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# Do investors optimize, follow heuristics, or listen to experts?

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**Abstract**

In the experimental scenario several agents repeatedly invest in $n$ ($n \geq 2$) state-specific assets. The evolutionarily stable and equilibrium (Blume and Easley, 1992) portfolio for this situation requires to distribute funds according to the constant probabilities of the various states. The different treatments endow none, one, three, or all subjects in groups of eight investors each with probability information. Will investments follow the theoretical benchmark or the $1/n$-heuristic of equal investments in all assets? Further, will agents with probability information be asked and paid for advice on how to invest? Although investment does not converge as predicted, portfolios of informed agents reflect the probabilities of states, and even uninformed agents do not invest according to the $1/n$-heuristic. Advice is demanded and readily paid for. Surprisingly, clients do not always follow the recommendation. Competition among advisors reduces their fees as expected.

JEL Classification: G11, C73

Key words: portfolio selection, evolution of expertise, advice, heuristics, evolutionary finance, experiments

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## 1 Introduction

Often important decisions are made on the basis of simple heuristics. And often it seems that the usual availability of experts in the market does not substantially change the evidence. For example, people seem to rely on simple rules of thumb for their retirement fund investments (Benartzi and Thaler, 2001). This is all the more surprising since well developed theories are available to guide such important lifetime investments. Moreover, a whole service industry stands ready to offer its expertise. The naive heuristic to invest evenly across n asset categories, for instance, is widely used and even - at least for some environments - claimed to be “ecologically” rational (Gigerenzer and Todd, 1999). Why do investors not simply follow investment strategies of more competent investors? In many cases, at least the coarse sector allocations of investment funds are available online on the Internet, and typically they deviate substantially from any nave heuristics. To shed light on such issues, we study a recursive market with asymmetrically informed traders and explore whether or not better informed agents become professional investment advisors.

While the laboratory design necessarily has to abstract from the richness of the real world, it allows to control and test for factors that may be crucial in understanding individual investment behavior. Starting from a framework similar to Blume and Easley (1992), investors expect three states of the world, each occurring with a certain probability. No one knows which state will occur. While some investors, whom we will call experts, know the objective probabilities of the states, nonexpert investors are unaware of these probabilities. The common task of all agents is to repeatedly invest their capital in the three state-specific assets. Only investments in the realized state generate a positive return, while all other investments are lost. The equilibrium and evolutionary stable Blume and Easley (1992) strategy is to invest proportionally to the probabilities of the states.[1]

Will investors in the laboratory follow the game theoretic predictions, or will they rather use the simple heuristic? Will experience affect their behavior? Previous work on learning in recurrent allocation tasks reports ambiguous results, depending on the complexity and difficulty of the underlying task. While Langholtz et al. (1993), Ball et al. (1998) find fast convergence to equilibrium, non-convergence is observed when several local optima exist (e.g., Busemeyer et al., 1986; Rieskamp et al., 2003) or when the task is too difficult (Langholtz et al., 1994). In our experimental design, we find that heuristics work well - initially for uniformed investors, the so-called non-experts. However, individuals learn quickly and move away from simple heuristics. Informed investors choose portfolios that are closer to the evolutionarily stable ones.

Finally, will professional expertise evolve endogenously? What are the conditions that favor evolution of expertise and what are the obstacles? Will experts sell their information, and will individuals actually value expert advice? We do indeed find strong evidence that experts sell their information and that uninformed investors develop the "expert heuristic" of following the expert's advice, which can be justified by the fact that experts know the underlying probabilities and, hence, can design better portfolios. In our setup, expertise and the expert heuristic are especially dominant when there is competitive pressure (i.e., more than one expert) and the prices, charged for expert services, are lower. However, nonexperts seem to be skeptical and do not completely follow expert advice. Rather, they idiosyncratically deviate from expert suggestions and, therefore, their portfolios deviate more from the evolutionarily stable portfolios than the portfolios of experts.

[1] Unlike in probability matching (see Vulkan, 2000), such an investment policy is therefore optimal (whereas simple probability matching is suboptimal).

Thus we study investing with and without knowing prior probabilities as well as decision making based on costly advice. Previous studies have focused on each of these aspects separately. Additionally, we investigate the evolution of professional expertise. In section 2, we describe the basic scenario and the evolutionarily stable portfolio which is also an equilibrium of the one-shot interaction. The experimental protocol and the hypotheses to be tested are specified in section 3. The results of the statistical analysis are reported in section 4. Section 5 concludes and suggests possible extensions.

## 2 The model

Let $N = \{1, \ldots, n\}$ denote the set of interacting agents in the stochastic environment with the (finite) set of possible states of nature denoted by $S = \{1, \ldots, s\}$. All agents are endowed with an equal amount of capital $K > 0$. Agents $i \in M \subset N$ with $M = \{1, \ldots, m\}$ whom we call experts may be consulted by agents $j \in N \setminus M = \{m + 1, \ldots, n\}$ to whom we refer as nonexperts. It is commonly known that only experts have probability information, i.e., are aware of the vector $w = (w_1, ..., w_s)$ of the state probabilities $w_k$ with $w_k > 0$ for all $k \in S$ and $w_1 + ... + w_s = 1$.

We rely on the following course of events:

1. The probability vector $w = (w_1, \ldots, w_s)$ is exogenously given. Only experts $i \in M$ learn $w$, whereas nonexperts $j \in N \setminus M$ only know the number of possible states and that each of these states occurs with positive probability: $w_k > 0$ for $k \in S$. All this is commonly known.

