de/wpeconomics/index.htm

English papers are also available from the SSRN website:
http://www.ssrn.com

Working paper coordinator:

Dominik Maltritz
e-mail: wpeconomics@mailbox.tu-dresden.de

Dresden Discussion Paper in Economics No. 07/07

The New Basel Accord and the Nature of Risk: A Game Theoretic Perspective

Volker Bieta
University of Trier
Money, Credit und Finance
54286 Trier
bieta@uni-trier.de

Udo Broll
Dresden University of Technology
Faculty of Business Management and Economics
01062 Dresden
Udo.Broll@tu-dresden.de

Hellmuth Milde
University of Trier
Department IV - Money, Credit and Finance
54286 Trier
milde@uni-trier.de

Wilfried Siebe
University of Rostock
Department of Business Management and Economics
18057 Rostock
wilfried.siebe@uni-rostock.de

Abstract:

Basel II changes risk management in banks strongly. Internal rating procedures would lead one to expect that banks are changing over to active risk control. But, if risk management is no longer a simple "game against nature", if all agents involved are active players then a shift from a non-strategic model setting (measuring event risk stochastically) to a more general strategic model setting (measuring behavioral risk adequately) comes true. Knowing that a game is any situation in which the players make strategic decisions – i.e., decisions that take into account each other's actions and responses – game theory is a useful set of tools for better understanding different risk settings. Embedded in a short history of the Basel Accord in this article we introduce some basic ideas of game theory in the context of rating procedures in accordance with Basel II. As well, some insight is given how game theory works. Here, the primary value of game theory stems from its focus on behavioral risk: risk when all agents are presumed rational, each attempting to anticipate likely actions and reactions by its rivals

JEL-Classification: A10, A22, C79

Keywords: New Basel Accord, event risk, behavioral risk, rating, simple game, Nash-equilibrium, game theory

1. Introduction

The roots of "systemic thinking" lie in ancient Greece. Aristotle wrote about it in his "Metaphysics", for example. "Everything that is made up of many parts but that is not merely the sum of these parts – like an arbitrary accumulation – , rather, that exists as a structure beyond its parts, inevitably has a cause." The fact that even Aristotle had a version of the dictum "The whole is greater than the sum of its parts", which today has become the credo of the holistic paradigm, is not without a certain irony. In many enterprises the hierarchically defined notions of organization and management also seem to date from the days of the pyramids. Organization charts are tapered at the top and broad at the bottom. The organizational and operational processes are organized in line with the simple model: there is a clear and above all, calculable, linear relationship between "input" (cause) and "output" (effect).

The holistic paradigm has significantly changed this view: The theoretical anticipation of situations is true for working with nature as it is for working with people. In the post-industrial age of virtual relationships, risk management must also make allowance for the de facto circumstance that in light of the varied reciprocity and repercussions, linear concepts on a simple cause-effect basis are no longer effective. In the "worst case" the increase in complexity results in forecasting, planning, simulation and calculation techniques becomes risks in themselves. Interfering in events generates effects that retroact because of the intervention and this in turn can trigger entirely new reactions. In this case, the whole is indeed more than the sum of its parts. There is no longer a final state, if each result can become the starting point for a new development.

What developments will occur in risk management as a result of Basel II? How is the as yet familiar emerging "Spirit" of Basel II to be implemented, if Basel II is only the fundamental idea of how modern banking should be in the future? To put it another way: how does the following analogy become part of risk management? – Before players make a move in a game of chess, they first goes through the various possible moves in their heads.[1] Each player thinks of their own

[1] Since the work of John von Neumann & Oskar Morgenstern (Games and Economic Behavior, Princeton 1944) “games” have been a scientific metaphor for a much wider range of human interactions. In it, Neumann & Morgenstern conceived a groundbreaking mathematical theory of economic and social organization, based on a theory of games of strategy. In the 60 years since 1944, game theory has been applied to a growing number of practical problems (real-world phenomena): from antitrust analysis to monetary policy; from the design of auction institutions to the structuring of incentive within firms; from patent races to dispute resolution; and the listing goes

moves, anticipates the possible counter moves of their opponent and their own possible return moves in response to that. Only when a player has found a rational result for himself will he actually execute the move on the chess board.[2] At best, this move is then only the best among the various possible combinations that the player has carefully worked out beforehand.

To put it colloquially, game theory is the approach that focuses on the fact that someone who says A must not only say B but also C and D and then possibly B again.[3] It is no longer just the isolated decision maker that undertakes the action. He is influenced by the other player or players. With the game model as an inner model, game theory gives a player the possibility of testing the moves they have in mind before putting them into practice. If the bow is not drawn too tight and the "spirit" of Basel II is not sealed too quickly into a formula mechanism, some questions must be answered in the game rule system to be implemented with Basel II, such as: What are the right moves for risk management? What knowledge and settings are necessary to allow risk management make the right moves? How can adverse moves be avoided? In short: with Basel II the question now becomes: What is the right strategy in the right game? The scenario sketches in broad strokes a possible image, if we can apply the gist of the words of Johann Wolfgang von Goethe, spoken by Mephisto to Faust, to modern risk management: "There's nothing here to take by storm, to strategy we must conform".[4]

2 The New View (Part I)

The idea of business risk management is a comparatively old one. It can be traced back to 1878. At that point, for the first time, railway companies in the USA were integrating an insurance function to protect themselves against financial risks and other damage. The standard integration of risk insurance concepts then followed around 1930 as the American management association first created a specialized department for active insurance management.

---

on. Roughly speaking, a game in the sense of game theory is a formal representation of a situation in which the participants (called players) make strategic decisions that take into account each other's actions and responses.

[2] From the viewpoint of game theory rational behavior means: The players are perfect calculators and flawless followers of their best strategies. Thereby, superficial spoken, strategies are simply choices available to the players.

[3] Game theory is the systematic study of how rational agents behave in strategic situations, or in games, where each agent must first know the decision of the other agents before knowing which decision is best for herself.

[4] It is worth mentioning, that all main branches of economic theory are closely connected to game theory. For example (1) decision theory can be viewed as a theory of one person games, or a game of a single player against nature, (2) general equilibrium theory can be viewed as a specialized branch of game theory that deals with trade and production, and typically with a relatively large number of individual consumers and producers, (3) mechanism design is part of game theory in that sense that game theory takes the rules of the game as given, while mechanism design theory asks about the consequences of different types of rules.

Since the beginning of the 1990s with, for example, the emergence of derivatives of the banking business, the practices of risk management and financial markets has once again changed radically. At the same time, the financial sector has become consistently globalised. One manifest sign of this is that (in)conceivably large sums of capital move around the world every day. The financial sector has developed a largely self-contained momentum and complexity, the risks of which can no longer be overviewed from any one place, let alone be controlled in any way. One reason for this is the fact that the financial markets and markets for goods and non-financial services have become separated to the greatest possible extent.

Thanks to spectacular blunders in the recent past, risk management today has somewhat negative connotations. On the one hand, risk management was unable to prevent spectacular insolvencies and complications in companies. We can cite examples such as Metallgesellschaft in Germany who lost out through speculation with oil futures, Proctor & Gamble in the USA who bore heavy losses because of swap transactions and Koshima Oil from Japan who lost several billion US dollars with currency forwards. On the other hand, the mistakes of risk management are not limited to companies. Banks are also affected: For example, the Negara Bank in Malaysia lost over 5 billion US dollars through currency speculation on the British pound, Banesto Bank from Spain also had to record a loss of five billion US dollars due to obligations in bonds and investments, the French Credit Lyonnais needed government help to the tune of 10 billion US dollars when it sank into threatening difficulties thanks to dubious real estate management; and the British Barings Bank lost almost 1.5 billion US dollars through speculation with future contracts on stock indices.

