SONDERFORSCHUNGSBEREICH 504

Rationalitätskonzepte,
Entscheidungsverhalten und
ökonomische Modellierung

No. 03-23

Modeling the Use of Nonrenewable Resources Using a Genetic Algorithm

Daniel Schunk*

August 2003

Financial support from the Deutsche Forschungsgemeinschaft, SFB 504, at the University of Mannheim, is gratefully acknowledged.

*Sonderforschungsbereich 504, email: dschunk@uni-mannheim.de

Universität Mannheim
L 13,15
68131 Mannheim

Modeling the Use of Nonrenewable Resources Using a Genetic Algorithm

Daniel Schunk[*]

This Version: February 2003

Abstract:

This paper shows, how a genetic algorithm (GA) can be used to model an economic process: the interaction of profit-maximizing oil-exploration firms that compete with each other for a limited amount of oil. After a brief introduction to the concept of multi-agent-modeling in economics, a GA-based resource-economic model is developed. Several model runs based on different economic policy assumptions are presented and discussed in order to show how the GA-model can be used to gain insight into the dynamic properties of economic systems. The remainder outlines deficiencies of GA-based multi-agent approaches and sketches how the present model can be improved.

---

[*] Daniel Schunk is member of the Sonderforschungsbereich 504 and of the Mannheim Research Institute for the Economics of Aging (MEA), University of Mannheim, D-68131 Mannheim. e-mail: dschunk@uni-mannheim.de. The author wants to thank Prof. David Goldberg from the University of Illinois at Urbana-Champaign for detailed comments on an earlier draft of this paper and for introducing him to the fascination of genetic algorithms in late 2000.

1. Introduction

Using evolutionary algorithms to model economic behavior is still relatively new to scientific literature, but since the early nineties the interest in evolutionary economics is growing steadily. There are several reasons, why the application of Genetic Algorithms (GAs) in economic modeling is attractive, the most important being: The common neoclassical economic models are based on the assumption that individuals are *rational*. But nobody is taking all his economic decisions according to completely rational optimization decisions, a big deal of our economic behavior can a priori not be optimal, since we do not have the complete information that is necessary to take the optimal decision; we are not globally intelligent. In these situations our behavior is sometimes rather inductive than deductive (see Arthur, 1994). This insight has led to the notion of "*bounded rationality*", which has been heavily discussed in economics in recent years (e.g. Selten, 1990 and Conslik, 1996). Furthermore, our learning processes in economics are rather *decentralized* than centralized. Different economic agents have different beliefs. They react differently to different economic situations, based on their personal experiences and dispositions. Real economic agents interact via a given environment in a *local* and *autonomous* way.

Bounded rationality and decentralized learning can be modeled using a GA. GAs are most frequently used for all kinds of optimization problems, face recognition etc.; these are applications where we use GAs as an *instrumental* tool. GAs are applied as a *descriptive* tool, when we use them to model the behavior of economic, biological, physical etc. systems. In these cases, we expect the behavior of real systems to be similar to the behavior of a GA. Mostly this behavior is time-dependent, but GAs can also be used for spatial modeling approaches. My interest in modeling a time dependent process using a GA was ultimately inspired by former work in dynamic systems theory.

Before setting up the economic model that underlies the multi-agent-model presented in this paper, we should think briefly about the goals of socio-economic modeling. Unlike modeling in engineering sciences, the primary goal in socio-economic modeling and simulation is not optimization and optimal control. This is mainly due to the fact that we usually do not have the possibility of making repeated socio-economic experiments. Moreover, socio-economic systems are usually highly complex and very aggregated; in contrast to engineering problems, it is often impossible to break down a problem into various sub-problems.

Thus, one of the primary aims of modeling in the social and economic sciences is to promote our understanding of the phenomena that we observe. By running different scenarios, we obtain useful information for assessing the implications of different assumptions and policies, we can predict possible paths of development. Hence, the particular models are of great importance in all kinds of decision-making problems under uncertainty.

In this paper we use GAs as a descriptive tool to build a resource economics model with bounded rational agents. The economic agents, in our case oil firms, copy the elements of the strategic decisions of other agents by crossover. Mutation assures some kind of innovative behavior of the firms. The agents in our model undergo a simple "adaptation process"[1], their decisions are evaluated by their environment, which we set up according to common *micro*economic assumptions for a competitive market[2].

Our agents are not very skillful, they do not know the remaining amount of the resource, and profits are their only concern. This idea of less skillful (=bounded rational) agents is relatively new to *resource economics*, but, as mentioned above, it got a big deal of attention in *evolutionary economics* in recent

---

[1] *I do not dare to call it "learning process". Only the agents presented in chapter 3.4 really show some kind of simple learning behavior.*

[2] *This is another interesting feature of the use of multi-agent-Systems for economic modeling: We make our assumptions only for the behavior at the* micro *level, but we observe not only* micro- *but also* macroscopic *variables; thus, multi-agent models give us not only the possibility to study both, the microeconomic and the macroeconomic level, but also to study the dependencies between these two levels.*

years. Beckenbach (Beckenbach, 2000) gives a good overview of the use of GAs in resource economic models and he even presents a spatial approach. Geisendorf (Geisendorf, 1999) uses GAs for modeling "a profit oriented fishery with GA generated catching potential".

The economic problem presented in this paper is to find the optimal path for the extraction of the nonrenewable resource oil. It can be solved using optimal control theory (Dorfman, 1969), but so far, it has not been handled using a multi-agent-approach.

The interesting feature of this problem is that optimal or quasi-optimal behavior requires either that the firms collaborate voluntarily or that some sort of regulator or "economic planner" forces collaboration by prescribing the production decision of each firm at every time-step. Completely competitive behavior of all firms will lead to very inefficient behavior in terms of the particular profit of the firms.

The goal of this project is to find a very small set of economically reasonable regulating policies that assure a quasi-optimal behavior of the competitive firms under the given assumptions about their behavior. We lay down assumptions concerning the computational and behavioral limits of the agents and we will then investigate their consequences under different economic policies.

2. The model: Firms competing for a finite amount of crude oil

2.1 The economic background and model assumptions

Assume that we have an oil field, which is owned by n firms. The reservoir under the oil field holds a finite and not renewable amount of petroleum, and the n firms compete with each other for the oil. When the oil reservoir is depleted, the wells run dry. All the firms want to maximize the current value of their profits from selling the crude oil.

We further make the following assumptions for our small economy.

1. The demand curve is downward sloping, i.e. the higher the amount of oil on the market, the lower the oil price. The demand function that determines the market price of the oil, is given by the function:

   $$P(t) = 11 - \alpha * Q(t), \tag{1}$$

   where Q(t) is the total amount of oil pumped at time-step t, P(t) is the price for one unit of oil at time-step t, and α, the slope parameter, is arbitrarily set to 0.00003[3].
2. The firms face a convex cost function without fixed cost, marginal costs are positive, the costs grow at an in-creasing rate.

   $$C_j(t) = B * Q_j(t)^{\delta} \tag{2}$$

   The cost function has the form:
   $C_j(t)$ are the costs for firm j at time t and $Q_j(t)$ is the oil pumped by firm j at time t. B has the value 0.1 and δ is set to 1.25.
3. All firms maximize their current value profit (CVP) which is given by:

   $$CVP_j(t) = P(t) * Q_j(t) - C_j(t) \tag{3}$$

   for each firm j = 1, …, n.

In order to keep the model simple, we assume that no substitute for oil will be discovered and that the costs of extraction will remain the same over time.

The description so far leads to a model of competitive scarcity. If we further assume that the firms know the size of the oil reservoir and that the cumulative stream of current value profits is discounted

---

[3] Note that we do not investigate the sensitivity of the model towards the parameter α.

each period at an interest rate I, we obtain a well-defined optimal-path problem for every firm: Maximize the cumulative stream of discounted current value profits:

$$\int_0^T (P(t)*Q_j(t)-C_j(t))*e^{-I*t}dt=\int_0^T CVP_j(t)*e^{-I*t}dt \tag{4}$$

This problem can be solved using optimal control theory (Dorfman, 1969). In the competitive optimal case, all firms have the same strategy decisions at every time-step. A dynamic simulation model of the resource-economic model that has been explained above can be found with slightly different assumptions in (Ruth&Hannon, 1997).

Optimal behavior means that firms maximize the present value of cumulative profits. We realize from FIGURE 1 that this requires firms to make the appropriate pumping and selling decisions over time such that the oil price is rising constantly. These ideas led to the establishment of OPEC. The present paper was partly inspired by the huge amount of oil price and OPEC-policy-discussions that took place in late summer 2000.

2.2 The GA-implementation of the economic model

2.2.1 The general idea

In our genetic algorithm, every string represents the market strategy of a certain firm. The market strategy of our firms is simply the amount of oil that they pump at a certain time-step: The value coded by the string at time-step t represents the amount of oil that a particular firm pumps at time t.

Every firm wants to maximize its own profit. The firms try to achieve profit-maximization by imitating the strategy decision of the more successful firms. This is represented by the selection and crossover process: The higher the realized benefits of a certain firm, the more likely a less successful firm chooses this firm as a crossover partner. Completely new strategy decisions - which are assumed to be relatively seldom - are represented by a small mutation probability.

To make simulation realistic, we want to assure the continuity of existing firms[4]: To achieve this, we slightly change the common selection and crossover process: An individual in the population in generation t (call it $X_{i,t}$) selects another individual $X_{j,t}$ (based on the particular selection method). Then, crossover takes place (with a certain crossover probability p_{cross}), and a new individual $X_{i,t+1}$ is generated. That way, the resulting offspring $X_{i,t+1}$ is uniquely identified with its parental individual $X_{i,t}$. This is done for all i = 1,….,n , so that the continuity of each firm is guaranteed.

Furthermore, the standard setup of our GA model includes the feature that only those firms, whose average profit at time t is below mean profit at this time-step, are allowed to take part in crossover. My GA-runs have shown that this idea assures quicker and more stable convergence than the classical idea that all individuals are allowed to take part in crossover. It prevents the case that a fit individual $X_{i,t}$ has a relatively unfit crossover partner $X_{j,t}$. This is of particular importance in the present economic model, since the firms are all very similar.

Although tournament selection led to even quicker convergence in most cases, we choose roulette-wheel selection for the following model runs, since roulette-wheel selection has led to more uniform behavior in the standard run (FIGURE 1), independent of the different random seeds. Furthermore, the goal of agent-

---

[4] *This means that string number j of the population can be identified with the same firm number j in all time-steps. Each offspring firm can be uniquely attributed to one parent firm. To my astonishment, this idea seems to be totally uncommon in economic multi-agent modeling. For example, Arifovic ((Arifovic, 1990) and Geisendorf (Geisendorf, 1999) have not implemented this feature in their economic GA-models.*

based modeling is not to obtain quick convergence, but to find a somewhat realistic mapping of real behavior. In this sense, the bigger uniformity of different roulette-wheel runs induces us to opt for this selection method.