2. Nonexperts $j = m + 1, \ldots, n$ can announce their willingness to pay $r_j^i \geq 0$

(hereafter WTP) for advice from some expert $i$. This means that nonexperts $j = m+1, \ldots, n$ are prepared to pay for the information any price in the interval $R_j^i = [0, r_i^i]$. Nonexperts set $R_j^i = \emptyset$ if they do not wish to acquire advice.

3. All experts $i \in M$ express their wish to act as consultants by stating their fee $\phi_i \geq 0$. Whenever $r_j^i \geq \phi_i$ for some pairs $i, j$, expert $i$ has to recommend nonexpert $j$ a portfolio composition

$$\gamma_i^j = (\gamma_{i1}^j, \ldots, \gamma_{is}^j) \text{ with } \gamma_{ik}^j \geq 0 \text{ for } k = 1, \ldots, s \text{ and } \gamma_{i1}^j + \ldots + \gamma_{is}^j = 1\,.$$

   If $r_j^i \geq \phi_i$ and $r_{j'}^i \geq \phi_i$ holds for two nonexperts $j$ and $j'$, then expert $i$ must propose the same portfolios to both $j$ and $j'$. Formally, $\gamma_i^j = \gamma_i^{j'} = \gamma_i$. Furthermore, the expert has to follow her own recommendation, i.e., the recommendation is binding for the consultant.[2]

   If, on the other hand, the WTP exceeds the required fee of several experts, i.e., $r_j^i \geq \phi_i$ holds for several $i$, then nonexpert $j$ may choose among all experts whose fees do not exceed her WTP. If the fees set by all experts are higher than the WTP of nonexpert $j$, then $j$ does not receive advice. An expert $i$ who does not want to be consulted chooses $\phi_i = +\infty$.

   Denoting the net transfers for information transmission by $p = (p_1, \ldots, p_n)$ with $p_1 + \ldots + p_n = 0$ the agents can invest specific capital $K_i = K + p_i$ freely.

4. After possibly receiving advice in the form of proposals $\gamma_i$ each agent individually chooses her portfolio, where the nonexperts do not have to follow the advice given, while experts are bound by their recommendation. We are

[2] Similar to the ban on insider trading, this rule prevents professional experts from exploiting their customers.

mainly interested in the relative shares of the various assets, i.e., in the portfolio composition of an investor $\ell \in N$

$$e_\ell = (e_{\ell 1} \ldots, e_{\ell s}) \text{ with } e_{\ell k} \geq 0 \text{ for } k = 1, \ldots, s \text{ and } e_{\ell 1} + \ldots + e_{\ell s} = 1.$$

5. Finally, chance selects the actual state $k \in S$ , and $k$ is publicly revealed.

The payoffs of all agents are determined by the following rules:

- Only investments in the realized state pay.
- Assuming unit supply for each asset, market clearing prices are given by the total monetary investment in each state-specific asset.
- Thus payoffs are proportional to the investment in the actually realized state, and the total capital of all traders in a given round remains constant.

More specifically, the sum $nK$ of the initially equal wealth $K$ is redistributed, and the payoff of agent $\ell$ in the realized state $k$ is determined as

$$\pi_{\ell k} = \frac{e_{\ell k} K_\ell}{\sum_{j=1}^{N} e_{jk} K_j} nK. \tag{1}$$

Here $\frac{e_{\ell k} K_\ell}{\sum_{j=1}^{N} e_{j,k} K_j}$ is trader $\ell$'s share of the one-unit supply of the winning (state-specific) asset $k \in S$ .

If this base game, consisting of the stages 1 to 5, is repeated infinitely often in rounds $t = 1, 2, \ldots$, which constant portfolio composition $e_\ell = (e_{\ell 1}, \ldots, e_{\ell s})$ for $\ell \in N$ would be evolutionarily stable? Obviously, an infinite horizon implies that even relatively improbable states are going to occur. Hence, investing nothing in some state will definitely lead to losing all available resources. So an evolutionarily stable portfolio requires every player to invest in all states when the new endowments $K_i$ in period t+1 are the gains $\pi_{ik\cdot}$ in period $t$ for all traders $i$. Actually, Blume and Easley (1992), who focus on the special case $M = \emptyset$, have shown that the only evolutionarily stable portfolio composition corresponds to the probability vector $w$, i.e.,

$$e^* = (e_1^*, \ldots, e_s^*) = w = (w_1, \ldots, w_s). \tag{2}$$

Note that this evolutionary approach relies on Darwinian selection and requires no cognition at all, especially no awareness of $w$. Since we are interested in whether professional expertise will evolve - a process that demands reasoning - we also justify (2) as an equilibrium of the one-shot interaction, i.e., the base game. Unlike the evolutionary analysis of Blume and Easley (1992), requiring no awareness of $w$, according to our analysis all $N$ investors will know $w$ only if all nonexperts consult an expert and all consultants recommend $e^* = w$. We now establish that $e^* = w$ is the game theoretic benchmark even without recurrent trading for constant $w$.

**Proposition 1** *Investing proportionally to probabilities of states according to*

$$e_\ell = e^* = w \text{ for all } \ell = 1, \ldots, N$$

*constitutes the unique equilibrium of the base game.*

Proof: in the appendix.

Awareness of $w$ can not only be provided by consulting experts but also result from learning when repeating the game infinitely with constant vector $w$. The latter justification would be questionable, however, if $w$ keeps changing regularly with only the experts knowing how. A Bayesian analysis of situations with nonexperts who are aware that $w$ has changed but not how, would have to specify commonly known prior beliefs of nonexperts about how $w$ is randomly selected. In our view, one would rather expect the "better rely on an expert!" heuristic to evolve.