Although for companies, financial risks have a somewhat subordinate role compared to banks, because credit and dealings in securities are generally not part of the economic activity of those in production industries, as early as 1988 international banking supervision (BIS: Bank for International Settlements) recognized the impending danger for the safety and soundness of the financial system. It was thanks to this "central bank for central banks", whose main task is to regulate systematic risks associated with the particular dynamic of the international financial system, that the banking regulations referred to as Basel I were adopted. In simplistic rather than differentiated way, it set down the new rules of the game for the financial industry.

But nevertheless: With Basel I the development of risk management in banks gradually became an issue (the process of identification, measuring/evaluation, control, checks). The BIS visor progressively focused on at least three risk categories:

- Market risks: Price risks arising from changes in the price of financial securities that cause fluctuations in interest rates, exchange rates, share indexes, prices of goods or fluctuations of other financial securities.
- Credit risks: These arise as a result of the complete or partial inability to pay on the part of a borrower (address non-payment risk)
- Operational risks: These result from defective technical systems, human errors ("people risk"), insufficient checks and legal risks. This type of risk is still difficult to gauge using a measure concept.

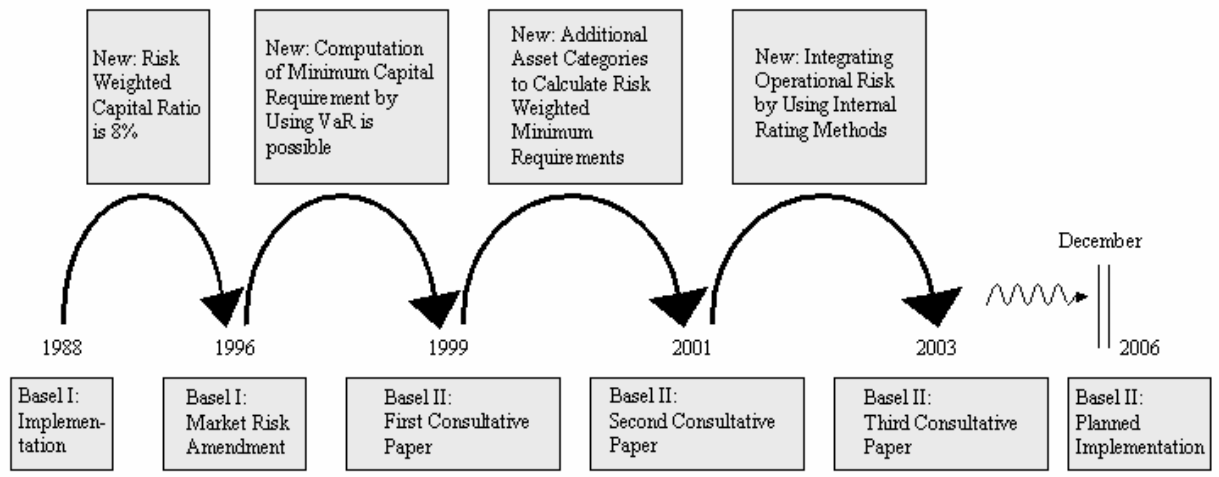
3 The Road to Basel II

According to the core idea of Basel I the required bank equity capital is closely related to the volume of bank loans. The Basel I Accord called for a minimum capital ratio of 8%. In order to protect bank depositors by bank owners‘ equity, Basel I created an incentive deficit to the banking industry. Briefly: Basel I gave no incentive for avoiding the cross-subsidisation of "bad" loans with "good" loans.

Given that the high level of innovation makes the financial sector a moving target, in hindsight, it is no wonder that Basel I ran aground on the reef of reality. The standardized and only very vague risk categories are responsible for the fact that the regulatory capital requirements do not really correspond to the actual economic risk involved. As we have said: taking an average percentage of the bank's own funds as a basis for securing credit cases means, on the one hand: that "bad" debtors are subsidized at the cost of "best in class" debtors. At the same time, taking an average percentage of the banks own funds as a basis for securing credit losses means, on the other hand: Without knowing the economic risk content, the amount of the security cushion needed by the bank to protect against unexpected losses, cannot be estimated with sufficient precision. It was essential to improve this. This is the root of what today is called: "the path from quantitative to qualitative supervision"

4 The New Basel Accord

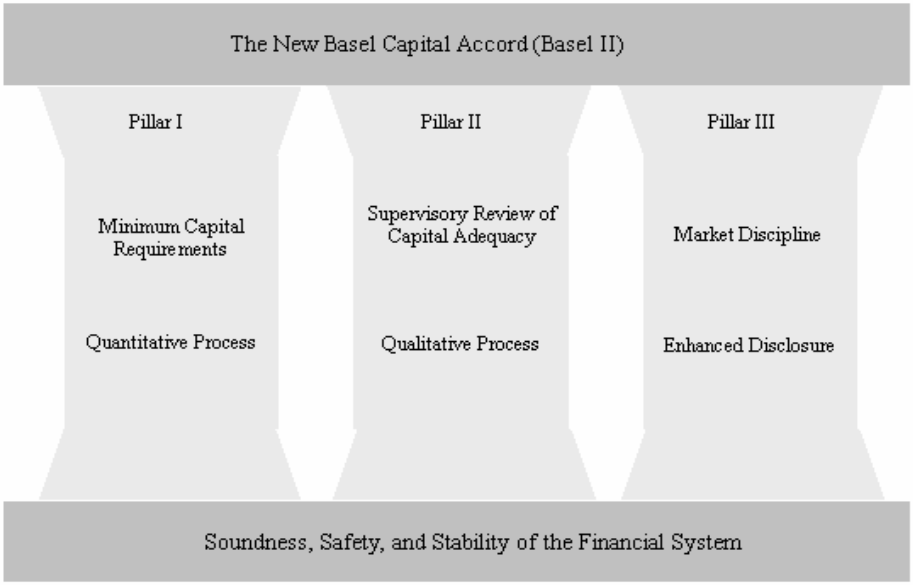
The new Basel Capital Accord of 1999 (Basel II) grasps at the "predetermined breaking point" of Basel I. Basel II promotes an approach by which the Basel committee for banking supervision replaces the equity agreement of 1988 with a regulation that takes more account of risk. Basel II was developed as a result of the specific demand to establish transparent and actual risk-sensitive measurement procedures, which would also provide the stimulus for the continued improvement of internal risk management in banks.



Graphic 1: The Road to Basel II

Basically, Basel II rests on three pillars, which complement one another. They are:

- Pillar I rules the minimum requirements, from a quantitative and qualitative outlook, for calculating the supervisory equity funds of banks. The risks to be considered here include credit risk, market risk and operational risk. The procedures and approaches for measuring risks are specified for each of the three risk classes. The banks must also adhere to the specified qualitative minimum requirements.
- Pillar II controls the procedure by which the supervisory body checks and evaluates the banks' internal processes. There must be dialog between the supervisory body and banks so that risks can be identified early on. If necessary, the banking supervisory committee may recommend that certain measures are introduced.
- Pillar III provides guidelines on transparency and extended disclosure obligations to control the intended increase in market discipline. At the core is a catalogue of some wide-ranging recommendations/guidelines for presenting the equity and risk situation of the bank.