The GA-model is based on the economic model presented in the previous chapter. Since we are modeling the oil-decision of the firms over time and since we assume that the firms are not able to behave anticipatory, we do not include the discount rate in our model. To make the model more realistic, we include the cost of extension of a firm according to standard economic assumptions. The equation for the costs of each firm has the form:

$$Cost_j(t) = \left\{ \begin{array}{ll} \sqrt{\dfrac{C_j(t)}{C_j(t-1)}} * C_j(t) & if \ \dfrac{Q_j(t)}{Q_j(t-1)} > 1.05 \\ C_j(t) & else \end{array} \right\} \qquad (5)$$

$C_j(t)$ has the same form as given in (2), so that equation (5) just stands for slightly increased costs for those firms that increase their amount of pumped-oil by more than 5% from one time-step to the next time-step.

In early stages of my GA-work, I implemented niching (based on phenotypic sharing, as outlined in Deb&Goldberg, 1989), but I found that niching is not reasonable given my assumption of a competitive market, where the firms' only concern is to maximize their profits. In order to assure as much analogy as possible to the classical microeconomic assumptions for optimal path problems, I abandoned the idea of niching and I have stuck to the idea of the competing agents with identical goals and properties.

2.2.2 Coding and parameter considerations

For building a realistic multi-agent model, the appropriate choice of coding and parameters is extremely important. At the beginning of my experiments I had some problems to find the appropriate coding for my GA. To avoid Hamming-cliff problems of a normal binary coding and to avoid that mutations occurring at starting positions of the binary string can have an overwhelming influence on the individuals' strategy decisions, I implemented a Gray code representation of the firms' strategy. But I found that the Gray coding sometimes caused convergence problems and that I still didn't control the mutation problem very well. Therefore, I switched to "normal" binary coding and introduced a mutation probability that is dependent on the particular position of a bit in the bit-string. The mutation probability is calculated according to the following formula:

$$\mathrm{P_{mut}(bitpos) = P_{mut}} * \frac{1}{\mathrm{(lchrom - bitpos)}^2} \qquad (6)$$

This assures that the mutation probability decreases when the real value represented by the particular bit increases.

In order to provide for a realistic behavior, problems of genetic drift and inter-building-block-difficulties had to be avoided. At the beginning of my trials, I chose a population size of 10 and a string length of 10, used the economic model parameters (such as initial amount of oil etc.) given in the resource-economic model described in (Ruth&Hannon, 1997). I initialized the firms according to a uniform random distribution with a given mean and a maximal deviation of 10% of the mean. This resulted either in genetic drift, mainly because I had low signal building blocks, or in premature convergence. This couldn't be found by only looking at the decoded results of the firms' decisions but it became clear when I looked at the binary strings that were generated after some generations. As described in (Goldberg, 1992 & 1993) an increase of the population size is likely to help. I increased my population size to 40, but the GA was still very dependent on the initial mixing. In order to avoid this, I worked out the following idea that assures a good initial mixing of the population:

The first (and highest) bit of every initial population member should be set to one. All the other bits should be either a one or a zero with 50% probability. I scaled the problem given in (Ruth&Hannon, 1997) so that the population is initialized according to a symmetric and uniform random distribution with the mean value 6144. Now, a string length of 13 assures that the initial mixing corresponds to the idea that I described above, provided that the symmetric interval lies within the range of [$6144-2048 = 2^{11}$, $6144+2048=2^{13}$] and has the mean value 6144. This can easily be shown using some simple mathematical arguments.

The initial mixing is essential for the success of the presented model and together with the higher population size, phenomena such as genetic drift and premature convergence can be avoided. Furthermore, even when the GA converged to a relatively stable price level (such as in FIGURE 1), there was still some variability in the population and the GA permanently tried to improve the short-term profits of the firms under the given economic constraints.

An interesting result of the work so far is that multi-agent-problems are very sensitive to problems such as genetic drift and premature convergence[5]. The GA-based multi-agent models that are found in literature do not pay sufficient attention to problems that are associated with a reasonable initial setup and parameter choice of the GA[6]. Instead, they only focus on extensive sensitivity analyses of mutation probability, crossover probability and population size and they try to interpret the particular results from an economic point of view. In my opinion, it is more reasonable to perform sensitivity analyses on the pure economic parameters of the model, and not on the GA-parameters. A sensitivity analysis on the GA-parameters is more interesting from the point of view of a GA-researcher than from the point of view of an economist. In some cases, it is not the economic assumptions that lead to great differences in the results, but it is the parameter setting of the GA that leads to specific GA-behavior. On the other hand, problems such as genetic drift can have a reasonable economic interpretation, so I do not dare to say that it is a priori wrong to play too much with GA-parameters in a GA-economic model. But at least, one should pay attention to the fact that the simulation results are not only dependent on the economic assumptions but also on the "self-dynamics" of the GA, which sometimes does not have an economic interpretation.

In my opinion, when one uses GA-models (such as the one presented in this paper) that are concerned with testing different economic hypothesis, one shouldn't play too much with pure GA-parameters (such as different crossover probabilities etc.). I propose the following procedure: First, choose a GA-parameter setting that (a) results in realistic economic behavior given the economic assumptions of the model and (b) yields stable and robust behavior for slight changes of GA-parameters and different random seeds. That is, problems such as premature convergence etc. should be avoided. Second, test different economic assumptions or policies by changing the economic environment; interpret the results.

This is the proceeding we follow in the present work: Having found appropriate parameters, we examine the implications of different economic policies on our multi-agent-model.

For the presented model, I found the following parameters to be the most appropriate:

◆ population size n = 40 ◆ string-length = 13 ◆ $P_{mut} = 0.1$ ◆ $P_{cross}=0.5$.

---

[5] *For descriptive GA-applications, unlike optimization applications, not only the final result of the GA-run is important, it is also the behavior over time that is important, because the time path of the multi-agent simulations is expected to comply roughly with the real systems' behavior over time, in order to qualify the multi-agent model as a reasonable mapping of reality.*

[6] *E.g. (Geisendorf, 1999) chooses population size n = 10 for her standard runs and checks the sensitivity of her model to different mutation and crossover probabilities.*

3. Results

3.1 The theoretically optimal case with uniform agents

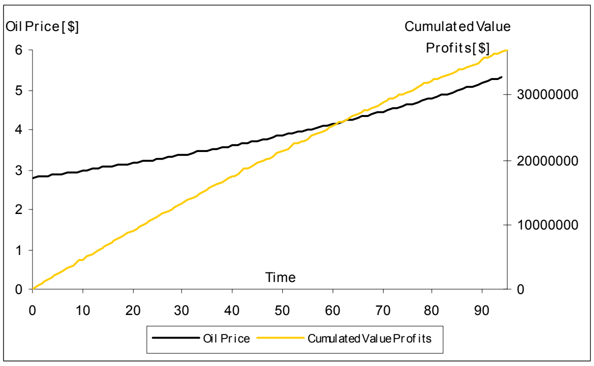

FIGURE 1

As I have described above, if all n oil-firms would collaborate, if all of them could trust in each other and if they were all oriented towards long-term profit goals, the optimal time-path of the oil price that maximizes the cumulated value profits of all firms could be found with the aid of optimal control theory. We simulate this optimal case under the assumption of a discount rate of 1%. FIGURE 1 shows the generated optimal path of prices and of cumulated value profit.

Reality shows that complete collaboration, uniform behavior, complete information on the other firms' behavior and long-term orientation for all firms is a highly idealized microeconomic assumption. In this paper, we chose the opposite assumption: We assume that the firms do not collaborate, that they are only interested in their own advantages over the other firms and that they do not have complete information. Furthermore, they only have short-term goals: Try to improve the oil strategy and maximize the profit as soon as possible!

The economic question of this paper is: Given the underlying assumptions concerning the modeled behavior of the individual firms, what economic policy can lead to a *quasi-optimal* behavior of the n firms? "Quasi-optimal" is defined here as a constantly rising oil price.

If we abstract from some economic assumptions of our multi-agent-model and if we tackle the problem from the perspective of a GA-researcher (and not from the perspective of an economist), the underlying question of this paper is now reduced to the simple and sobering question: How can I assure that the average fitness of my GA (which is the amount of oil pumped by a particular firm) goes down ?

Again, should I want to point out that the interpretation of the presented model runs can be considered from the perspective of both, economics and evolutionary computation. It is important to have that in mind, in order not to misinterpret the results. Nevertheless, we will see that GAs can yield some interesting information for economic policy analysis that cannot be obtained from the traditional static and comparative-static economic models.

3.2 Results of different model runs

In Figure 2 we see the results of the standard run. As expected, the profit-maximizing firms increase their oil-pumping over time in order to maximize their particular profits. This leads to a slow decrease in the market price of oil, which is inefficient in the long run. After a certain amount of time-steps the system reaches a low but relatively stable market price that guarantees very small positive profits for all firms. A slightly lower price would result in negative profits for the firms. Areas of negative profits are avoided in all GA runs, because firms with negative profits would immediately take part in crossover with a better firm and so they improve their strategy. Furthermore, we see that the GA is relatively robust. In all my runs, the same behavior

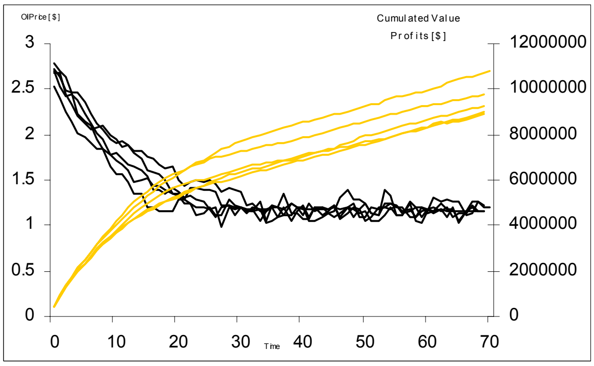

FIGURE 2

as that shown in the five representative runs in FIGURE 2 occurred. This is mainly due to the sensible parameter setting as described in chapter 2.1.
Note that the graphs stop at the time-step when the oil reservoir is empty. Therefore, different runs stop at different points of time. In comparison with the optimal graph, we see that in the non-optimal behavior in FIGURE 2 the oil-reservoir is depleted earlier, because the firms pump more.

In the following part of this paper, we will investigate some policies or rules that can be implemented by some kind of economic regulator (such as the government) in order to provide incentives for more resource efficient behavior on the part of the firms. These policies (such as subsidies etc.) are used by many governments in order to influence firms' behavior[7]. There is a comprehensive discussion in economic literature on whether these policies are efficient and what their influence on firms' behavior might be.
In order to prevent graphical confusion, only the oil price development will be presented in the following graphs. Since the development of the oil price is a good indicator for the efficiency of the examined policy, presenting the oil price is sufficient for evaluating the different policy implications.