What if one wants to play safe by investing the same amount in all states? If all investors do so, each investor $l$ receives the same share $s_k$ of the unit supply of each asset $k$. Thus, regardless of the state chosen, investor $l \in N$ gets back $K$. In our view, the unbiased portfolio composition

$$e^+ = (1, \ldots, 1)$$

for all $\ell \in N$ is a likely focal point, at least for nonexperts without advice (hereafter naive nonexperts). We refer to relying on $e^+$ as the $1/n$-heuristic[3] (Gigerenzer and Todd, 1999).

## 3 Experimental protocol

The computerized experiment (using z-Tree, Fischbacher (2007)) was conducted in March and April 2007 in the experimental laboratory of the Max Planck Institute of Economics in Jena. The participants were undergraduate students from the University of Jena, mainly of economics, business administration, and the sciences. For inviting them, we relied on the online recruitment system for economic experiments ORSEE (Greiner, 2004). We conducted eight sessions, each starting with reading the instructions, running four practice rounds, and answering a control questionnaire to assure that the instructions were fully understood. In each session, only the 24 subjects with the highest score on the questionnaire were selected for participation.

[3]Given the notation used in our model, it would be more appropriate to call the heuristic "1/s". However, we prefer to stick to the name, which is common in the literature.

Eventually, only 192 students took part in the experiment.[4] The sessions lasted about 90 minutes. Subjects earned 15 euros on average (we did not pay a show-up fee), and the exchange rate was 300 experimental currency units for 1 euro.[5]

Each treatment consisted of three phases of 15 rounds, i.e., 45 rounds in total. In each round, subjects received an endowment, which they were supposed to invest in three different states of nature, each occurring with a given positive probability. After the investment decisions[6] were made, with or without knowing $w$ and with or without advice, subjects were informed about which state occurred and their resulting profits. The profits (see equation (1)) were calculated for each matching group of eight participants.

In each treatment, there were six matching groups with eight subjects each. The four treatments differed in the number of experts per group. In treatment T 0+8 the number of experts per matching group was zero, in T 1+7 one, in T 3+5 three and in T 8+0 eight. Participants were randomly assigned to a group and (in T 1+7 and T 3+5) to a role (of an expert or nonexpert). Groups and individual roles remained constant throughout the 45 rounds.

During the experiment three different probability vectors $w$ were applied, each of them lasting for 15 rounds. More specifically, probabilities were exogenously given in rounds 1, 16, and 31. All subjects were reminded that the probabilities had changed. The vectors were the following:

[4] Those students who did not qualify to take part in the experiment received a compensation of 5 euros.

[5] An English translation of the instructions and the questionnaires are placed in the appendix.

[6] Consulted experts, of course, had to follow their own recommendations.

- in phase 1: $w = (0.25, 0.25, 0.5)$
- in phase 2: $w = (0.4, 0.2, 0.4)$
- in phase 3: $w = (0.15, 0.3, 0.55)$

To keep the experiment comparable across treatments, matching groups with the same label (e.g., "two") received the same sequence of randomly chosen states in rounds 1,...,45, independent of the treatment. Applying the same random realizations across treatments means that treatments differ only in the number of experts. Thus shifts in behavior across treatments will be interpreted as $m$-effects, i.e., resulting from changes in the number $m$ of experts. The six groups for each treatment faced the same probability distribution but different random sequences of selected states.[7]

In T 1+7 and T 3+5, nonexperts were allowed to offer rewards to the informed agents in exchange for advice on how to invest. The experts, in turn, could choose their fees. Whenever a reward offered exceeded the fee, the expert became an advisor for the nonexpert, who had to pay the required fee. In T 3+5, it was possible for one reward to be higher than the fees of two or three experts. In this case, the nonexpert had to select only one advisor, whereas experts could give advice to more than one nonexpert. Experts could not reveal their private information about $w$, the probabilities of the states, but only recommend a portfolio composition which they were obliged to use themselves.

Based on our benchmark analysis, we wanted to test the following hypotheses:

[7] If one matching group observes nonrepresentative realizations, this will not affect other matching groups. Thus most nonexperts have a realistic chance to infer the true probabilities by observing the random realizations.

$H_1$. Investment will depend on the role of the agent.

**a.** Investment in treatments with more experts will be closer to $w$.

**b.** Experts will invest closer to $w$, followed by advised nonexperts and naive nonexperts.

$H_2$. Initially in each phase, mainly the naive nonexperts will invest according to the $1/n$-heuristic; later portfolios will gradually develop away from the $1/n$-heuristic and converge to $w$.

$H_3$. Professional expertise will evolve.

**a.** Nonexperts will be willing to pay for advice.

**b.** Experts will require positive fees for their services.

**c.** Advised nonexperts will follow recommendations.

$H_4$. Competition among experts will lower the average willingness to pay as well as the fees and thereby induce more advice and faster convergence to $w$ .

$H_5$. Agents investing closer to $w$ will earn more.

# 4 Results

## 4.1 Does investment follow $w$ or *1/n*?

Table 1 summarizes mean, median, and standard deviation of investment by treatment and phase. Clearly, the median investment in T 8+0 and T 3+5 corresponds to $w$. In contrast, the median investment in T 0+8 resembles *1/n*. In T 1+7, investment depends on the phase - in phase 2, it is consistent with $w$, whereas in phases 1 and 3 it better matches $1/n$. The latter finding can be explained by the fewer nonexperts in T 1+7, who received advice in phases 1 and 3.[8] Thus, with more experts per market portfolio choices are more accurate, and when nonexperts receive advice, they follow it.