Graphic 2: The Pillar – Concept

At first, the pillar concept of Basel II may seem static, but because of the intertwining static of the pillars, its ramifications are many and diverse. Let us once again take note: The overriding task of the second Basel agreement is to compel banks to measure and control the typical financial risks (credit, market and operational risks).

The upshot is that the "spirit" of Basel II does not juxtapose three isolated pillars. To use an analogy: With Basel II, a bank can no longer be like a sailing crew that, before a trip, carefully checks the weather reports and the forecasts for wind, but by not checking the sea-worthiness of the boat, disregards its own contribution to the success of the sailing trip. Only systematic early detection measures, carried out in good time, and suitable financial management will guide you to the right course at the right time. Every good sailor knows this and behaves accordingly: The position of the sail and the sea-worthiness of the boat determine the course – not the wind.

Seneca's words: "You can tell a good helmsman in a storm", robs the analogy of the sailing trip of its innocuousness. If banks are to safely navigate "through unknown waters", then Basel II provides the instruments for plotting the course. Basel II means that when calculating risks, banks can no longer limit themselves to routinely checking external risk factors. With the implementation of Basel II it is no longer sufficient to only check the risk that a customer will not

fulfil their contractual obligations (credit risk). After Basel II implementation it will no longer be sufficient to forecast the probability of interest rate fluctuations on financial markets. The fact is: Basel II requires strategic risk control. One reason for this is: Basel II makes banks take note that they must also critically check their own performance, say, operational risks (business processes), where the required equity capitalisation (EC) of bank can be calculated using the following basic formula:

$$EC := \frac{\text{Regulatory Equity}}{\text{Credit Risk} + (\text{Market Risk} + \text{Operational Risk}) \times 12{,}5} \geq 8\%$$

5 Rating: The Time and Space for Games

"Rating" is riding high in the hit parade of present-day questions in enterprise management. Rating has also become topical because of Basel II. In small- and medium-sized companies the rating principle implies serious changes. This lies in the fact that rating culture is not as developed in Europe as it is in the USA. Thus in Germany, for example, relationship banking, which focuses on the long-term bank-customer relationship, dominates over deal-based banking (transaction banking). The latter is based on a more casual customer-bank relationship and cost and profitability considerations are more decisive control values than the closing of an individual deal. It is therefore not surprising that during the consultation talks for Basel II, two questions in particular were the main subject of discussion: How will the new regulations affect borrowers? and: How will the new regulations affect credit institutions?

Use of the term "rating" can be traced back to 1849, when Bradstreet's Improved Commercial Agency evaluated the credit-worthiness of commercial borrowers using the Commercial Credit Rating. During the second half of the 19th century, as the USA was being opened up with the construction of the railways mainly thanks to borrowings financed by American railway companies, the profession of rating specialists came into play on a large scale. This made sure that issuers were subject to risk assessment although at the time of the railway boom, the issue of loans increased enormously and the anonymous capital market was growing quickly.

John Moody & Company was founded in 1900. And as early as 1909, John Moody had introduced a rating system using the scale of Aaa to C, which is still commonly used today and has also been adopted, in principle, by other agencies. At first, only railway loans were evaluated;

loans for industry and utilities and public authority bonds followed later. In 1922 the Fitch Investors Services rating was extended to all issuers. In 1941 the Standard & Poor's Corporation merged to form what is still today one of the leading rating agencies, alongside Moody's Investor Services. In a rating an object is evaluated with regard to an aim and is classified within an ordinal scale. A whole range of facts and complex circumstances are compressed into a key figure (somewhere between Aaa/C). Through the compilation of forecasts, in an independent judgement, the key figure represents the future ability of an enterprise to meet its obligations.

Basel II provides an evolutionary approach for the three big credit areas of every bank: credit risk, market risk and operational risk. Banks are given the possibility of selecting the risk measuring procedure best suited to the risk management complexities of their individual institute. The main improvement in Basel II over the current regulations is that in future a bank's credit positions should be underlaid with equity consistent with the credit standing of the borrower in question. In this way Basel II facilitates the further development of internal bank risk management systems, as internal ratings may soon be used in the process of determining regulatory capital requirements. The EU Commission is working on banking supervisory regulations closely in line with Basel II. The European regulations would be obligatory for all banks in the EU and not just for banks that operate internationally, as is the case with Basel II.

Basel II requires that equity securitisation for loans is linked through a rating to the creditworthiness of the borrower. Two alternatives have been suggested: The standardised approach and the internal rating based (IRB) approach. The standardised method is theoretically the same as the 1988 equity agreement currently in force (Basel I). The equity capital requirement is calculated as the product of the outstanding credit amount by the risk weighting. The risk weightings with Basel II are now dependent on assessment by an external rating agency. An international impact study carried out by the Basel committee: the Quantitative Impact Study (QIS), shows that given the low incidence of external ratings in Germany, most German credit institutions will opt for the IRB approach.

In contrast to the standardised approach, with which the risk weightings pre-set by the supervisory authority must be used, with the IRB approach, risk weightings are calculated individually by the banks for the risk components of each individual loan using a default

function. The Basel agreement gives a definition of when a borrower is deemed to have failed to pay (credit event). This ensures that risk components are appraised.

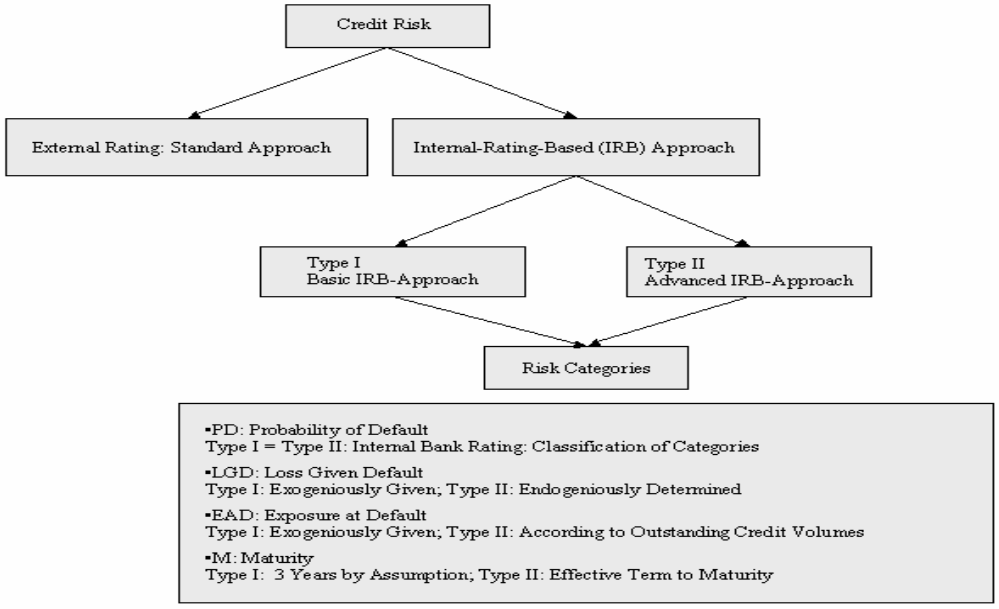
With (N) as standard normal distribution and (N^{-1}) as the related inverse function, in the basic version (foundation approach) and the advanced version (advanced approach) of IRB, the risk-weighted asset (RA) is currently determined using the formula:

$$RA := 12{,}5 \; x \; LGD \; x \; M \; x \; N\left(\frac{1}{\sqrt{1-R}} \; x \; N^{-1}(PD) + \sqrt{\frac{R}{1-R}} \; x \; N^{-1}(0{,}999)\right)$$

where

$$R := 0{,}1 \; x \; \frac{1-e^{-50 \; x \; PD}}{1-e^{-50}} + 0{,}2 \; x \; \frac{1-(1-e^{-50 \; x \; PD})}{1-e^{-50}} \text{ and } M := 1 + 0{,}047 \; x \; \frac{1-PD}{PD^{0{,}44}}$$

The diagram shows the risk components to be taken into consideration in the IRB approach.