(1) The first scenario is based on the idea that 15 firms of the 40 firms are given a subsidy of $ 8000 at every time-step. Note that the policy-maker doesn't care to whom these subsidies are given - the firms are randomly chosen at the beginning of the simulation period. Some resulting GA-runs are shown in FIGURE 3. We see that this policy leads to an oil price that is oscillating irregularly about the level of approximately $ 2.60. Obviously, in this scenario the oil wells run dry later than in the standard scenario presented above. Hence, the cumulated profit of the firms is much higher than in FIGURE 2.

(2) The second scenario is shown in FIGURE 4. In this scenario, I assumed that at every time-step the 15 weakest firms receive a subsidy of $ 8000. The price rises steeply in the first time-steps, but shortly after, it comes down and again we perceive irregular oscillations; but this time they are fluctuating about the level of approximately $ 2.90.

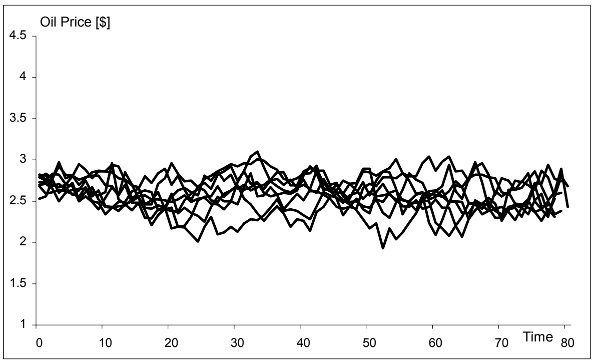

FIGURE 3

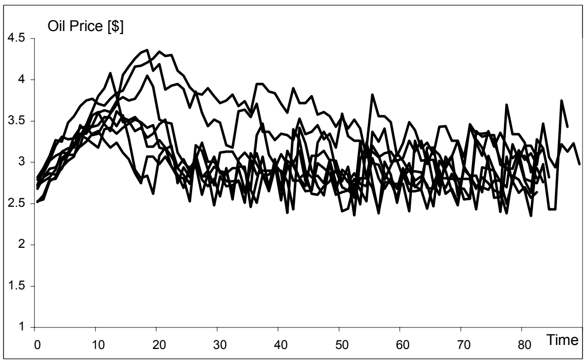

FIGURE 4

(3) The next scenario is based on the following idea: Every time-step we reduce by 5% the expected amount of oil of those firms, which were among the 15 best in the preceding time-step. This means that every firm takes place in the usual crossover and mutation process, but then the generated amount of oil of the 15 best firms in the preceding time-step is reduced by 5%. Consequently, the particular coding of those 15 firms has to be readjusted and the calculation of the economic background has to be reevaluated, since the oil amount has changed for 15 firms. This idea was born, when I was thinking about the possibilities of self-organization in artificial societies: I assumed that the competition among the firms induces the weaker firms to collaborate and to aggravate the oil pumping process for their successful

---

[7] *The current worldwide oil market is characterized by all kinds of subsidies, depletion allowances and price supports.*

competitors. But the idea can also be interpreted as a policy-makers' decision to cut down by 5% the proposed amounts of oil of those firms, which were among the best in the last time period.
The results of this assumption are shown in FIGURE 5. We see that this measure seems to be efficient; at least it leads to a rising price. On the other hand, the extremely high variability of the price is not attractive from the point of view of the policy-maker[8].

(4) In the fourth scenario, the policy-maker increases by 20% *the cost* of pumping oil of the 15 best firms. He does this every time-step. We can interpret this policy as a tax on the firms. The tax is dependent on the amount of oil pumped. As can be seen in FIGURE 6, the result is amazingly good. The price is rising constantly and the fluctuation of the price is extremely small, which is desirable from the perspective of the policy-maker. Nevertheless, we shouldn't be too enthusiastic, since the increase in the price is not very high and the GA will converge to a price level of about $ 3.25.

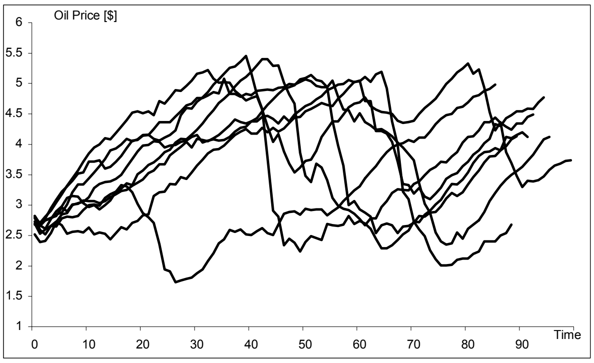

FIGURE 5

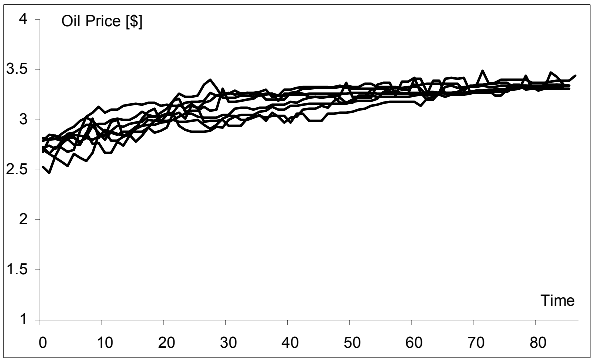

FIGURE 6

In order to check the sensibility of the outcomes of the policy analysis to an important model assumption about the behavior of the firms, I ran the policy scenarios (1)-(4) under the following assumption: Not the current value profit but the cumulated value profit of a particular firm is an indicator of its success. This means that in this case, only the firms that are below the average of the *cumulated* value profit participate in crossover. Moreover, the 15 best firms in our policy scenarios are now chosen according to the firms *cumulated* value profit.
The results were qualitatively the same as the result that I have discussed above: Again, scenario (4) resulted in a constantly rising price without much fluctuation. Scenario (3) was very fluctuating, the same applies to scenario (1) and (2), although the amplitude of the oscillations in scenario (1) and (2) was relatively low compared to the amplitude in scenario (3).

3.3 Implications of the results

The GA-runs presented so far have shown how GAs can be used to investigate the implications of different economic policies.
Multi-agent-models differ from the classical static or comparative-static economic models in that they not only present the final equilibrium that will be reached after implementing a certain policy, but their scenarios also give examples for *the way to the equilibrium* and the impact of a certain policy on the behavior of the particular individuals *over time*. By modeling the behavior of individuals (this means: making assumptions about the *micro*-level), we obtain results about the behavior of some aggregate economic entity (the *macro*-level), such as the oil market.

---

[8] *Even if it looks as if the price is constantly rising at the end of our examined time-period, this is not the case: If we run the scenario for more time-steps (by increasing the amount of oil in the reservoir), the price will continue to oscillate with the observed high amplitude and without coming to a stable level.*

Which of the presented scenarios would be the most attractive for a policy maker? Policy (3) seems to cause an efficient increase in the oil price, but the high variability of the oil price shows that this policy is likely not to produce a robust and economically optimal behavior.

Although policy (1) assures price stability to a certain extent, it is less efficient than policy (2), although the same amount of subsidy-money is spent. Policy (4) seems to be very attractive. As common in economic policy analysis, we examine the transfer payments (which means the amount of money that has to be transferred "to another destination", either in the form of subsidies to the firm, as in (2), or in the form of tax payments from the firm, as in (4)), that occur under policies (2) and (4). Similar to assumptions in classical economic policy analysis, subsidies for the firms should simply be considered as transfer payment from society to the firms; but they do not by themselves constitute a change in overall welfare of the society. We should think of all the transfer payments as redistribution measures with the goal of influencing firms' behavior.

For policy (4), we just multiply the subsidy of $ 8000 by the number of firms that receive the subsidy and by the number of time-steps that this subsidy has to be paid. We obtain $ 10,800,000 of transfer payments.

For estimating the transfer payments of policy (4), we perform 20 GA runs (with different random seeds) and let the computer calculate the cumulated tax payments each time. The average tax payment per GA-run is $ 3,398,989 and the standard deviation is $ 240,914.

This shows that policy (4) comes along with significantly less transfer payments. Moreover, since the standard deviation of the tax payment is relatively low, this policy seems to be relatively robust.

Based on the information of this model, a policy-maker would probably opt for policy (4).

The new information that we obtained by running our four scenarios is: Though leading to a more profitable behavior than in the standard scenario (FIGURE 2), the policies (1), (2) and (3) are likely to produce a relatively fluctuating price; policy (4) induces robust behavior and the desired rising oil price. This information is not obvious, it cannot be obtained by classical economic methods, since the classical economic methods typically examine the possibility and the level of an equilibrium, but they are *not* able to study the time path to the equilibrium. The present work shows that some interesting information about possible development paths under different economic assumptions and policies can be obtained when using a multi-agent framework. Agent-based modeling approaches allow the investigation and analysis of previously inaccessible phenomena.

In this sense, classical economic modeling approaches and multi-agents models of economic systems, are not competing with each other, but they are complementary: Multi-agent-models can examine features of economic systems that cannot be investigated using traditional approaches, and vice versa.

3.4 Critical remarks and areas for future research

Despite the interesting and promising insights into the dynamic properties of economic systems that we gained due to the use of GAs as a modeling tool, we shouldn't forget to think briefly about some deficiencies of the GA approach.

Taking a closer look at the mechanics of our GA, we realize that there are significant differences between the GA-agents and human learning or strategy choice.

First of all, it is evident that just having a look at other firms benefit is not sufficient for adapting its whole production program. This idea is a highly idealized picture of real behavior. Furthermore, our GA-model assumes that human interaction takes place pair-wise. In real economic systems this is certainly not the case. Some information (such as statistical market data etc.) is available to all economic agents, other pieces of information are exchanged pair-wise. A more sophisticated GA-model should therefore consider a more adequate way of information transmission than that way presented in this paper.

The most important inadequateness of our GA-model is probably the lack of some cognitive aspects of our agents:
Real economic agents have a memory; they not only remember past experiences, but they are also able to compare new strategies with old ones or check whether the intended new strategy decisions have already been tried in the past.