Checking for equality between actual investment and the game theoretic benchmark versus actual investment and $1/n$ statistically yields a rather consistent picture in the two treatments with more informed agents (Table 2). In most cases, equality between investment and $w$ cannot be rejected, while equality to $1/n$ is frequently rejected (Wilcoxon-Mann-Whitney rank-sum test). For example in T 8+0 equality to $w$ can be rejected only in 1 out of 9 cases. In contrast, equality to *1/n* can be rejected in all cases. In T 1+7, equality to $w$ is rejected less often than equality to *1/n*. For treatment T 0+8 the results reverse - equality to $w$ is rejected more often (6 out of 9 cases) than equality to *1/n* (3 out of 9 cases).

Interestingly, the results in Table 2 even suggest that investment in T 3+5 is closer

[8] Due to the high fees for advice on the monopoly market for expertise, a much smaller fraction of nonexperts receives a recommendation in T 1+7 as compared to T 3+5, especially in phases 1 and 3 (see Table 6).

| Treat-ment | Pha-se | Mean | | | Median | | | SD | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | A | B | C | A | B | C |
| 8+0 | 1 | 27.8 | 26.6 | 45.6 | 25 | 25 | 50 | 12.7 | 12.9 | 20.8 |
| | 2 | 39.2 | 22.4 | 38.4 | 40 | 20 | 40 | 12.4 | 19 | 12.2 |
| | 3 | 18.2 | 29.6 | 52.2 | 15 | 30 | 55 | 14.3 | 11.9 | 18.3 |
| 3+5 | 1 | 25.2 | 26.7 | 48 | 25 | 25 | 50 | 16.9 | 18.4 | 25.8 |
| | 2 | 39.8 | 21.1 | 39 | 40 | 20 | 40 | 17.6 | 17.7 | 17.6 |
| | 3 | 18.9 | 28.8 | 52.3 | 15 | 30 | 55 | 17.7 | 14.1 | 23.1 |
| 1+7 | 1 | 29.5 | 29.1 | 41.3 | 30 | 30 | 40 | 17.3 | 19.4 | 22.3 |
| | 2 | 39.1 | 23 | 37.8 | 40 | 20 | 35 | 19.1 | 17.9 | 20.1 |
| | 3 | 25.2 | 30.6 | 44.2 | 30 | 33 | 40 | 18.4 | 14.8 | 21.9 |
| 0+8 | 1 | 30.6 | 35.4 | 34 | 32 | 33 | 34 | 19.9 | 20.2 | 20.3 |
| | 2 | 36.7 | 30 | 33.2 | 33 | 30 | 34 | 17.6 | 17.1 | 16.9 |
| | 3 | 26.9 | 30.2 | 42.9 | 30 | 33 | 40 | 17.8 | 16.6 | 22.7 |

Table 1: Descriptive statistics on investment behavior across treatments; benchmark: $w_1 = (25, 25, 50), w_2 = (40, 20, 40), w_3 = (15, 30, 55)$, *1/n* heuristic= $(100/3, 100/3, 100/3)$; states are denoted by A, B, C

to $w$ than investment in T 8+0 in spite of the larger number of experts in T 8+0. Apparently in T 3+5, the lower number of experts has been compensated by advice. According to Iyengar and Schotter (2008), advisors as well as advised[9] learn faster and do better in the presence of advice as compared to decision makers facing the same task without advice. Could the process of providing and taking advice induce more thorough deliberation and better insights than making decisions in isolation? It seems reasonable that the additional responsibility advisors face makes them think more carefully about their recommendation.[10] Clients, on the other hand, can compare their own opinion with that of a more informed and probably more

[9]Advisors in this study were neither trained nor had access to more information than their clients. Still, learning of both clients as well as advisors was facilitated by available advice.

[10]One of the findings of Iyengar and Schotter (2008) is that advisors whose advice cannot be neglected learn faster than advisors whose advice can be ignored.

competent trader, possibly rendering the former more reflective and thoughtful. Such arguments may explain why experts and their clients invest closer to $w$ than experts who do not advise, as in T 8+0.

| Treat-ment | Pha-se | $p$ for equality to $w$ | | | $p$ for equality to $1/n$ | | |
|---|---|---|---|---|---|---|---|
| | | A | B | C | A | B | C |
| 8+0 | 1 | 0.31 | 0.31 | 0.05 | 0.002 | 0.002 | 0.002 |
| | 2 | 0.31 | 1 | 0.31 | 0.002 | 0.002 | 0.002 |
| | 3 | 0.31 | 1 | 1 | 0.002 | 0.04 | 0.002 |
| 3+5 | 1 | 1 | 1 | 0.04 | 0.002 | 0.04 | 0.002 |
| | 2 | 1 | 1 | 0.31 | 0.04 | 0.04 | 0.04 |
| | 3 | 1 | 1 | 1 | 0.002 | 0.002 | 0.002 |
| 1+7 | 1 | 0.04 | 0.31 | 0.31 | 0.04 | 0.31 | 0.04 |
| | 2 | 0.31 | 0.04 | 0.31 | 0.04 | 0.002 | 0.04 |
| | 3 | 0.002 | 1 | 0.002 | 0.04 | 1 | 0.04 |
| 0+8 | 1 | 0.31 | 0.04 | 0.04 | 0.31 | 1 | 1 |
| | 2 | 0.04 | 0.002 | 1 | 0.31 | 0.04 | 1 |
| | 3 | 0.002 | 0.31 | 0.002 | 0.04 | 0.31 | 0.04 |