Graphic 3: Basel II Credit Risk Measurement: Alternative Approaches

Particularly important here is the fact that, on the one hand the probability of default (PD) is the central parameter in the risk weighting function. On the other hand, the risk weighting function increases with the probability of default (PD). This means: the higher the risk weighting, then the higher the equity requirements for the loan in question.[5]

[5] In the light of game theory there is a systematic flaw in today's risk management in general. It entails assessing and managing the bank's exposure to various kinds of risk. The two kinds are event risk on the one hand and behavioral

6 The New View (Part II)

Insofar as the rough outline of the Basel II arithmetic unit does not obstruct the view of the "spirit" of Basel II, it can be noted that: traditional methods of risk management are not in a position to consider the multi-layer interdependencies of the individual risk types. The question remains open as to whether RA adequately analyses the future in its burdened past. One cause of this is: systems are usually developed in a department-specific way, so that these systems cannot know how individual risks condition each other.[6]

If we consider the fact that risk models basically consider unexpected risk, whereas expected losses must be covered by pricing and value reports, yet Basel II also requires that the "cost of doing business", as a component of operational risk, is securitised with regulatory capital, we can see how Basel II generally places new demands on risk management. These demands must be satisfied.

The crux for the approach to strategic risk management also originates in this gap. For this reason, for instance, only with precise knowledge of how the individual risk types intertwine are banks in a position to consider risk-related factors when developing their strategies. This in turn means that strategic guidelines must also be implemented in operative risk management. In this case, it will not be possible to implement models that are too complex (complicated) and tricky to realize, because they are difficult to comprehend, on a continuing basis. The dilemma is as follows: There will be no simulator model with which all risks can be evaluated in consideration of their interrelations, and a bank cannot afford only to realize the regulatory required minimum because security premiums fall the more subtly the model misses the risks.

Banks have to deal with this dilemma. The actual facts of the case must be weighed up: management acts within the system, strategic decisions have an effect on the system. Here,

---

risk on the other hand. Event risk can best be managed by using probabilistic tools. Alternatively, behavioral risk can only be managed with the use of a strategic approach. Unfortunately, today's dominating behavioral risks are managed with probabilistic tools. This is a basic inconsistency. One has to ask: How we can manage a risk we don't know exist, if we can manage risks only when we can identify them and ponder their possible outcomes in probabilistic terms.

[6] At this point we can illustrate the mayor difference between the analysis of games (the strategic case) and the analysis of single player decisions (the non-strategic case): In a decision, there is a single decision-maker, whose only uncertainty is about the possible moves of "nature", and the decision-maker is assumed to have fixed, exogenous beliefs about the probabilities of nature's move. In a game, there are several decision-makers, and the expectations players have about their opponents' play are not exogenous.

despite the undeniable usefulness of refining measurement procedures for the standardized qualification of risks, unconventional thinking must also find a place if, instead of regulatory requirements (minimum requirements), economical considerations must turn the balance for which risks are taken, how they are measured and, if necessary, to where they are transferred.

It is important to remember here that strategy can be pragmatically defined as the planned setting of all its levers. So a bank that has fixed a target setting for all its levers at a certain point in time, has a strategy. There may be some doubt as to whether the risk weighting function (RWF) provides sufficient information for the right lever settings if the management decision making process is to formulate strategy in the sense that the setting of all levers needs to be changed and the implementation of strategy means the execution of all measures, so that the actual settings of the levers also correspond to the newly established target settings.

"Helmsman, stand watch!": Whether with or without RA, not seeing the wood for the trees is also an operational risk. According to Basel II it must be underlaid with equity capital. One thing is clear: Basel II concerns the bank as a whole. If every bank has different structure, processes and agents, hopes for standard Basel II software are an illusion: On the one hand it should not be the maxim of modern bank management to do everything to avoid risks, if risks can be taken knowledgeably with adequate premiums and corresponding potential for success. On the other hand, managing risks means identifying, evaluating and controlling risks.

So its clear: If, as a rule strategies, involve the selection of new settings for all levers, behind the question as to how it should be done, lies the question of how the right game should be played with the right strategies. Let us roll Basel II from behind, so to speak, and in answering this question, look to the advanced internal rating based (IRB) approach. In the little scenario developed below, "due diligence" (comprehensive company analysis) and business appraisal (rating) are more or less synonymous.[7]

[7] Why study game theory in today's business?; What is the advantage for treating economic situations as games?; What does it mean to behave rationally? Because the press tells us (1) "As for the firms that want to get their hands on a sliver of airwaves, their best bet is to go out first and hire themselves a good game theorist" (The Economist, July 23, 1994 p. 70, (2) "Game theory, long an intellectual pastime, came into its own as a business tool" (Forbes, July 3, 1995, p. 62), (3) "Game theory is hot" (The Wall Street Journal 13 February 1995, p A 14). More technically spoken because we can (1) formulate effective strategy, (2) predict the outcome of strategic situations, (3) select or design the best game for us to be playing.

7 Basel II: Games through Order or Order through Games?

A decision-maker (but not a standard model) is almost always in a position to completely formulate the alternatives to an action. If they have a "map" (overview) of the situation, all conceivable problems can be anticipated in advance. They can give subjective probabilities for conceivable future events and results if they can access the drivers of complex situations with the risk bearers. However, it not only seems difficult to get a view of the future, not least because decision-makers often do not obey the simple rule: "carefully think everything out as far as possible in advance". It is also difficult to deal with the fact that in reality, several alternative (and often even concurrent) decisions have to be taken one after the other and the consequences can (un)forseeably influence the advantageousness of decisions that have already been made.

With difficult decisions it is important to look closely at each problem and under no circumstances should experience from situation (*X*) be automatically transferred to situation (*Y*). Here is the alternative structure tip: The possible future should not simply be run through routinely as a string of freeze images, like a "serial film". At a higher organizational level of decision-making, rather than the "serial film" there should be a sequence of "internal images". This series of internal images is the internal model of the outside world, which develops as part of the whole, just as "moves" are played through in the mind first before they are put into practice, to identify possible advantages and disadvantages. Thus, knowing a possible end to the mental games, the right course can now be suggested with the right strategy.

In this sense, a decision maker often stands, as it were, before a wide trench over which there is no bridge. First, they jump the ditch in their mind and only after carefully weighing up the chances and risks, do they decide whether or not to go for it and chance the jump. In this sense, the filtering out of success models determined by the situation should not tempt you to the deceptive conclusion that there are generally applicable panaceas for developing success (strategies). In this sense, a bank is also an open system with many trenches running through it, the characteristics and structural features of which can be relevant to innovation in different ways, the suitability of which can vary against the background of dynamic change in environment and the status of which must constantly be re-established in search and development processes.