We can add some learning properties to my agents according to the following idea: Think of learning as updating the probabilities of taking a certain action on the basis of payoffs in preceding time-steps. Every individual has a two- dimensional learning-vector L[]. After each strategy decision, the individual evaluates its strategy, according to the following rule:
If $\Delta Q_{i,t} = Q_i(t) - Q_i(t-1)$ and $\Delta\ CVP_{i.t} = CVP_i\ (t) - CVP_i\ (t-1)$ have different signs (which means that there is a negative correlation between oil price and profit), then add the negative profit elasticity $-\Delta CVP_{i.} / \Delta Q_{i,t}$ to the first element L[1] of the learning vector. If $\Delta Q_{i,t}$ and $\Delta CVP_{i.t}$ have the same sign (positive correlation between oil price and profit), then add the profit elasticity $\Delta CVP_{i.} / \Delta Q_{i,t}$ to the second element L[2] in the learning vector.
At every time-step the individual calculates the updated probability of a negative correlation between price and profit: P[neg]=L[1]/(L[1]+L[2]). The probability of a positive correlation is calculated according to: P[pos]=L[2]/(L[1]+L[2])= 1-P[neg]. Then, with the probability P[neg] only a decrease in the amount of oil is accepted (because the individual has learned that a decrease in the amount of oil can lead to an increase in profits). Equally, an increase in the amount of oil pumped is only accepted with a probability P[pos].

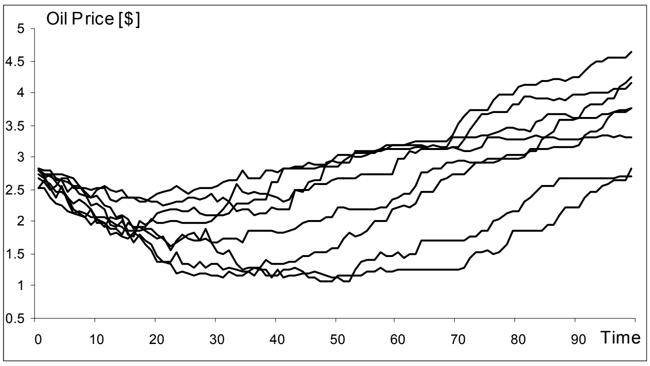

FIGURE 7

The result of the GA-run is shown in FIGURE 7. In order to obtain the best learning results, we have to increase the mutation rate to 0.75. This assures that there is enough innovation in the system to make the individuals learn quickly[9]. We can also test the four policies (1)-(4) on our learning agents. Although the subsidy scenarios (1) and (2) now result in significantly higher prices than the tax scenario (4), it is interesting to note that again, scenario (4) was the one which led to the least variability of the price level and had the most robust behavior.
Although this result seems promising, especially since scenario (4) led to the same robust behavior as in the previous GA-setups, the graph also shows how sensitive multi-agent models are to the assumptions that we make about the agents' capacities.
Thus, in order to obtain valid models that reflect observed behavior, we should think about how to calibrate our model against empirical data of real economic systems. Arthur (Arthur, 1991) shows with a simple learning task example that it is possible to calibrate learning-algorithm parameters against data on human learning. It should also be possible to calibrate GA-models, such as the one presented in this paper, against economic data.

---

[9] *Furthermore, we can test the implications of different learning parameters: Instead of adding elasticities, we can add the square root of the elasticities, which increases the impact of small learning events (elasticity < 1) and decreases the impact of huge learning events (elasticity >>1). We could as well just add a constant to the particular vector element of L[] in case of the particular learning event. Of all the learning scenarios that I have tested in my research, the one presented above is the best. But with some further research, the learning of the individuals can surely be improved to a certain extent.*

4. Summary and Conclusion

This paper has examined how a GA can be used to model economic behavior. It claims that for the examination of dynamic economic systems with the aid of GAs, some fundamental knowledge about GA-theory is necessary in order to prevent possible misinterpretations of the results. To accomplish this, a robust GA-behavior that can be achieved by a sensible choice of GA-parameters, is the prerequisite.

Furthermore, this paper has shown that a GA-based modeling approach can reveal interesting properties of dynamic systems that can't be found with traditional economic methods. An example is the finding that policy (4), presented in chapter 3, turned out to be the most stable policy in the sense of not leading to a high variability of the oil price. Multi-agent models complement traditional theoretical and empirical approaches in economics.

Chapter 4 has indicated that a big deal of research has to be done in the field of agent-based modeling. The agents' behavior has to be made more realistic and the models have to be calibrated against observed data.

References:

Arifovic, J. (1990). *Learning by Genetic Algorithms in Economic Environments.* Santa-Fe-Institute Working Papers #90-001

Arthur, Brian W. (1991). *Designing Economic Agents that Act Like Human Agents: A Behavioral Approach to Bounded Rationality*. AEA Papers and Proceedings. Learning and Adaptive Economic Behavior. p 353-359

Arthur, Brian W. (1993). *On Designing Agents that Behave Like Human Agents*. Journal of Evolutionary Economics, 3: 1-22

Arthur, Brian W. (1994). *Inductive Reasoning, Bounded Rationality and the Bar Problem*. Santa-Fe-Institute Working Papers #94-03-014

Beckenbach, F. (2000) *Multi-Agent Modeling of Resource Systems and Markets.* Working Papers of the University of Kassel.

Chattoe, E. (1997) *Modeling Economic Interaction Using a Genetic Algorithm*. In: Handbook of Evolutionary Computation. IOP Publishing Ltd and Oxford University Press. p. G7.1:1 - G7.1:5

Conslik, J. (1996) *Why Bounded Rationality?* Journal of Economic Literature, 6: 669-700

Dorfman, R. (1969). *An Economic Interpretation of Optimal Control Theory*, The American Economic Review 59:817-831

Geisendorf, S. (1999) *Genetic Algorithms in Resource Economic Models*. Santa-Fe-Institute Working Papers #99-08-058

Deb, K. and Goldberg, D.E. (1989). *An investigation of niche and species formation in genetic function optimization.* Proceedings of the Third International Conference on Genetic Algorithms, pp 42-50.

Goldberg, D.E., Deb, K. & Clark, J.H.(1992) *Genetic algorithms, noise, and the sizing of populations*. Complex Systems, 6, pp 333-362.

Goldberg, D.E., Deb, K. & Thierens, D. (1993) *Toward a better understanding of mixing in genetic algorithms*. Journal of the Society of Instrument and Control, 1993, Vol. 32, pp 10-16.

Harrald, P.G. (1996). *Evolutionary Algorithms and Economic Models: A View* in Evolutionary Programming V Fogel, L.J, P.J. Angeline and T. Baeck, Editors. MIT Press, Cambrigde Mass. p. 3-7.

Holland, J.H. and J.H. Miller. (1991) *Artificial Adaptive Agents in Economic Theory*. The American Economic Review 81: 365-370

Ruth, M. and B. Hannon (1997) *Modeling dynamic economic systems*. Springer-Verlag, New York.

Selten, R. (1990) *Bounded Rationality.* Journal of Institutional and Theoretical Economics v146, n4: 649-58

Nr.	Author	Title
03-34	Volker Stocké Bettina Langfeldt	Umfrageeinstellung und Umfrageerfahrung. Die relative Bedeutung unterschiedlicher Aspekte der Interviewerfahrung für die generalisierte Umfrageeinstellung
03-33	Volker Stocké	Measuring Information Accessibility and Predicting Response-Effects: The Validity of Response-Certainties and Response-Latencies
03-32	Siegfried K. Berninghaus Christian Korth Stefan Napel	Reciprocity - an indirect evolutionary analysis
03-31	Peter Albrecht Cemil Kantar	Random Walk oder Mean Reversion? Eine statistische Analyse des Kurs/Gewinn-Verhältnisses für den deutschen Aktienmarkt
03-30	Jürgen Eichberger David Kelsey Burkhard Schipper	Ambiguity and Social Interaction
03-29	Ulrich Schmidt Alexander Zimper	Security And Potential Level Preferences With Thresholds
03-28	Alexander Zimper	Uniqueness Conditions for Point-Rationalizable Solutions of Games with Metrizable Strategy Sets
03-27	Jürgen Eichberger David Kelsey	Sequential Two-Player Games with Ambiguity
03-26	Alain Chateauneuf Jürgen Eichberger Simon Grant	A Simple Axiomatization and Constructive Representation Proof for Choquet Expected Utility
03-25	Volker Stocké	Informationsverfügbarkeit und Response-Effects: Die Prognose von Einflüssen unterschiedlich kategorisierter Antwortskalen durch Antwortsicherheiten und Antwortlatenzen
03-24	Volker Stocké	Entstehungsbedingungen von Antwortverzerrungen durch soziale Erwünschtheit. Ein Vergleich der Prognosen der Rational-Choice Theorie und des Modells der Frame-Selektion

SONDERFORSCHUNGSBereich 504 WORKING PAPER SERIES

Nr.	Author	Title
03-23	Daniel Schunk	Modeling the Use of Nonrenewable Resources Using a Genetic Algorithm
03-22	Brian Deal Daniel Schunk	Spatial Dynamic Modeling and Urban Land Use Transformation: An Ecological Simulation Approach to Assessing the Costs of Urban Sprawl
03-21	Thomas Gschwend Franz Urban Pappi	Stimmensplitting und Koalitionswahl
03-20	Thomas Langer Martin Weber	Does Binding or Feeback Influence Myopic Loss Aversion - An Experimental Analysis
03-19	Peter Albrecht Carsten Weber	Asset/Liability Management of German Life Insurance Companies: A Value-at-Risk Approach in the Presence of Interest Rate Guarantees
03-18	Markus Glaser	Online Broker Investors: Demographic Information, Investment Strategy, Portfolio Positions, and Trading Activity
03-17	Markus Glaser Martin Weber	September 11 and Stock Return Expectations of Individual Investors
03-16	Siegfried K. Berninghaus Bodo Vogt	Network Formation and Coordination Games
03-15	Johannes Keller Herbert Bless	When negative expectancies turn into negative performance: The role of ease of retrieval.
03-14	Markus Glaser Markus Nöth Martin Weber	Behavioral Finance
03-13	Hendrik Hakenes	Banks as Delegated Risk Managers
03-12	Elena Carletti	The Structure of Bank Relationships, Endogenous Monitoring and Loan Rates
03-11	Isabel Schnabel	The Great Banks‘ Depression - Deposit Withdrawals in the German Crisis of 1931

Nr.	Author	Title
03-10	Alain Chateauneuf Jürgen Eichberger Simon Grant	Choice under Uncertainty with the Best and Worst in Mind: Neo-additive Capacities.
03-09	Peter Albrecht Carsten Weber	Combined Accumulation- and Decumulation-Plans with Risk-Controlled Capital Protection
03-08	Hans-Martin von Gaudecker Carsten Weber	Surprises in a Growing Market Niche - An Evaluation of the German Private Annuities Market
03-07	Markus Glaser Martin Weber	Overconfidence and Trading Volume
03-06	Markus Glaser Thomas Langer Martin Weber	On the trend recognition and forecasting ability of professional traders
03-05	Geschäftsstelle	Jahresbericht 2002
03-04	Oliver Kirchkamp Rosemarie Nagel	No imitation - on local and group interaction, learning and reciprocity in prisoners break
03-03	Michele Bernasconi Oliver Kirchkamp Paolo Paruolo	Expectations and perceived causality in fiscal policy: an experimental analysis using real world data
03-02	Peter Albrecht	Risk Based Capital Allocation
03-01	Peter Albrecht	Risk Measures
02-51	Peter Albrecht Ivica Dus Raimond Maurer Ulla Ruckpaul	Cost Average-Effekt: Fakt oder Mythos?
02-50	Thomas Langer Niels Nauhauser	Zur Bedeutung von Cost-Average-Effekten bei Einzahlungsplänen und Portefeuilleumschichtungen
02-49	Alexander Klos Thomas Langer Martin Weber	Über kurz oder lang - Welche Rolle spielt der Anlagehorizont bei Investitionsentscheidungen?
02-48	Isabel Schnabel	The German Twin Crisis of 1931