Table 2: Wilcoxon rank-sum test $p$ values for equality between actual investment and $w$ and actual investment and $1/n$, respectively; states are denoted by A, B, C; N=6

**Regularity 1 :** *With more experts and more nonexperts taking advice investments are closer to $w$ than to $1/n$.*

## 4.2 Does investment converge to $w$ or to $1/n$?

To check for learning effects over time, the average Euclidean distances of actual investments to $1/n$ and $w$ are listed in Table 3 and Table 4, respectively. The significant constants convey that investment is closest to $1/n$ in treatment T 0+8, followed by treatment T 1+7. The positive and significant time dummies ("Phase1 *

| Independent variable | $ED^{1/n}_{T0+8}$ | | $ED^{1/n}_{T1+7}$ | | $ED^{1/n}_{T3+5}$ | | $ED^{1/n}_{T8+0}$ | |
|---|---|---|---|---|---|---|---|---|
| Expert | | | 10.4** | (5.1) | 8.7** | (4.0) | | |
| Advised nonexpert | | | 10.2*** | (1.3) | 3.99*** | (1.0) | | |
| Phase1 * round | 2.436*** | (0.13) | 1.4*** | (0.13) | 0.5*** | (0.1) | 0.163 | (0.1) |
| Phase2 * round | 0.730*** | (0.05) | 0.4*** | (0.06) | 0.04 | (0.05) | 0.0303 | (0.04) |
| Phase3 * round | 0.567*** | (0.03) | 0.3*** | (0.04) | 0.2*** | (0.03) | 0.198*** | (0.03) |
| Constant | 6.063*** | (2.3) | 13.4*** | (2.2) | 23.1*** | (2.7) | 24.83*** | (1.6) |
| R-sq. | 0.0939 | | 0.0941 | | 0.0763 | | 0.0395 | |

$N = 2160$, Groups = 48, standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$,* $p < 0.1$

Table 3: Linear random effects regressions explaining the development of the Euclidean distance $ED^{1/n}$ from the heuristic 1/n by treatment

round", "Phase2 * round", "Phase3 * round") indicate that within the same phase the distance to *1/n* increases with time for most of the phases in all treatments. Also, the distance to the *1/n* is larger for experts and advised nonexperts, the latter suggesting once again that nonexperts follow recommendations.

**Regularity 2 :** *Some participants, mostly nonexperts without advice, initially rely on the 1/n heuristic but then try to develop a more sophisticated investment strategy.*

Although investment moves away from *1/n*, it does not always come close to $w$. The time dummies from the regressions in Table 4 are again positive and significant pointing to divergence from $w$ over time. This contradicts the last part of $H_2$, predicting an evolution toward $w$ when the phase ends. Nevertheless, not only experts but also advised nonexperts invest closer to $w$ (see the negative and significant coefficients for the variables "Expert" and "Advised nonexpert") than naive nonexperts and investments in T 8+0 are closest to $w$ (see constant for T 8+0, Table 4). Both regressions are illustrated in the appendix (Fig. 2 and Fig. 3).

**Regularity 3 :** *Experts invest closer to $w$ than advised nonexperts, who in turn*

| Coefficient | $ED^w_{0+8}$ | | $ED^w_{1+7}$ | | $ED^w_{3+5}$ | | $ED^w_{8+0}$ | |
|---|---|---|---|---|---|---|---|---|
| Expert | | | –13.6*** | (4.5) | –10*** | (4) | | |
| Advised nonexpert | | | –3.3*** | (1.2) | –9*** | (1.2) | | |
| Phase1 * round | 1.130*** | (0.12) | 0.83*** | (0.1) | 0.8*** | (0.1) | 0.799*** | (0.11) |
| Phase2 * round | 0.112** | (0.05) | 0.22*** | (0.05) | 0.1** | (0.05) | 0.167*** | (0.05) |
| Phase3 * round | 0.213*** | (0.03) | 0.21*** | (0.03) | 0.2*** | (0.03) | 0.120*** | (0.03) |
| Constant | 24.55*** | (2.04) | 25.3*** | (2.0) | 29.2*** | (2.6) | 14.25*** | (2.03) |
| R-sq. | 0.0429 | | 0.0775 | | 0.0259 | | 0.0153 | |

$N = 2160$, Groups = 48, standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$,* $p < 0.1$

Table 4: Linear random effects regressions explaining the development of the Euclidean distance $ED^w$ from $w$ by treatment

*invest closer to $w$ than naive nonexperts. However, learning*[11] *does not imply convergence to $w$.*

The qualitative analysis of the pilot session conducted in the video lab of the Max Planck Institute of Economics in Jena suggests one reason why investment does not converge to $w$: in spite of the random procedure according to which one of the states is selected in each round (of course depending on $w$, but on nothing else), not only naive nonexperts but also advised nonexperts and experts pay much attention to the past realizations of states when composing their portfolios. To check this conjecture quantitatively, we ran a three stage least squares regression[12] that takes into account the simultaneous determination of the independent investment in states A and C. Investment in state B was omitted since it is automatically determined by investments in states A and C. The findings in Table 5 show that subjects tend

[11]Since all traders in a group receive the same feedback, the different behavior of experts, clients, and naive nonexperts questions the possible claim that behavior is shaped by reinforcement learning.