The scenario to be developed is a more complex view of credit risk. A rough outline is drawn up, which acts on the basic idea of the IRB approach (type II). It takes up the simple circumstance that in reality, contrary to the constant risk weighting function (*RWF*), for a long time now, the dividing line does not need to be so clear as this smart function would suggest. We shall see: If the "spirit" of Basel II is not rigorously sealed in a formula, it is often best to have a simple outline. A strategic scenario can give information about where the real dangers lurk and the actual chances await.

8 A Basic Game

If for instance you look at the interrelationship between Rating and Due Diligence and take it seriously, with a credit arrangement, a bank's internal rating promotes an active solution to a complex problem, and not, in any way, a merely passive acting on figures or ratios. Given that the quality of an internal rating, under the maxim "honesty in information transfer", is directly determined by the quality of communication between the bank and the borrower, the rating scenario, from the bank's point of view goes under the motto: "Constructive ambiguity keeps moral hazard in check".

The latter is hardly surprising, but in a credit agreement, to optimise the arrangements between the bank and borrower it is usually a case of balancing often opposing interests. For the purposes of gaining good conditions, borrowers want a good credit rating (a good result). Since Basel II, banks must draw up comprehensive analyses of clients instead of a pure risk management approach.

In the credit transaction, seeds of doubt take root on the side of the bank with regard to the question: Is the borrower playing an "earning game"? The complexity of the situation supplies the simple facts: in a credit relationship the information balance is always in the bank's favour, if the borrower frequently uses "creative" balancing policies to try to come up to the bank's expectations. It can soon become difficult to interlock the classes of credit risks and operational risks, which according to Basel II are, theoretically at least, separable. In the "game" between the bank and borrower, focus is now centred on the process of creating and evaluating the corporate reporting supply chain.

In this sense, the scenario takes on a simple aspect of risk in "trade in information". Here we see, in the sense of the words of Max Planck, that "knowledge must precede application", the potential for an innovative (risk-sensitive) credit awarding process, if a bank, in the context of active general economic interest, correctly identifies incentive structures and above all, sets them correctly.

9 Finding and Making Up the Game

A bank can issue secured or unsecured loans. An enterprise can invest the loan in a secure or unsecure project. It is in the interest of the company to put a cost-effective, unsecured loan into an unsecure project. From the bank's point of view, however, it is better if the borrower puts an unsecured loan into a secure project and only a secured loan into an unsecure project. From the bank's point of view, the company can follow an honest information strategy or a dishonest information strategy. From the point of view of the company, when preparing ratings the bank can check rigorously or not rigorously.[8]

		Player 2	
		$s_{21}: \gamma$ Honesty	$S_{22}: \delta$ Dishonesty
Player 1	$S_{11}: \alpha$ Check Rigorously	$(B_{\alpha\gamma}, K_{\alpha\gamma})$	$(B_{\alpha\delta}, K_{\alpha\delta})$
	$S_{12}: \beta$ Do not Check Rigorously	$(B_{\beta\gamma}, K_{\beta\gamma})$	$(B_{\beta\delta}, K_{\beta\delta})$

Graphic 4: Credit Arrangement as a Strategic Decision

By the graphic 4 the strategic situation outlined above is presented as a simple game in its so called normal (or strategic) form[9]. There are:

[8] The game in question is a so called non-cooperative game. Players move together, in ignorance of the others' moves. Each player must try to reason what his opponent will do now, knowing that she will be asking the same question herself, and so on.

[9] In the strategic form (or normal form) of a game one notes all possible strategies of each agent together with the payoff that results from strategy choices of the agents. The normal form game consists of three elements: (1) the players in the game, (2) the strategies available to the players, (3) the payoff each player receives for each possible combination of strategies. Thus, a strategic form of the game for two players is an *m* by *n* table, where one player has

- Two players: $N = \{1, 2\}$; Player 1 is the bank, as lender; player 2 is the company, as borrower
- The players' possible strategies:

$S_1 = \{s_{11}, s_{12}\} = \{\alpha, \beta\} = \{$check rigorously, do not check rigorously$\}$ for player 1

$S_2 = \{s_{21}, s_{22}\} = \{\gamma, \delta\} = \{$honesty, dishonesty$\}$ for player 2

- Achievement of objectives (B) by player 1; achievement of objectives (K) by player 2.

If both players are informed of the situation set by the normal form of the game (the players therefore know the rules of the game) and if the players must make their decisions independently of each other (simultaneous), the last outstanding game component for a complete description of the strategic situation are the players' evaluations (payoffs) regarding the concurrence of possible strategies.

The preferences of player 1 are: $B_{\beta\gamma}$ is better (more favourable) than $B_{\alpha\gamma}$. This means: $B_{\beta\gamma} > B_{\alpha\gamma}$.
Here it is evident: it is better for the bank not to check rigorously if the borrower does not cheat, than to check rigorously if the borrower does not cheat. In other words: if the borrower does not cheat and the bank checks, the bank incurs unnecessary costs, which it should try to avoid.

The preferences of player 2 are:

- $K_{\beta\delta}$ is better (more favourable) than $K_{\beta\gamma}$. This means: $K_{\beta\delta} > K_{\beta\gamma}$

Here it is obvious: the borrower would prefer not to be checked when cheating and to be checked when not cheating.

- $K_{\alpha\gamma}$ is better (more favourable) than $K_{\alpha\delta}$. This means that $K_{\alpha\gamma} > K_{\alpha\delta}$.

Here it is evident: the borrower would prefer to be checked when not cheating than to be checked when cheating.

---

m strategies and the other has *n* strategies; each cell of the matrix show an outcome of the game in terms of the players' payoffs. A player's payoff is simply the number assigned by her ordinal utility function to the state of affairs corresponding to the outcome in question. For each outcome, row's payoff is always listed first, followed by column's. Thus, for example, the upper right-hand corner above shows that when the player 1 checks rigorously and the player 2 is dishonesty, the player 1 gets a payoff $B_{\alpha\ \delta}$ and the player 2 gets a payoff $K_{\alpha\ \delta}$. It makes sense to display or game on a matrix, since in that game both the player 1 and the player 2 have just one move each, and each chooses their move in ignorance of what the other has decided to do.

In other words: The borrower benefits from dishonest communication with the bank so long as the bank does not find out. If, in contrast, the bank detects that something is amiss, there are disadvantages for the borrower: The borrower will drop in the rating.

10 Designing the Game

A realistic example for the complexity of credit relationships leads to two types of the basic scenario. A loss of reputation can occur practically overnight, whereas building up trust can be a long and laborious process. When transferred to the scenario, this means that: the bank must take into account that the attitude of the borrower is based on a "moral hazard" premise. The aim of the bank is therefore that player 2 will not give a distorted presentation. The latter is the characteristic by which the bank proves the quality of its internal rating to the market.

What are the alternatives for the bank? If you take account of the fact that on the one hand, investment decisions are often based on a mix of psychological and technical factors and on the other hand, careful credit checks are often considered to be too involved and investment decisions are often just determined by herd instinct, then at least two types are possible here. These are:

- Type I: The bank is concerned about tougher competition. It does not check every borrower rigorously. It considers the fact that to carry out a rigorous check on the wrong people may lead to a loss of clientele. If, however, the bank does not carry out a rigorous check, it is threatened with the loss of its own reputation if the borrower misleads them, an unsecure project fails and the bank has not secured its loan. The bank accepts this risk
- Type II: The bank routinely (thus, not differentiated) carries out rigorous checks. This means that strategy (α) is put into play, without restrictions.