Nr.	Author	Title
02-47	Axel Börsch-Supan Annamaria Lusardi	Saving Viewed from a Cross-National Perspective
02-46	Isabel Schnabel Hyun Song Shin	Foreshadowing LTCM: The Crisis of 1763
02-45	Ulrich Koch	Inkrementaler Wandel und adaptive Dynamik in Regelsystemen
02-44	Alexander Klos	Die Risikoprämie am deutschen Kapitalmarkt
02-43	Markus Glaser Martin Weber	Momentum and Turnover: Evidence from the German Stock Market
02-42	Mohammed Abdellaoui Frank Voßmann Martin Weber	An Experimental Analysis of Decision Weights in Cumulative Prospect Theory under Uncertainty
02-41	Carlo Kraemer Martin Weber	To buy or not to buy: Why do people buy too much information?
02-40	Nikolaus Beck	Kumulation und Verweildauerabhängigkeit von Regeländerungen
02-39	Eric Igou	The Role of Lay Theories of Affect Progressions in Affective Forecasting
02-38	Eric Igou Herbert Bless	My future emotions versus your future emotions: The self-other effect in affective forecasting
02-37	Stefan Schwarz Dagmar Stahlberg Sabine Sczesny	Denying the foreseeability of an event as a means of self-protection. The impact of self-threatening outcome information on the strength of the hindsight bias
02-36	Susanne Abele Herbert Bless Karl-Martin Ehrhart	Social Information Processing in Strategic Decision Making: Why Timing Matters
02-35	Joachim Winter	Bracketing effects in categorized survey questions and the measurement of economic quantities

Nr.	Author	Title
02-34	Joachim Winter	Design effects in survey-based measures of household consumption
02-33	Stefan Schwarz Dagmar Stahlberg	Motivational influences on the strength of the hindsight bias
02-32	Stefan Schwarz Dagmar Stahlberg	Strength of hindsight bias as a consequence of meta-cognitions
02-31	Roman Grunwald	Inter-Organisationales Lernen und die Integration spezialisierten Wissens in Kooperationen - Eine empirische Untersuchung anhand von kooperativen Entwicklungsprojekten
02-30	Martin Hellwig	The Relation Between Real Wage Rates and Employment: An Intertemporal General-Equilibrium Analysis
02-29	Moshe Ben-Akiva Daniel McFadden Kenneth Train Axel Börsch-Supan	Hybrid Choice Models: Progress and Challenges
02-28	Angelika Eymann Axel Börsch-Supan Rob Euwals	Risk Attitude, Impatience, and Asset Choice
02-27	Axel Börsch-Supan Alexander Ludwig Joachim Winter	Aging and International Capital Flows
02-26	Rüdiger F. Pohl Stefan Schwarz Sabine Sczesny Dagmar Stahlberg	Gustatory hindsight bias
02-25	Axel Börsch-Supan	What We Know and What We Do NOT Know About the Willingness to Provide Self-Financed Old-Age Insurance
02-24	Florian Heiss	Specification(s) of Nested Logit Models

Nr.	Author	Title
02-23	Axel Börsch-Supan	Kann die Finanz- und Sozialpolitik die Auswirkungen der Bevölkerungsalterung auf den Arbeitsmarkt lindern?
02-22	Tito Boeri Axel Börsch-Supan Guido Tabellini	Would you Like to Reform the Pension System? The Opinions of European Citizens
02-21	Axel Börsch-Supan Florian Heiss Miki Seko	Housing Demand in Germany and Japan - Paper in memoriam of Stephen Mayo
02-20	Siegfried K. Berninghaus Karl-Martin Ehrhart	The power of ESS: An experimental study
02-19	Douglas Gale Martin Hellwig	Competitive Insurance Markets with Asymmetric Information: A Cournot-Arrow-Debreu Approach*
02-18	Michele Bernasconi Oliver Kirchkamp	The Expectations view on fiscal policy - An experiment using real world data
02-17	Oliver Kirchkamp Rosemarie Nagel	Reinforcement, repeated games, and local interaction
02-16	Volker Stocké	Die Vorhersage von Fragenreihenfolgeeffekten durch Antwortlatenzen: Eine Validierungsstudie
02-15	Thomas Kittsteiner Jörg Nikutta Eyal Winter	Discounting in Sequential Auctions
02-14	Christian Ewerhart	Banks, Internal Models and the Problem of Adverse Selection
02-13	Christian Ewerhart Eyal Winter	Limited Backward Induction as an Expression of Bayesian Rationality
02-12	Christian Ewerhart	Enabling Goal-Directed Planning and Control: Experiences with the Implementation of Value Management in an Internationally Operating Stock Exchange

Nr.	Author	Title
02-11	Christian Ewerhart Karsten Fieseler	Procurement Auctions and Unit-Price Contracts
02-10	Susanne Abele	How to Influence Cooperation Subtly
02-01	Geschäftsstelle	Jahresbericht 2001
02-09	Volker Stocké	Soziale Erwünschtheit bei der Erfassung von Einstellungen gegenüber Ausländern. Theoretische Prognosen und deren empirische Überprüfung
02-08	Volker Stocké Bettina Langfeldt	Ex-post Implementation with Interdependent Valuations
02-07	Benny Moldovanu Christian Ewerhart	A Stylized Model of the German UMTS Auction
02-06	Benny Moldovanu Aner Sela	Contest Architecture
02-05	Benny Moldovanu Christian Ewerhart	The German UMTS Design: Insights From Multi-Object Auction Theory
02-04	Alex Possajennikov	Cooperative Prisoners and Aggressive Chickens: Evolution of Strategies and Preferences in 2x2 Games
02-03	Alex Possajennikov	Two-Speed Evolution of Strategies and Preferences in Symmetric Games
02-02	Markus Ruder Herbert Bless	Mood and the reliance on the ease of retrieval heuristic
01-52	Martin Hellwig Klaus M. Schmidt	Discrete-Time Approximations of the Holmström-Milgrom Brownian-Motion Model of Intertemporal Incentive Provision
01-51	Martin Hellwig	The Role of Boundary Solutions in Principal-Agent Problems with Effort Costs Depending on Mean Returns
01-50	Siegfried K. Berninghaus	Evolution of conventions - some theoretical and experimental aspects

Nr.	Author	Title
01-49	Dezsö Szalay	Procurement with an Endogenous Type Distribution
01-48	Martin Weber Heiko Zuchel	How Do Prior Outcomes Affect Risky Choice? Further Evidence on the House-Money Effect and Escalation of Commitment
01-47	Nikolaus Beck Alfred Kieser	The Complexity of Rule Systems, Experience, and Organizational Learning
01-46	Martin Schulz Nikolaus Beck	Organizational Rules and Rule Histories
01-45	Nikolaus Beck Peter Walgenbach	Formalization and ISO 9000 - Changes in the German Machine Building Industry
01-44	Anna Maffioletti Ulrich Schmidt	The Effect of Elicitation Methods on Ambiguity Aversion: An Experimental Investigation
01-43	Anna Maffioletti Michele Santoni	Do Trade Union Leaders Violate Subjective Expected Utility?Some Insights from Experimental Data
01-42	Axel Börsch-Supan	Incentive Effects of Social Security Under an Uncertain Disability Option
01-41	Carmela Di Mauro Anna Maffioletti	Reaction to Uncertainty and Market Mechanism:Experimental Evidence
01-40	Marcel Normann Thomas Langer	Altersvorsorge, Konsumwunsch und mangelnde Selbstdisziplin: Zur Relevanz deskriptiver Theorien für die Gestaltung von Altersvorsorgeprodukten
01-39	Heiko Zuchel	What Drives the Disposition Effect?
01-38	Karl-Martin Ehrhart	European Central Bank Operations: Experimental Investigation of the Fixed Rate Tender
01-37	Karl-Martin Ehrhart	European Central Bank Operations: Experimental Investigation of Variable Rate Tenders
01-36	Karl-Martin Ehrhart	A Well-known Rationing Game

Nr.	Author	Title
01-35	Peter Albrecht Raimond Maurer	Self-Annuitization, Ruin Risk in Retirement and Asset Allocation: The Annuity Benchmark
01-34	Daniel Houser Joachim Winter	Time preference and decision rules in a price search experiment
01-33	Christian Ewerhart	Iterated Weak Dominance in Strictly Competitive Games of Perfect Information
01-32	Christian Ewerhart	THE K-DIMENSIONAL FIXED POINT THEOREM OF PROVABILITY LOGIC
01-31	Christian Ewerhart	A Decision-Theoretic Characterization of Iterated Weak Dominance
01-30	Christian Ewerhart	Heterogeneous Awareness and the Possibility of Agreement
01-29	Christian Ewerhart	An Example for a Game Involving Unawareness: The Tragedy of Romeo and Juliet
01-28	Christian Ewerhart	Backward Induction and the Game-Theoretic Analysis of Chess
01-27	Eric Igou Herbert Bless	About the Importance of Arguments, or: Order Effects and Conversational Rules
01-26	Heiko Zuchel Martin Weber	The Disposition Effect and Momentum
01-25	Volker Stocké	An Empirical Test of the Contingency Model for the Explanation of Heuristic-Based Framing-Effects
01-24	Volker Stocké	The Influence of Frequency Scales on the Response Behavior. A Theoretical Model and its Empirical Examination
01-23	Volker Stocké	An Empirical Examination of Different Interpretations of the Prospect Theoryś Framing-Hypothesis
01-22	Volker Stocké	Socially Desirable Response Behavior as Rational Choice: The Case of Attitudes Towards Foreigners