[12]The individual and group dummies that were included in the regression to account for the panel character of the data are not listed in Table 5.

to reduce their investment in the state that was previously realized (a phenomenon known as gambler's fallacy). This holds for all types of agents in T 1+7 and T 3+5 (at least when state A is concerned - see the negative and significant coefficients of the three variables called past realization for state A in Table 5). Subjects in T 8+0 and T 0+8 also exhibit the gambler's fallacy (see Table 10 in the appendix).

| Independent variables | Investment in state A | Investment in state C |
|---|---|---|
| Investment in C | -0.511***(0.046) | |
| $w_A$ * expert | 0.560***(0.047) | |
| $w_A$ * advised nonexpert | -0.0546(0.062) | |
| Advice about investment in A * advised nonexpert | 0.251***(0.048) | |
| Advice about investment in A * T 1+7 | -0.0501*(0.03) | |
| Past realization A * expert | -4.662***(0.9) | |
| Past realization A * advised nonexpert | -2.808***(.8) | |
| Past realization A * naive nonexpert | -1.193**(0.55 ) | |
| Investment in A | | -0.498***(0.055) |
| $w_C$ * expert | | 0.0877(0.094) |
| $w_C$ * advised nonexpert | | -0.208***(0.037) |
| Advice about investment in C * advised nonexpert | | 0.387***(0.033) |
| Advice about investment in C * T 1+7 | | 0.0226(0.027) |
| Past realization C * expert | | 0.596(1.11) |
| Past realization C * advised nonexpert | | -1.222(0.77) |
| Past realization C * naive nonexpert | | -0.926(0.68) |
| Phase1 * period | -0.304***(0.077) | -0.0345(0.089) |
| Phase2 * period | 0.105***(0.036) | -0.0146(0.04) |
| Phase3 * period | -0.122***(0.022) | 0.00568(0.026) |
| N | 4224 | 4224 |
| R-squared | 0.61 | 0.63 |

Table 5: 3SLS regression explaining investment behavior in T 1+7 and T 3+5, standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

**Regularity 4 :** *Investment behavior of experts and advised nonexperts is not only* *shaped by $w$ and the recommendations but also by past random realizations of states.*

## 4.3 Does professional expertise evolve?

Nonexperts readily demand advice (see Table 6). In treatments T 3+5 and T 1+7, on average over 90% of all nonexperts are prepared to pay for advice.[13] Experts on the supply side demonstrate a lively interest in becoming consultants – about 80% in both treatments are willing to give advice. The shares of agents asking for, and offering advice in both treatments are very similar. The frequency of actual consulting, however, differs considerably. In T 1+7, one third of the agents who request advice also receive it. In T 3+5, about two thirds get recommendations. Only 41% of the experts in T 3+5 are actually hired, compared to 72% in T 1+7 due to competition effects on the supply side in T 3+5. In both treatments, all experts require a fee greater than zero for their services.[14]

| Treat-ment | Share of nonexperts who... | | Share of experts who... | |
|---|---|---|---|---|
| | ...ask for advice | ...receive advice | ...are willing to advise | ...become advisors |
| 3+5 (by phase) | 90% | 63% (50%, 63%, 77%) | 79% | 41% |
| 1+7 (by phase) | 95% | 29% (24%, 45%, 17%) | 83% | 72% |

Table 6: Supply and demand on the market for professional expertise by treatment

**Regularity 5 :** *In case of asymmetric information, professional expertise, i.e., experts offering costly advice and nonexperts paying for it, is a robust phenomenon*

[13] Only nonexperts willing to pay a sum greater than zero are considered.

[14] Among the nonexperts, only one participant per treatment stated a zero willingness to pay, and this only in one of the three phases.

*especially when experts compete in offering their services.*

Do nonexperts follow recommendations being aware that experts cannot cheat? The evidence from Tables 3 and 4 above already indicates that advice is followed. Tables 7 and 8 verify this claim once again. Table 7 lists descriptive statistics on mean and median investment of advised nonexperts as well as the recommendation they receive. The Wilcoxon rank-sum test cannot reject the equality between these two variables in most of the cases (Table 8).[15] Still, the Euclidean distance between advice and investment by advised nonexperts is not zero (Fig. 4 in the appendix). Hence, advice is followed closely but not blindly.

Here it is needed to elaborate on the question why advised nonexperts do not just imitate the behavior of advisors.

In economics, the effect of advice on behavior in different games has been studied by Schotter (2003), Schotter and Sopher (2003), Schotter and Sopher (2007), Schotter and Sopher (2006), Chaudhuri et al. (2006), and Kuang et al. (2007). All these studies find that advice is followed and that it changes behavior.

In psychology, the research on this topic is more detailed and more controversial. The literature on Judge-Advisor Systems (for a comprehensive review, see Bonaccio and Dalal (2006)) provides insights on when, why and to which extent recommendations are implemented. For example, clients are more likely to follow recommendations when they are less knowledgeable than their advisor (e.g., Harvey and Fischer, 1997), when advice is solicited rather than provided without request (Gibbons et al., 2003), when tasks are complex (Schrah et al., 2006), when advice is accurate, and

[15] We are aware of the fact that two independent observations in phase 3 of T 1+7 are not enough to conduct the test in a reliable way. Nevertheless, we list the results for the sake of completeness.