Thus, in the preliminary stages of credit arrangements, the bank must carefully think through the strategic alternatives open to it regarding the achievement of their objectives:

- Type I: (Consideration of their own reputation plays a part)

$B_{\beta\delta}$ is better (more favourable) than $B_{\alpha\delta}$. This means that $B_{\beta\delta} > B_{\alpha\delta}$

- Type II: (Reputation is not considered)

$B_{\alpha\delta}$ is better (more favourable) than $B_{\beta\delta}$. This means that $B_{\alpha\delta} > B_{\beta\delta}$.

The strategic alternatives for the bank define, as a working hypothesis, two possible variants (types) for credit negotiations in the normal form of the basic game. Both games are solved using the well-known Nash equilibrium.[10] It determines game solutions as the best strategies under the premise: The players polish their strategies (game moves) to the point where, given the conditions of the situation, they reach a certain equilibrium where neither player would gain by changing their position in view of the possible reactions of their opponent.[11]

Where is the point of Nash equilibrium for type I of the game?
Here the bank prefers not to check rigorously. Thus: $B_{\beta\delta} > B_{\alpha\delta}$. The condition also applies that: $B_{\beta\gamma} > B_{\alpha\gamma}$ so if we look at the normal form of the game we see that the bank has a dominant strategy (β). This means that the bank will always select strategy (β). The borrower will work this out. It will therefore follow the idea that $K_{\beta\delta} > K_{\beta\gamma}$. It selects strategy (δ). The Nash equilibrium $N = \{(\beta,\delta)\}$ is therefore the solution to the game. From the point of view of the bank, this is the "worst case". It does not check while the borrower cheats. On the contrary, from the point of view of the borrower, this is the "best case".

What is the point of Nash equilibrium for type II of the game?
In this case, the banks prefers to check rigorously. In the normal form of the game, the strategy combinations $\{(\alpha,\gamma), (\alpha,\delta), (\beta,\gamma) (\beta,\delta)\}$ must be checked for their Nash property. We maintain that the strategy combination (α,γ) is a Nash equilibrium.

Here the normal form of the game shows:
•If the bank chooses strategy (α), then the borrower will not select strategy (δ). Thus: $K_{\alpha\gamma} > K_{\alpha\delta}$. This means that from the point of view of the borrower the Nash property is achieved. They will not change from the strategy combination (α,γ).

---

[10] The Nash equilibrium, introduced by John Nash 1951, is the most important equilibrium concept in all of game theory. Informally, a joint strategy $s^* \in S$ constitutes a Nash equilibrium as long as each individual, while fully aware of the others' behavior, has no incentive to change his own. Thus, a Nash equilibrium describes behavior that can be rational sustained. In other words, the intuition of the Nash equilibrium is: Nobody regrets his decision after seeing everybody else's decisions.

[11] The Nash equilibrium abstracts the way we reason about strategies in a competitive situation: it codifies "I think he will do *X* because he thinks I will do *Y*, so I should do *Z*, ….Formally, the Nash equilibrium concept is defined as follows: Given a strategic form game $G = (S_i, u_i)_{i=1}^N$, the strategy $s^* \in S$ is a pure strategy Nash equilibrium of *G* if for each player i, $u_i(s^*) \geq u_i(s_i, s_{-i}^*) \forall s_i \in S_i$.

• If the borrower selects strategy (γ) then the bank will not choose strategy (α). It will select strategy (β) because: $B_{\beta\gamma} > B_{\alpha\gamma}$. This means that the bank will unilaterally move from the strategy combination (α,γ). Clearly: (α,γ) does not fulfil the Nash property. In other words: (α,γ) is not a Nash equilibrium.

Here the normal form of the game also shows, however: for the same reasons, the strategy combinations {(α,δ), (β,γ) (β,δ)} do not fulfil the Nash property either. Thus, a strategic analysis of type II of the game shows that the game has no solution in pure strategies, because there is no Nash equilibrium in pure strategies.[12]

11 Playing the Right Game with the Right Strategy

The changeover to Nash equilibrium in mixed strategies shows the bank the necessary alternatives for finding the necessary starting points in the strategic quandary for an innovative (risk-sensitive) awarding procedure for the credit arrangement in question.[13]

The possible strategies open to the players are now probability distributions: $M_1 = \{x, 1\text{-}x\}$, $M_2 = \{y, 1\text{-}y\}$ with: $m_1(s_{11}) = x$, $m_1(s_{12}) = 1\text{-}x$, $m_2(s_{21}) = y$, $m_2(s_{22}) = 1\text{-}y$. If for example, you use the characteristic property for a Nash equilibrium in mixed strategies, whereby both players choose a mixed strategy in such a way that the opponent becomes indifferent to their own pure strategies and follows the other player for optimal strategies (probability distributions):

$$M_1^* = \left(\frac{K_{\alpha\gamma} - K_{\alpha\delta}}{(K_{\beta\delta} - K_{\beta\gamma}) + (K_{\alpha\gamma} - K_{\alpha\delta})}, 1 - \frac{K_{\alpha\gamma} - K_{\alpha\delta}}{(K_{\beta\delta} - K_{\beta\gamma}) + (K_{\alpha\gamma} - K_{\alpha\delta})} \right) = (a,b)$$

$$M_2^* = \left(\frac{B_{\beta\gamma} - B_{\alpha\gamma}}{(B_{\beta\gamma} - B_{\alpha\gamma}) + (B_{\alpha\delta} - B_{\beta\delta})}, 1 - \frac{B_{\beta\gamma} - B_{\alpha\gamma}}{(B_{\beta\gamma} - B_{\alpha\gamma}) + (B_{\alpha\delta} - B_{\beta\delta})} \right) = (c,d)$$ [14]

[12] A strategy is a rule or plan of action for playing a game. A pure strategy is a strategy in which a player makes a specific choice or takes a specific action. In contrast, a mixed strategy is a strategy in which a player makes a random choice among two or more possible actions, based on a set of chosen probabilities.

[13] Choosing a mixed strategy simply means that a player chooses a random device for selecting the pure strategy to be played. The type of random device chosen determines the probabilities with which the different pure strategies will be selected. Therefore such a random device represents a probability distribution on the set of the pure strategies. Players are assumed to choose their random device independently. By intuition, one could say: Be unpredictable when there is no equilibrium in pure strategies!

[14] Formally, a Nash equilibrium in mixed strategies is defined as follows: Fix a finite strategic form game $G = (S_i, u_i)_{i=1}^N$. A mixed strategy for player i is a probability distribution over S_i . The set of mixed strategies for

12 Game Theory: What is the Message?

Decision-makers do not, of course, have to worry about how optimal mixed strategies came about. We shall therefore not go into it in greater detail. But if we recall the core question of the scenario: "How should incentive structures be correctly identified and correctly set?" Nash equilibrium in mixed strategies does provide at least some relevant insights for decision makers:

- In the Nash equilibrium in mixed strategies there is a certain probability that the borrower will cheat and a certain probability that the bank will check rigorously. The borrower must therefore reckon that the bank will discover shortcomings.
- The probabilities only determine the individual motivations of the players. The strategic action interdependencies thus depend on if objectives are achieved by the opponent in each case. The first interesting conclusion that can be drawn here is: the higher the rating costs are for a bank, the lower the borrower will estimate the risk of being found out. And a second interesting conclusion is that: if a bank has efficient structures to help lower their rating costs, this improves market discipline.
- In the equilibrium the probability for undiscovered shortcomings (Ψ) is: prob (Ψ) = $b \cdot d$. It is a gauge for the honesty of information (publication quality) of the borrower and is directly related to the risk of default of the loan. This means that the incentive structures that can only be identified in mixed Nash equilibrium should be appropriately controlled by the bank so that they can better consider the risk of default.
- In a very simple game model only very basic considerations are made. Presumed qualitative interrelations can be quantified here however. The simple scenario in question here can thus also be expanded in many ways. For example, with repeated games (relationship banking) or with different types of banks and borrowers (deal-based banking).