Nr.	Author	Title
01-21	Phillipe Jehiel Benny Moldovanu	License Auctions and Market Structure
01-20	Phillipe Jehiel Benny Moldovanu	The European UMTS/IMT-2000 License Auctions
01-19	Arieh Gavious Benny Moldovanu Aner Sela	Bid Costs and Endogenous Bid Caps
01-18	Benny Moldovanu Karsten Fieseler Thomas Kittsteiner	Partnerships, Lemons and Efficient Trade
01-17	Raimond Maurer Martin Pitzer Steffen Sebastian	Construction of a Transaction Based Real Estate Index for the Paris Housing Market
01-16	Martin Hellwig	The Impact of the Number of Participants on the Provision of a Public Good
01-15	Thomas Kittsteiner	Partnerships and Double Auctions with Interdependent Valuations
01-14	Axel Börsch-Supan Agar Brugiavini	Savings: The Policy Debate in Europe
01-13	Thomas Langer	Fallstudie zum rationalen Entscheiden: Contingent Valuation und der Fall der Exxon Valdez
01-12	Peter Albrecht Raimond Maurer Ulla Ruckpaul	On the Risks of Stocks in the Long Run:A Probabilistic Approach Based on Measures of Shortfall Risk
01-11	Peter Albrecht Raimond Maurer	Zum systematischen Vergleich von Rentenversicherung und Fondsentnahmeplänen unter dem Aspekt des Kapitalverzehrrisikos - der Fall nach Steuern
01-10	Gyöngyi Bugàr Raimond Maurer	International Equity Portfolios and Currency Hedging: The Viewpoint of German and Hungarian Investors

Nr.	Author	Title
01-09	Erich Kirchler Boris Maciejovsky Martin Weber	Framing Effects on Asset Markets - An Experimental Analysis -
01-08	Axel Börsch-Supan Alexander Ludwig Joachim Winter	Aging, pension reform, and capital flows: A multi-country simulation model
01-07	Axel Börsch-Supan Annette Reil-Held Ralf Rodepeter Reinhold Schnabel Joachim Winter	The German Savings Puzzle
01-06	Markus Glaser	Behavioral Financial Engineering: eine Fallstudie zum Rationalen Entscheiden
01-05	Peter Albrecht Raimond Maurer	Zum systematischen Vergleich von Rentenversicherung und Fondsentnahmeplänen unter dem Aspekt des Kapitalverzehrrisikos
01-04	Thomas Hintz Dagmar Stahlberg Stefan Schwarz	Cognitive processes that work in hindsight: Meta-cognitions or probability-matching?
01-03	Dagmar Stahlberg Sabine Sczesny Friederike Braun	Name your favourite musician: Effects of masculine generics and of their alternatives in german
01-02	Sabine Sczesny Sandra Spreemann Dagmar Stahlberg	The influence of gender-stereotyped perfumes on the attribution of leadership competence
01-01	Geschäftsstelle	Jahresbericht 2000
00-51	Angelika Eymann	Portfolio Choice and Knowledge
00-50	Oliver Kirchkamp Rosemarie Nagel	Repeated Game Strategies in Local and Group Prisoner‘s Dilemma
00-49	Thomas Langer Martin Weber	The Impact of Feedback Frequency on Risk Taking: How general is the Phenomenon?

Nr.	Author	Title
00-48	Niklas Siebenmorgen Martin Weber	The Influence of Different Investment Horizons on Risk Behavior
00-47	Roman Inderst Christian Laux	Incentives in Internal Capital Markets
00-46	Niklas Siebenmorgen Martin Weber	A Behavioral Approach to the Asset Allocation Puzzle
00-45	Thomas Langer Rakesh Sarin Martin Weber	The Retrospective Evaluation of Payment Sequences: Duration Neglect and Peak-and-End-Effects
00-44	Axel Börsch-Supan	Soziale Sicherung: Herausforderungen an der Jahrhundertwende
00-43	Rolf Elgeti Raimond Maurer	Zur Quantifizierung der Risikoprämien deutscher Versicherungsaktien im Kontext eines Multifaktorenmodells
00-42	Martin Hellwig	Nonlinear Incentive Contracting in Walrasian Markets: A Cournot Approach
00-41	Tone Dieckmann	A Dynamic Model of a Local Public Goods Economy with Crowding
00-40	Claudia Keser Bodo Vogt	Why do experimental subjects choose an equilibrium which is neither risk nor payoff dominant
00-39	Christian Dustmann Oliver Kirchkamp	The Optimal Migration Duration and Activity Choice after Re-migration
00-38	Niklas Siebenmorgen Elke U. Weber Martin Weber	Communicating Asset Risk: How the format of historic volatility information affects risk perception and investment decisions
00-37	Siegfried K. Berninghaus	The impact of monopolistic wage setting on innovation and market structure
00-36	Siegfried K. Berninghaus Karl-Martin Ehrhart	Coordination and information: Recent experimental evidence

SONDERFORSCHUNGSBEREICH 504 WORKING PAPER SERIES

Nr.	Author	Title
00-35	Carlo Kraemer Markus Nöth Martin Weber	Information Aggregation with Costly Information and Random Ordering: Experimental Evidence
00-34	Markus Nöth Martin Weber	Information Aggregation with Random Ordering: Cascades and Overconfidence
00-33	Tone Dieckmann Ulrich Schwalbe	Dynamic Coalition Formation and the Core
00-32	Martin Hellwig	Corporate Governance and the Financing of Investment for Structural Change
00-31	Peter Albrecht Thorsten Göbel	Rentenversicherung versus Fondsentnahmepläne, oder: Wie groß ist die Gefahr, den Verzehr des eigenen Vermögens zu überleben?
00-30	Roman Inderst Holger M. Müller Karl Wärneryd	Influence Costs and Hierarchy
00-29	Dezsö Szalay	Optimal Delegation
00-28	Dezsö Szalay	Financial Contracting, R&D and Growth
00-27	Axel Börsch-Supan	Rentabilitätsvergleiche im Umlage- und Kapitaldeckungsverfahren: Konzepte, empirische Ergebnisse, sozialpolitische Konsequenzen
00-26	Axel Börsch-Supan Annette Reil-Held	How much is transfer and how much insurance in a pay-as-you-go system? The German Case.
00-25	Axel Börsch-Supan	Rentenreform und die Bereitschaft zur Eigenvorsorge: Umfrageergebnisse in Deutschland
00-24	Christian Ewerhart	Chess-like games are dominancesolvable in at most two steps
00-23	Christian Ewerhart	An Alternative Proof of Marshallś Rule
00-22	Christian Ewerhart	Market Risks, Internal Models, and Optimal Regulation: Does Backtesting Induce Banks to Report Their True Risks?

Nr.	Author	Title
00-21	Axel Börsch-Supan	A Blue Print for Germany’s Pension Reform
00-20	Axel Börsch-Supan	Data and Research on Retirement in Germany
00-19	Henning Plessner Tilmann Betsch	Sequential effects in important sport-decisions: The case of penalties in soccer
00-18	Susanne Haberstroh Ulrich Kühnen Daphna Oyserman Norbert Schwarz	Is the interdependent self a better communicator than the independent self? Self-construal and the observation of conversational norms
00-17	Tilmann Betsch Susanne Haberstroh Connie Höhle	Explaining and Predicting Routinized Decision Making: A Review of Theories
00-16	Susanne Haberstroh Tilmann Betsch Henk Aarts	When guessing is better than thinking: Multiple bases for frequency judgments
00-15	Axel Börsch-Supan Angelika Eymann	Household Portfolios in Germany
00-14	Annette Reil-Held	Einkommen und Sterblichkeit in Deutschland: Leben Reiche länger?
00-13	Nikolaus Beck Martin Schulz	Comparing Rule Histories in the U.S. and in Germany: Searching for General Principles of Organizational Rules
00-12	Volker Stocké	Framing ist nicht gleich Framing. Eine Typologie unterschiedlicher Framing-Effekte und Theorien zu deren Erklärung
00-11	Oliver Kirchkamp Rosemarie Nagel	Local and Group Interaction in Prisoners‘ Dilemmas
00-10	Oliver Kirchkamp Benny Moldovanu	An experimental analysis of auctions with interdependent valuations
00-09	Oliver Kirchkamp	WWW Experiments for Economists, a Technical Introduction

Nr.	Author	Title
00-08	Alain Chateauneuf Alain Chateauneuf	Organizational Learning through Rule Adaptation: From the Behavioral Theory to Transactive Organizational Learning
00-07	Raimond Maurer Steffen Sebastian	Inflation Risk Analysis of European Real Estate Securities
00-06	Martin Hellwig	Costly State Verification: The Choice Between Ex Ante and Ex Post Verification Mechanisms
00-05	Peter Albrecht Raimond Maurer	100% Aktien zur Altersvorsorge - Über die Langfristrisiken einer Aktienanlage
00-04	Douglas Gale	Aging and the Pension Crisis: Flexibilization through Capital Markets
00-03	Axel Börsch-Supan	Data and Research on Saving in Germany
00-02	Raimond Maurer Alexander Mertz	Internationale Diversifikation von Aktien- und Anleiheportfolios aus der Perspektive deutscher Investoren
00-01	Office SFB504	Jahresbericht 1999
99-89	Holger M. Müller Roman Inderst	Project Bundling, Liquidity Spillovers, and Capital Market Discipline
99-88	Raimond Maurer Gyöngyi Bugàr	Efficient Risk Reducing Strategies by International Diversification: Evidence from a Central European Emerging Market
99-87	Berit Ernst Alfred Kieser	In Search of Explanations for the Consulting Explosion. A Critical Perspective on Managers' Decisions to Contract a Consultancy
99-86	Martin Hellwig Andreas Irmen	Wage Growth, Productivity Growth, and the Evolution of Employment
99-85	Siegfried K. Berninghaus Werner Gueth Claudia Keser	Decentralized or Collective Bargaining in a Strategy Experiment

SONDERFORSCHUNGSBereich 504 WORKING PAPER SERIES

Nr.	Author	Title
99-84	Jan Vleugels	Bidding Against an Unknown Number of Competitors With Affiliated Information
99-83	Stefan Schwarz Ulf-Dietrich Reips	Drop-out wegen JavaScript:
99-82	Holger M. Müller Karl Wärneryd	Inside vs Outside Ownership - A Political Theory of the Firm
99-81	Ralf Rodepeter Joachim Winter	Rules of thumb in life-cycle savings models
99-80	Michael Adam Raimond Maurer	Risk Value Analysis of Covered Short Call and Protective Put Portfolio Strategies
99-79	Peter Albrecht	Rendite oder Sicherheit in der Altersversorgung - unvereinbare Gegensätze?
99-78	Karsten Fieseler	The Efficient Bilateral Trade of an Indivisible Good: Successively Arriving Information
99-77	Karsten Fieseler	Optimal Leasing Durations: Options for Extension
99-76	Peter Albrecht Raimond Maurer	Zur Bedeutung einer Ausfallbedrohtheit von Versicherungskontrakten - ein Beitrag zur Behavioral Insurance
99-75	Benny Moldovanu Aner Sela	The Optimal Allocation of Prizes in Contests
99-74	Phillipe Jehiel Benny Moldovanu	Efficient Design with Interdependent Valuations
99-73	Phillipe Jehiel Benny Moldovanu	A Note on Revenue Maximization and Efficiency in Multi-Object Auctions
99-72	Eva Brit Kramer Martin Weber	Über kurz oder lang - Spielt der Anlagehorizont eine berechtigte Rolle bei der Beurteilung von Investments?
99-71	Karsten Fieseler Thomas Kittsteiner Benny Moldovanu	Partnerships, Lemons and Efficient Trade