| Treatment | Phase | Mean A | Mean B | Mean C | Median A | Median B | Median C | SD A | SD B | SD C |
|---|---|---|---|---|---|---|---|---|---|---|
| 3+5 Investment | 1 | 22 | 21 | 58 | 20 | 20 | 60 | 15 | 15 | 27 |
| | 2 | 42 | 18 | 40 | 40 | 15 | 40 | 17 | 16 | 17 |
| | 3 | 19 | 29 | 52 | 15 | 30 | 55 | 18 | 15 | 25 |
| 3+5 Advice | 1 | 20 | 19 | 61 | 20 | 20 | 60 | 14 | 12 | 24 |
| | 2 | 43 | 16 | 41 | 40 | 20 | 40 | 7 | 9 | 7 |
| | 3 | 11 | 28 | 61 | 10 | 30 | 60 | 8 | 9 | 10 |
| 1+7 Investment | 1 | 25 | 24 | 51 | 25 | 25 | 50 | 11 | 18 | 22 |
| | 2 | 40 | 20 | 40 | 40 | 15 | 40 | 20 | 22 | 21 |
| | 3 | 14 | 31 | 54 | 10 | 30 | 50 | 15 | 17 | 23 |
| 1+7 Advice | 1 | 21 | 21 | 58 | 20 | 20 | 60 | 7 | 9 | 13 |
| | 2 | 43 | 13 | 44 | 40 | 10 | 45 | 13 | 9 | 11 |
| | 3 | 8 | 28 | 64 | 10 | 30 | 65 | 5 | 13 | 14 |

Table 7: Mean, median, and standard deviation of investment of advised nonexperts as well as advice they receive by treatment, phase, and state; benchmark: $w_1 = (25, 25, 50), w_2 = (40, 20, 40), w_3 = (15, 30, 55)$, *1/n* heuristic= $(100/3, 100/3, 100/3)$; states are denoted by A, B, C

when the goals of clients and advisors are aligned (Schotter, 2003). In our setup, following recommendations is facilitated by rendering experts more knowledgeable than nonexperts, by challenging nonexperts with a nontrivial task, by aligning the interestes of advisors and advised (experts are forced to invest according to their recommendation), and by giving nonexperts the chance to freely decide whether to purchase advice. Why then nonexperts do not simply implement the advice one-to-one? According to the literature on Judge-Advisor Systems one well-established reason is that of "egocentric advice discounting" (e.g., Yaniv, 2004b; Yaniv and Kleinberger, 2000). Decision makers often do not follow advice as closely as they

| Treatment | Phase | Number of obs. | p value | | |
|---|---|---|---|---|---|
| | | | A | B | C |
| T 3+5 | 1 | 6 | 0.75 | 0.75 | 0.87 |
| | 2 | 5 | 0.92 | 0.92 | 0.46 |
| | 3 | 6 | 0.08 | 0.87 | 0.11 |
| T 1+7 | 1 | 5 | 0.25 | 0.46 | 0.35 |
| | 2 | 6 | 0.34 | 0.15 | 0.42 |
| | 3 | 2 | 0.12 | 1 | 0.43 |

Table 8: Wilcoxon rank-sum test $p$ values for equality between average investment of advised nonexperts and average recommendations by treatment, phase, and state; states are denoted by A, B, C

should to truly benefit from it. Thereby clients discount the opinion of the advisor too strongly, when combining it with their own. This behavior is believed to be due to the client's impossibility to grasp the advisor's internal justification for the recommendation. In contrast, clients are fully aware of their own arguments, rendering their own opinion less ambiguous than the recommendation (Yaniv and Kleinberger, 2000; Yaniv, 2004a,b). Other reasons for discounting advice may be an anchoring and adjustment strategy (Tversky and Kahnemann, 1974), with the own initial opinion being the anchor that is gradually but insufficiently adjusted toward the advisor's recommendation (e.g., Harvey and Fischer, 1997), an egocentric bias (Krueger, 2003), and conservatism (Harvey and Harries, 2004). These arguments give some hint on why our nonexpert participants do not fully rely on the recommendations they receive.

**Regularity 6 :** *Although advised nonexperts do not implement recommendations blindly, they are strongly influenced by them.*