13 Leaving More Time and Space for Games

Just as the preoccupation with the principles of design of a score cannot replace the experience of music, preoccupation with the principles of the design of Basel II cannot substitute experience

---

player i is denoted by M_i. The set of joint mixed strategies is denoted by $M = \times_{i=1}^{N} M_i$. Given a finite strategic form game $G = (S_i, u_i)_{i=1}^{N}$, a joint ("mixed") strategy $m^* \in M$ is a Nash equilibrium of G if for each player i, $u_i(m^*) \geq u_i(m_i, m_{-i}^*) \; \forall \; m_i \in M_i$.

with Basel II. Precisely for this reason games should be deliberated seriously: Basel II is the framework, like a new bike, into which the old, tried-and-tested wheels must be fitted. If the wheels are screwed in too tightly, the bicycle will not move. If, on the other hand, the wheels are not fitted tightly enough, the bicycle will "wobble". Only when the screws are tightened correctly will there be enough "play" between the wheel and the frame, so that the whole thing works properly.

With Basel II banks can no longer remain stuck in old routines. In the sense of the bicycle metaphor, the "play" is the mediating entity that implements the "spirit" of Basel II. From the point of view of the banking supervisory committee, Basel II is an evolutionary concept that is not only relevant to the area of borrowing, but to banking as a whole. In this sense it is not so much a question of collecting the relevant data but of preparing it so that it turns up at the right time and in the correct format to the decision makers in question. A simultaneous model that can be used to evaluate all risks with regard to their interrelations, is a dream of the future. Game theory can help in the changeover from Basel II to the "spirit" of Basel II. It is a first approximation to the "new": a sort of ideal standard. If the risks of the entire process chain, with interrelated dealings, are to be considered, and operational risks (behavioural risks) lurk in every sub-process, then the words of John MacMillan in his book "Games, Strategies & Managers: How managers can use game theory to make better business decisions, Oxford 1999" should apply: "Experience teaches you to see the trees; game theory helps you to see the forest."

As a proven, holistic way of thinking, which can provide a step towards strategic models, game theory can be used in the Basel II environment comparatively easily. If we consider the operational risks that group together all risk classes, it should be pointed out: In light of the complexity of the interrelations provoked by composite risks (interaction) and due to the lack of empirically relevant data, in the absence of flagstaffs to limit the scope of possibility, game theory can provide clear standards for relevant and accurate arguments. The bottom line here is what game theory can turn into a factor of success in risk management through "being better prepared"; some questions need to be answered, such as: Is the game well defined? Is the strategy space of the players correctly presented? Are the assumptions on the players' information plausible? Is it possible that game (X) is embedded in a more comprehensive game (Y) with an entirely different Nash equilibrium than game (X)?

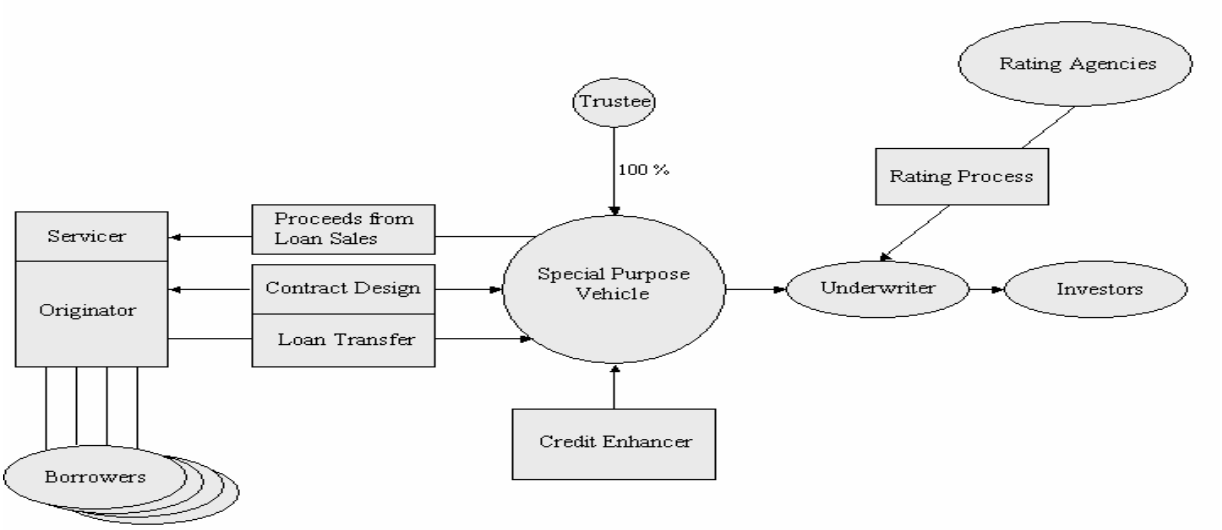
The fact that a whole catalogue of questions of this type must be posed and processed and that a conclusive answer may never be found, also applies, naturally, to the scenario outlined. This implies that flexibility in developing game models (strategies) has a "price": The relative nature of the situation must be carefully thought through, to come up with the clearest prognosis possible. We do not know if this is achieved with the above scenario or not. What we do know, however, is that: you will be better prepared if you know the framework in which the game takes place as well as possible, even if not everything can be calculated down to the last detail. If the search for solutions to problems is involved with strategy, then this must count for something.

14 What is the Nature of Risk in an Asset Backed Security Game?

The apparent "arbitrariness" in modelling and the resulting diversity of results is of course a serious problem if the strategy dimension is to be correctly clarified with game models. That how it is: Whether you can explain everything or you can explain nothing. Here, game models "only" help to make the situation clearer. A game model should not be vulnerable to small changes to the game components. If this happens, then warning lights will go on and decision-makers must be familiar with them. Whether of not the most important criterion fulfils a strategic analysis is a matter for the relevant decision-maker. Thus: the more precisely the few components of a game are known, the clearer the strategic (game theoretic) assessment of the situation. In this sense, then, it is not really important if the above scenario is "right" as a model for further discussion or "not right". Although Basel II makes banks realise that they should tentatively open up risks and the steps towards this are in the right direction, not everything can be achieved at first go. In this sense, the scenario also "only" aims to bring interrelations that would otherwise not be considered into focus.

In times of increasingly obscure information, the need to identify and set appropriate incentive structures and the progressively quicker cycles of regulatory requirements, there is, realistically, only one way for banks to improve their positions for the future: to doubt their own perfection and to learn to deal with it "gamefully". This actual state would please René Descartes. His personal motto was not the famous "Cogito ergo sum (I think, therefore I am)", but the sentence

describing the next highest level of development: "Dubium sapientiae initium (doubt is the origin of wisdom)". Game theory stands for the latter, on the strength of it inner logic.[15]



Graphic 5: Asset Backed Security Game

One final remark: What are the improved approaches (incentive structures) for adjusting the equity volume to the individual risk profile ("risk appetite") of the institute, if on the one hand the prevalent risk weighting function (RA) is actually not very helpful, and if on the other hand the bank has to play as a real life scenario an asset-backed security game?