Nr.	Author	Title
99-70	Dagmar Stahlberg Sabine Sczesny Stefan Schwarz	Exculpating Victims and the Reversal of Hindsight Bias
99-69	Karl-Martin Ehrhart Claudia Keser	Mobility and cooperation: on the run
99-68	Roman Inderst Holger M. Müller	Delegation of Control Rights, Ownership Concentration, and the Decline of External Finance
99-67	Eric Igou Herbert Bless Michaela Wänke	Ursachen der Verwässerung oder: Konversationslogische Aspekte des ”Dilution-Effektes”
99-66	Stefan Schwarz Dagmar Stahlberg	Auswirkungen des Hindsight Bias auf ökonomische Entscheidungen
99-65	Susanne Abele Karl-Martin Ehrhart	Why Timing Matters: Differential Effects of Uncertainty about the Outcome of Past versus Current Events
99-64	Thomas Langer Martin Weber	Prospect-Theory, Mental Accounting and Differences in Aggregated and Segregated Evaluation of Lottery Portfolios
99-63	Andreas Laschke Martin Weber	Der ”Overconfidence Bias” und seine Konsequenzen in Finanzmärkten
99-62	Nikolaus Beck Peter Walgenbach	From Statistical Quality Control, over Quality Systems to Total Quality Management - The Institutionalization of a New Management Approach
99-61	Paul Povel Michael Raith	Endogenous Debt Contracts With Undistorted Incentives
99-60	Nikolaus Beck Alfred Kieser	Unspectacular Organizational Change in Normal Times: Rule Change as a Routine Activity
99-59	Roman Inderst Holger M. Müller	Why Peaches Must Circulate Longer than Lemons

Nr.	Author	Title
99-58	Roman Inderst	Bargaining with Sequential Buyers under Incomplete Information
99-57	Roman Inderst	Bargaining with a Possibly Committed Seller
99-56	Roman Inderst	Efficiency Wages under Adverse Selection and the Role of Rigid Wages
99-55	Daniel Probst	Evolution, Automata and Repeated Games
99-54	Christian Laux Daniel Probst	The Ambiguous Effects of Rankings: Strategically Biased Forecasting by Advisers
99-53	Martin Hellwig Andreas Irmen	Endogenous Technical Change in a Competitive Economy
99-52	Roman Inderst Holger M. Müller	Competitive Search Markets with Adverse Selection
99-51	Abdolkarim Sadrieh Werner Gueth Peter Hammerstein Stevan Harnard Ulrich Hoffrage Bettina Kuon Betrand R. Munier Peter M. Todd Massimo Warglien Martin Weber	Is there evidence for an adaptive toolbox?
99-50	Ulrich Hoffrage Gerd Gigerenzer	How to Foster Diagnostic Insight in Experts
99-49	Martin Lages Ulrich Hoffrage Gerd Gigerenzer	Intransitivity of fast and frugal heuristics
99-48	Axel Börsch-Supan Joachim Winter	Pension reform, savings behavior and corporate governance
99-47	Craig R. Fox Martin Weber	Ambiguity Aversion, Comparative Ignorance, and the Role of Context

Nr.	Author	Title
99-46	Manfred Hassebrauck Cornelia Vogt Michael Diehl	Der Einfluß von Prototypen auf die Informationssuche bei Entscheidungen
99-45	Manfred Hassebrauck Cornelia Vogt Michael Diehl	Das ”prototype matching”-Modell des Entscheidungsverhaltens: Der Einfluß kognitiver Belastung, Zeitdruck und Stimmung
99-44	Axel Börsch-Supan Patrizia Tumbarello Robert Palacios	Pension systems in the Middle East and North Africa: A window of opportunity
99-43	Reinhold Schnabel	Vermögen und Ersparnis im Lebenszyklus in Westdeutschland
99-42	Reinhold Schnabel	The Declining Participation in the German PAYG-Pension System
99-41	Reinhold Schnabel	Social Security Reform and Intergenerational Redistribution in Germany
99-40	Reinhold Schnabel	The Golden Years of Social Security – Life-cycle Income, Pensions and Savings in Germany
99-39	Stefan Schwarz Sabine Sczesny Dagmar Stahlberg	Der Hindsight Bias bei gustatorischen Entscheidungen
99-38	Axel Börsch-Supan Annette Reil-Held	Family Resources in Retirement. Germany
99-37	Axel Börsch-Supan Rob Euwals Angelika Eymann	Portfolio Choice with Behavioral Decision Mechanisms
99-36	Axel Börsch-Supan	Template for International Savings Comparisons Project
99-35	Stefan Schwarz Dagmar Stahlberg	Hindsight Bias: The Role of Perfect Memory and Meta-Cognitions

Nr.	Author	Title
99-34	Dagmar Stahlberg Stefan Schwarz	Would I Have Known It All Along if I Would Hate to Know It? The Hindsight Bias in Situations of High and Low Self Esteem Relevance
99-33	Ulrich Hoffrage Ralph Hertwig Gerd Gigerenzer	Hindsight Bias: A By-product of Knowledge Updating
99-32	Ralph Hertwig Ulrich Hoffrage	Begrenzte Rationalität: Die Alternative zu Laplace’schen und schlechter Software
99-31	Raimond Maurer Ulrich Hoffrage	An Expected Utility Approach to Probabilistic Insurance: A Comment on Wakker, Thaler and Tversky (1997)
99-30	Henning Plessner Susanne Haberstroh Tilmann Betsch	The effects of affect-based attitudes on judgment and decision making
99-29	Tilmann Betsch Andreas Glöckner Susanne Haberstroh	A Micro-World Simulation to Study Routine Maintenance and Deviation in Repeated Decision Making
99-28	Jan Walliser Joachim Winter	Tax incentives, bequest motives and the demand for life insurance: evidence from Germany
99-27	Joachim Winter	Ökonometrische Analyse diskreter dynamischer Entscheidungsprozesse
99-26	Gerd Bohner Dagmar Stahlberg Dieter Frey	Einstellungen
99-25	Ulrich Hoffrage Martin Weber Ralph Hertwig Valerie Chase	How to keep children save in traffic: Find the daredevils while they are young.
99-24	Elke Kurz Gerd Gigerenzer Ulrich Hoffrage	Representations of uncertainty and change: Three case studies with experts

SONDERFORSCHUNGSBereich 504 WORKING PAPER SERIES

Nr.	Author	Title
99-23	Stefan Krauss Laura Martignon Ulrich Hoffrage	Simplifying Bayesian Inference: The General Case
99-22	Ulrich Hoffrage Ralph Hertwig	Hindsight Bias: A Price Worth Paying for Fast and Frugal Memory
99-21	Ulrich Hoffrage	Irren ist wahrscheinlich. Medizinische Experten und Laien bewerten Risiken oft falsch.
99-20	Claudia Keser Jean-Louis Rulliére Marie-Claire Villeval	Union Bargaining Strength as a Public Good: Experimental Evidence
99-19	Rüdiger F. Pohl Dagmar Stahlberg Dieter Frey	I’m not trying to impress you, but I surely knew it all along! Self-presentation and hindsight bias
99-18	Dagmar Stahlberg Lars-Eric Petersen Dirk Dauenheimer	Preferences for and Evaluation on Self-Relevant Information Depending on the Elaboration of the Self-Schemata Involved
99-17	Rob Euwals	Do mandatory pensions decrease household savings? Evidence for the Netherlands.
99-16	Roman Inderst	A Note on the Strategic Foundation of Competitive Equilibrium in Buyer Markets
99-15	Michael Adam Raimond Maurer	An Empirical Test of Risk-Adjusted Performance of Call Option Writing and Put Option Buying Hedge-Strategies
99-14	Annette Reil-Held Reinhold Schnabel	Vom Arbeitsmarkt in den Ruhestand: Die Einkommen deutscher Rentner und Rentnerinnen
99-13	Peter Walgenbach	Das Konzept der Vertrauensorganisation - Eine theoriegeleitete Betrachtung
99-12	Herbert Bless Michaela Wänke	Can the same information be typical and atypical? How perceived typicality moderates assimilation and contrast in evaluative judgements

Nr.	Author	Title
99-11	Eric Igou Herbert Bless Wolfram Schenck	Stärkere Framing Effekte durch mehr Nachdenken? Einflüsse der Bearbeitungszeit auf Lösungen des ”Asian-disease”-Problems
99-10	Dirk Dauenheimer Dagmar Stahlberg Sandra Spreemann Constantine Sedikides	Self-Enhancement, Self-Verification, or Self-Assessment? The Intricate Role of Trait Modifiability in the Self-Evaluation Process
99-09	Cornelia Hegele Peter Walgenbach	Was kann der Apfel von der Birne lernen, oder wozu brauchen Unternehmen Benchmarking?
99-08	Michaela Wänke	Assimilation and Contrast as a Function of the direction of Comparison
99-07	Michael Woywode	Ein lerntheoretisches Modell zur Erklärung der Unternehmensent-wicklung
99-06	Tilmann Betsch Susanne Haberstroh Andreas Glöckner Klaus Fiedler	The Pros and Cons of Expertise: Routine Strength and Adaptation in Recurrent Acquisition and Disposal Decisions
99-05	Ulrich Koch	Regeländerungsprozesse und organisatorisches Lernen: Zum Übergang individueller Erfahrungen in eine organisationale Wissensbasis
99-04	Alfred Kieser Ulrich Koch Michael Woywode	Wie man Bürokratien das Lernen beibringt
99-03	Joachim Winter	Strukturelle ökonometrische Verfahren zur Analyse von Renteneintrittsentscheidungen
99-02	Axel Börsch-Supan Annette Reil-Held Ralf Rodepeter Reinhold Schnabel Joachim Winter	Ersparnisbildung in Deutschland: Meßkonzepte und Ergebnisse auf Basis der EVS
99-01	Office SFB504	Jahresbericht 1998

Nr.	Author	Title
98-61	Siegfried K. Berninghaus Karl-Martin Ehrhart	Long-run Evolution of Local Interaction Structures in Games
98-60	Isabel Gödde Reinhold Schnabel	Does Family Background Matter? - Returns to Education and Family Characteristics in Germany
98-59	Holger M. Müller	Why Tender Offers Should be Financed with Debt
98-58	Ralf Rodepeter Joachim Winter	Savings decisions under life-time and earnings uncertainty:
98-57	Thomas Langer Martin Weber	Entscheidungsanalyse
98-56	Reinhold Schnabel	Rates of Return of the German Pay-As-You-Go Pension System
98-55	Raimond Maurer Steffen Sebastian	Immobilienfonds und Immobilienaktiengesellschaften als finanzwirtschaftliche Substitute für Immobiliendirektanlagen
98-54	Michaela Wänke Herbert Bless Eric Igou	Next to a star: Paling, shining or both? Turning inter-exemplar contrast into inter-exemplar assimilation
98-53	Gerd Gigerenzer Laura Martignon Ulrich Hoffrage Joerg Rieskamp Jean Czerlinski Dan G. Goldstein	One-reason decision making.
98-52	Gerd Gigerenzer Ralph Hertwig Ulrich Hoffrage Peter Sedlmeier	Cognitive illusions reconsidered
98-51	Gerd Gigerenzer Ulrich Hoffrage	Overcoming Difficulties in Bayesian Reasoning: A Reply to Lewis & Keren and Mellers & McGraw
98-50	Roman Inderst	Signaling in a Search Market