15 Conclusion

A sufficient equity securitisation, as per Basel II, should not be deemed comprehensive insurance. Standards must be met and room must be found for solutions that go further. Since event risk, i.e.; nature made risk, and behavioural risk, i.e., man made risk, are not the same in risk management both strategic thinking and a mathematic of strategy comes up quite naturally.

[15] To shed more light on the matter let us add some words about the logic of the Nash equilibrium. It doesn't necessarily predict how players will behave in the real world. Rather, it provides a measure for how purely rational people might behave. It tells us what we might expect to see in a world where no one does anything wrong. Thus, one could say: By giving researchers a benchmark for rational behavior, it is a tool for investigating just how rational player really are. That players in some settings deviate from the kind of behavior the Nash equilibrium predicts is business. The essence of business success lies in making sure you're playing the right game. How do you know if it's the right game? What can you do about it if it's the wrong game? To help decision-makers answer those questions the Nash equilibrium is the tool that draws on the insights of games. Understanding those symmetries can help decision-makers come up with new strategies for changing the game or new applications of existing strategies. In this sense, successful business (risk management) strategies begin by assessing and ten changing one or more of the elements of the game. In this sense risk management using game theory for making better decisions is state of the art by changing the scope. The logic of the "all over (holistic) paradigm" is part of risk management: No game is an island because games are linked across space and over time.

Game theory, the natural tool to analyze situations that affect risk when agents follows their best strategies offers a flexible structure for modelling risk more realistic, if the decision-making process must be made more complex in banks as well. Embedded in a rating scenario the paper shows by using a simple game how game theory can be used to shape strategy for playing the right game in risk management.

References

Basel Committee on Banking Supervision: International Convergence of Capital Measurement and Capital Standards, A Revised Framework, Basel 2004.

Besanko, D.; Dravone, D.; Shanley, M.; Schaefer : Economics of Strategy, New York 2004.

Carmichael, F.: A Guide to Game Theory, Essex 2005.

Bieta, V.: Decisions Between Incomplete Informed Agents – A Basic Rating Game; To Appear: Periodical Yearbook of Game Theory and Applications.

Danielson, J.: The Emperor Has No Clothes – Limits of Risk Modeling, Journal of Banking and Finance, 26, p. 1273 – 1296, 2002.

Danielsson, J; Shin, H.: Endogenous Risk, Field, P (ed): Modern Risk Management, London 2003.

Gardner, R.: Games for Business and Economics, New York 2003.

Gintis, H.: Game Theory Evolving, Princeton 2000.

Gray, J.: Meta–Risks, Journal of Portfolio Management 26, 2000, p. 18 – 25.

Jovanovic, F.; Le Gall, P.: Does God Practise a Random Walk?, European Journal History of Economic Thought 3, 2001, p. 332 – 362.

Kelly, A.: Decision Making Using Game Theory, Cambridge Mass. 2003.

Miller, J.: Game Theory at Work, New York 2003.

Montet, C.; Serra, D.: Game Theory & Economics, New York 2003.

Osborne, M.J.: An Introduction to Game Theory, Oxford 2004.

Shleifer, A.: Inefficient Markets – An Introduction to Behavioral Finance, Oxford 2004.

Szegö, G.: Risk Measures for the 21st Century, London 2004.

Wahl, J.E.; Broll, U.: Value at Risk, Bank Equity and Credit Risk, in: Risk Management. Challenge and Opportunity, (eds.) Frenkel, M.; Hommel, U.; Rudolf, M.; second ed., Berlin et al., 2005, p. 159-168.

Watson, J.: Strategy – An Introduction to Game Theory, New York 2002.

Vega-Redondo, F.: Economics and the Theory of Games, Cambridge 2003.

Stulz, R. M.: Why Risk Management is not Rocket Science, Financial Times, Mastering Risk Series, June 27, 2000.

Dresden Discussion Paper Series in Economics

06/05 **Hirschhausen, Christian von / Cullmann, Astrid:** Efficiency Analysis of German Electricity Distribution Utilities

07/05 **Seitz, Helmut / Freigang, Dirk / Kempkes, Gerhard:** Demographic Change and Federal Systems: Some Preliminary Results for Germany

08/05 **Bemmann, Martin:** Verbesserung der Vergleichbarkeit von Schätzgüteergebnissen von Insolvenzprognosestudien

09/05 **Thum, Marcel:** Korruption und Schattenwirtschaft

10/05 **Seitz, Helmut / Kempkes, Gerhard:** Fiscal Federalism and Demography

01/06 **Bieta, Volker / Broll, Udo / Milde, Hellmuth / Siebe, Wilfried:** A Strategic Approach to Financial Options

02/06 **Battermann, Harald L. / Broll, Udo / Wahl, Jack E.:** Utility Functions of Equivalent Form and the Effect of Parameter Changes on Optimum Decision Making

03/06 **Broll, Udo / Wahl, Jack E.:** Value at risk, Equity and Diversification

04/06 **Broll, Udo / Fuchs, Frank / Wahl, Jack E.:** Optimale Fakturierung im Außenhandel

05/06 **Pontes, Jose Pedro:** A Non-monotonic Relationship between FDI and Trade

06/06 **Lehmann-Waffenschmidt, Marco:** Self-Referential Optimal Advising When Reactions are Delayed

07/06 **Dittrich, Marcus / Schirwitz, Beate:** A Dynamic Model of Union Behaviour. The Role of an Endogenous Outside Option and Bargaining Centralisation

08/06 **Kempkes, Gerhard / Pohl, Carsten:** The Efficiency of German Universities – Some Evidence from Non-Parametric and Parametric Methods

09/06 **Heinzel, Christoph / Winkler, Ralph:** Gradual versus structural technological change in the transition to a low-emission energy industry - How time-to-build and differing social and individual discount rates influence environmental and technology policies

10/06 **Heinzel, Christoph:** Schumpeter and Georgescu-Roegen on the foundations of an evolutionary analysis – The problem of qualitative change, its methodical implications and analytical treatment

11/06 **Wahl, Jack E. / Broll, Udo:** Bankmanagement mit Value at Risk

12/06 **Karmann, Alexander / Huschens, Stefan / Maltritz, Dominik / Vogl, Konstantin:** Country Default Probabilities: Assessing and Backtesting

13/06 **Kemnitz, Alexander:** Can Immigrant Employment Alleviatethe Demographic Burden? The Role of Union Centralization

14/06 **Kemnitz, Alexander / Eckhard Janeba / Ehrhart, Nick:** Studiengebühren in Deutschland: Drei Thesen und ihr empirischer Gehalt

01/07 **Kemnitz, Alexander:** University Funding Reform, Competition and Teaching Quality

02/07 **Sülzle, Kai:** Innovation and Adoption of Electronic Business Technologies

03/07 **Lehmann-Waffenschmidt, Marco / Sandri, Serena:** Recursivity and Self-Referentiality of Economic Theories and Their Implications for Bounded Rational Actors

04/07 **Lehmann-Waffenschmidt, Marco / Hain, Cornelia:** Neuroökonomie und Neuromarketing: Neurale Korrelate strategischer Entscheidungen

05/07 **Günther, Edeltraud / Lehmann-Waffenschmidt, Marco:** Deceleration - Revealed Preference in Society and Win-Win-Strategy for Sustainable Management

06/07 **Wahl, Jack E. / Broll, Udo:** Differential Taxation and Corporate Futures-Hedging

07/06 **Bieta, Volker / Broll, Udo / Milde, Hellmuth / Siebe, Wilfried:** The New Basel Accord and the Nature of Risk: A Game Theoretic Perspective