Nr.	Author	Title
98-49	Paul Povel Michael Raith	Liquidity Constraints, Production Costs and Output Decisions
98-48	Joachim Winter	Does Firms‘ Financial Status Affect Plant-Level Investment and Exit Decision
98-47	Michele Bernasconi Oliver Kirchkamp	Why monetary policy matters — An experimental study of saving, inflation and monetary policies in an overlapping generations model
98-46	Oliver Kirchkamp	Simultaneous Evolution of Learning Rules and Strategies
98-45	Martin Weber Jan Pieter Krahnen Frank Voßmann	Risikomessung im Kreditgeschäft: Eine empirische Analyse bankinterner Ratingverfahren
98-44	Axel Börsch-Supan	Anreizprobleme in der Renten- und Krankenversicherung
98-43	Martin Hellwig	On the Economics and Politics of Corporate Finance and Corporate Control
98-42	Axel Börsch-Supan	Demographie, Entwicklung und Stabilität der Sozialversicherung in Deutschland
98-41	Axel Börsch-Supan	Zur deutschen Diskussion eines Übergangs vom Umlage- zum Kapitaldeckungsverfahren in der Gesetzlichen Rentenversicherung
98-40	Axel Börsch-Supan	A Model under Siege: A Case Study of the Germany Retirement Insurance System
98-39	Martin Hellwig	Financial Intermediation with Risk Aversion
98-38	Martin Hellwig	Risk Aversion and Incentive Compatibility with Ex Post Information Asymmetry
98-37	Roman Inderst Christian Pfeil	Duopolistic Competition in Search Markets
98-36	Roman Inderst	Incentives Schemes as a Signaling Device

Nr.	Author	Title
98-35	Roman Inderst	Multi-Issue Bargaining with Endogenous Agenda
98-34	Roman Inderst	Competition Drives Up Prices
98-33	Roman Inderst	A Note on the Limited Value of Time for Screening
98-32	Roman Inderst	Screening With Endogenous Reservation Values
98-31	Paul Povel	optimal bankruptcy laws
98-30	Martin Hellwig	Systemische Risiken im Finanzsektor
98-29	Axel Börsch-Supan	Incentive Effects of Social Security on Labor Force Participation: Evidence in Germany and Across Europe
98-22	Phillipe Jehiel Benny Moldovanu	Efficient Design with Interdependent Valuations
98-21	Benny Moldovanu Aner Sela	Patent Licensing to Bertrand Competitors
98-20	Alfred Kieser	How Management Science, Consultancies and Business Companies (Do not) Learn from Each Other. Applying Concepts of Learning to Different Types of Organizations and to Interorganizational Learning
98-16	Tilmann Betsch Babette Brinkmann Klaus Fiedler Katja Breining	When prior knowledge overrules new evidence: Adaptive use of decision strategies and role behavioral routines
98-15	Klaus Fiedler	Illusory Correlations: Explicating and Stimulating Their Apparent and Less Apparent Origins
98-14	Klaus Fiedler Babette Brinkmann Tilmann Betsch Beate Wild	A Sampling Approach to Biases in Conditional Probability Judgments: Beyond Baserate-Neglect and Statistical Format

Nr.	Author	Title
98-13	Tilmann Betsch Stefan Krauss	Eine Kritik an der klassischen Framing - Studie, eine konzeptuelle Replikation und eine Bewertung der Prospect Theory.
98-12	Siegfried K. Berninghaus Karl-Martin Ehrhart Claudia Keser	Conventions and Local Interaction Structures: Experimental Evidence
98-11	Michael Kilka Martin Weber	What Determines the Shape of the Probability Weighting Function under Uncertainty?
98-10	Tilmann Betsch Frank Siebler Peter Marz Stefan Hormuth Dorothee Dickenberger	The moderating role of category salience and category focus in judgments of set size and frequency of occurence.
98-08	Peter Albrecht	Alterssicherung und Vorsorgebedarf im Spannungsfeld von Versicherungs- und Investmentprodukten
98-07	Axel Börsch-Supan Annette Reil-Held Reinhold Schnabel	Pension Provision in Germany
98-06	Martin Hellwig Klaus M. Schmidt	Discrete-Time Approximations of the Holmström-Milgrom Brownian-Motion, Model of Intertemporal Incentive Provision
98-05	Tilmann Betsch G. - M. Biel C. Eddelbuettel A. Mock	Natural sampling and base-rate neglect
98-04	Martin Hellwig	Allowing for Risk Choices in Diamond’s ”Financial Intermediation as Delegated Monitoring”
98-03	Martin Weber Lukas Mangelsdorff	Hindsight-Bias im Prinzipal-Agent-Kontext: Die Aktennotiz als Antwort?
98-02	Alfred Kieser Nikolaus Beck Risto Tainio	Limited Rationality, Formal Organizational Rules, and Organizational Learning (OL)

SONDERFORSCHUNGSBereich 504 WORKING PAPER SERIES

Nr.	Author	Title
98-01	Office SFB504	Sonderforschungsbereich 504 Jahresbericht 1998
97-44	Raimond Maurer Michael Adam	Analytische Evaluation des Risiko-Chance-Profils kombinierter Aktien- und Optionsstrategien
97-43	Holger M. Müller	The Mirrlees-Problem Revisited
97-42	Annette Reil-Held	Bequests and Aggregate Wealth Accumulation in Germany
97-41	Axel Börsch-Supan	Übergangsmodelle vom Umlage - zum Kapitaldeckungsverfahren in der deutschen Rentenversicherung
97-40	Siegfried K. Berninghaus Karl-Martin Ehrhart Claudia Keser	The invisible hand: Experiments on strategy selection in population games
97-39	Axel Börsch-Supan Annette Reil-Held	Retirement Income: Level, Risk, and Substitution Among Income Components
97-38	Holger M. Müller	The First-Best Sharing Rule in the Continuous-Time Principal-Agent Problem with Exponential Utility
97-37	Holger M. Müller	Randomization in Dynamic Principal-Agent Problems
97-36	Gyöngyi Bugàr Raimond Maurer	International Portfolio Diversification for European countries: The viewpoint of Hungarian and German investors
97-35	Martin Hellwig	Banks, Markets, and the Allocation of Risks in an Economy
97-34	Nikolaus Beck Alfred Kieser	Standard Operating Procedures and Organizational Learning
97-33	Thomas Langer Peter Waller	Implementing Behavioral Concepts into Banking Theory: The Impact of Loss Aversion on Collateralization

Nr.	Author	Title
97-32	Guenther Franke Martin Weber	Risk-Value Efficient Portfolios and Asset Pricing
97-31	Axel Börsch-Supan	Das deutsche Rentenversicherungssystem: Probleme und Perspektiven
97-30	Claudia Keser Marc Willinger	Principals
97-29	Siegfried K. Berninghaus Karl-Martin Ehrhart Claudia Keser	Coordination Games: Recent Experimental Results
97-28	Peter Albrecht	A Stochastic Approach for the Quantification of Default Risk of OTC-Financial Derivatives
97-27	Dagmar Stahlberg A. Maass	Hindsight bias: Impaired memory or biased reconstruction?
97-26	Manfred Hassebrauck Cornelia Vogt Michael Diehl	Das ”prototype matching”-Modell des Entscheidungsverhaltens: Darstellung des Modells und erste Ergebnisse
97-24	Claudia Keser	SUPER: Strategies used in public goods experimentation rounds
97-23	Axel Börsch-Supan	Germany: A social security system on the verge of collaps
97-22	Axel Börsch-Supan	Privatisierungsmöglichkeiten der Sozialversicherung in Europa
97-21	Axel Börsch-Supan	Capital productivity and the nature of competition
97-20	Axel Börsch-Supan Reinhold Schnabel	Social security and retirement in germany
97-19	Raimond Maurer	Ertrag und Shortfall Risiko von Wertsicherungsstrategien mit Optionen unter alternativen Zielrenditen: Empirische Evidenzen für den deutschen Aktienmarkt

Nr.	Author	Title
97-18	Peter Albrecht	Risk based capital allocation and risk adjusted performance management in property/liability-insurance: A risk theoretical framework
97-17	Peter Albrecht Raimond Maurer Matthias Möller	Shortfall-Risiko/Excess-Chance-Entscheidungskalküle: Grundlagen und Beziehungen zum Bernoulli-Prinzip
97-16	Claudia Keser Karl-Martin Ehrhart Siegfried K. Berninghaus	Coordination and local interaction: Experimental evidence
97-15	Herbert Bless Tilmann Betsch Axel Franzen	Framing the framing effect: The impact of context cues on solutions to the ”asian disease” problem
97-14	Michael Kilka Martin Weber	Home Bias in International Stock Return Expectation
97-13	Jan Vleugels	Bidding against an unknown number of competitiors sharing affiliated information
97-12	Dov Monderer Aner Sela	Fictitious play and- no-cycling conditions
97-11	S. Hon-Suir Dov Monderer Aner Sela	A learning approach to auctions
97-10	Karl H. Schlag Aner Sela	You play (an auction) only once
97-09	Aner Sela	One against all in the fictitious play process
97-08	Benny Moldovanu	William Vickrey und die Auktionstheorie - Anmerkungen zum Nobelpreis 1996
97-07	M. Tietzel Benny Moldovanu	Goethe
97-06	Phillipe Jehiel Benny Moldovanu	Auctions with Downstream Interaction among Buyers

Nr.	Author	Title
97-05	Phillipe Jehiel Benny Moldovanu	Resale Markets and the Assignment of Property Rights
97-04	Phillipe Jehiel Benny Moldovanu E. Stacchetti	Multidimensional Mechanism Design for Auctions with Externalities
97-03	Karsten Fieseler	Bidding for unit-price contracts - How craftsmen should bid
97-02	Martin Hellwig	Unternehmensfinanzierung, Unternehmenskontrolle und Ressourcenallokation: Was leistet das Finanzsystem?
97-01	Ralf Rodepeter	Identifikation von Sparprofilen im Lebenszyklus
	Daniel Schunk	The Pennsylvania Reemployment Bonus Experiments: How a survival model helps in the analysis of the data