## 4.4 Is there any impact of competition?

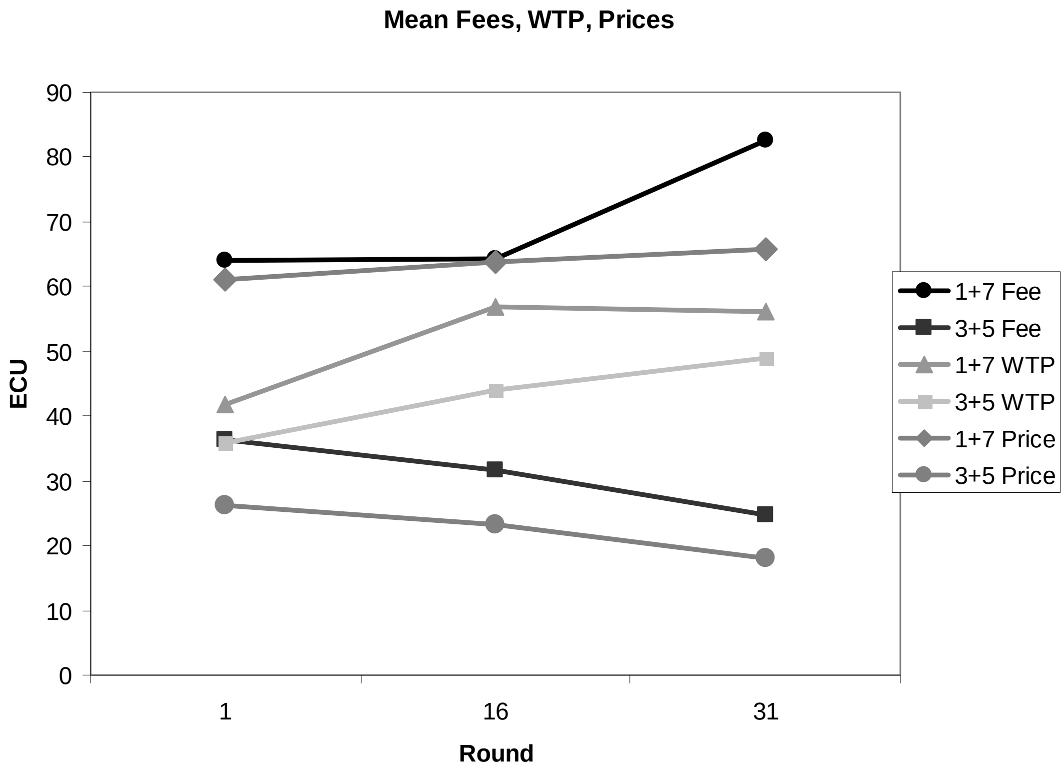


Figure 1: Mean fees, willingness to pay, and prices for advice in T 1+7 and T 3+5

Fig. 1 illustrates mean required fees, mean willingness to pay, and mean fees paid (=prices) on the market for expertise. All three variables in T 1+7 frequently lie above those in T 3+5. The actually paid fees in T 1+7 are significantly higher than those in T 3+5 in phases 1 and 2 (Wilcoxon rank-sum test, $p = 0.0264$ and $p = 0.0088$, respectively). [16] Over time, paid fees nonsignificantly increase when there is an expert-monopoly (Wilcoxon signed rank test, phase 1 versus phase 2, $p = 0.16$). Paid fees decrease when experts compete (nonsignificantly between phases 1 and 2 and significantly between phases 2 and 3, Wilcoxon signed rank test, $p = 0.5$ and $p = 0.08$, respectively). Willingness to pay does not differ significantly across

[16] For phase 3 the fees in T 1+7 are so high that advice is provided in only two out of six groups. Thus there are not enough independent observations for a reliable test.

treatments (Wilcoxon rank-sum test, $p = 0.34$, $p = 0.26$, $p = 0.75$, respectively for phases 1, 2 and 3).

**Regularity 7 :** *The fees for advice are higher on the monopolistic market for advice. Competing lowers fees over time.*

## 4.5 Profits

Does it pay to invest according to $w$? Table 9 shows that in all treatments earnings are higher the closer one invests to $w$. In T 1+7, profits also improve with a growing distance to $1/n$. In other treatments, either closeness to $w$ or distance from $1/n$ guarantees higher profits, questioning the "ecological rationality" of the $1/n$-heuristic (Gigerenzer and Todd, 1999).

| Coefficient | Profit T 8+0 | | Profit T 3+5 | | Profit T 1+7 | | Profit T 0+8 | |
|---|---|---|---|---|---|---|---|---|
| $ED_w$ | –0.21*** | (0.06) | –0.20** | (0.08) | –0.6*** | (0.09) | –0.49*** | (0.08) |
| $ED_{1/n}$ | –0.06 | (0.07) | –0.06 | (0.07) | 0.2*** | (0.08) | 0.09 | (0.07) |
| Round | 0.008 | (0.07) | 0.005 | (0.09) | 0.04 | (0.09) | –0.006 | (0.08) |
| Constant | 105.5*** | (2.4) | 107.2*** | (3.1) | 111.0*** | (3.2) | 113.0*** | (2.9) |
| R-sq. | 0.0101 | | 0.0067 | | 0.0268 | | 0.0289 | |

$N = 2160$, groups=48, standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, ED = Euclidian distance

Table 9: Linear random effects regression explaining profit by treatment

**Regularity 8 :** *Investing close to w pays.*

# 5 Conclusion

With field data it is rather difficult, maybe even impossible, to compare financial markets with and without investment advisors. Here we have concentrated on the evolution of expertise in a rather simplified market scenario. The advantages are that there is an intuitive and focal game theoretic benchmark ($e^* = w$) as well as a simple heuristic *1/n*. Furthermore, we were able to easily study the effect of competition on the market for financial advice.

As usual, we had to impose simplicity in order not to overburden our participants cognitively. Future research could therefore try to add more realism, e.g., by introducing advisors who may not follow their own recommendations. Crawford and Sobel (1982), for example, have initiated a burgeoning literature on the incentives of experts to manipulate information.[17] In our experiment, manipulation of advice was explicitly ruled out since each advised nonexpert was able to observe the portfolio of her expert. Moreover, the identity of experts was always known. Under manipulation of advice and imperfect information about the experts' identities we expect that the evolution of expertise might be impaired if not completely blocked by these strategic risks that investors will have to incur when relying on expert advice. On the other hand, evolving reputation of experts might help to restore expertise.

While in our setup every 15 rounds a new endowment of funds is distributed among participants, one could implement a scenario more closely to Blume and Easley (1992) by endowing participants only once in the first round. This would punish experimentation more heavily by marginalizing unlucky experimenters and support

[17]See Farrell and Rabin (1996), Sobel (2007), and Krishna and Morgan (2008) for recent surveys of this literature.

more defensive actions. Whether such a scenario is more favorable for the evolution of expertise, can only be described by future research.

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# 6 Appendix

## 6.1 Proof of Proposition 1

Normalize $K = 1$ so that

$$p_s = \sum_{\ell=1}^{N} e_{\ell s} \quad \text{for } s = 1, \ldots, S\,. \tag{3}$$

Choosing $e_\ell = (e_{\ell 1}, \ldots, e_{\ell S}) = \frac{1}{K_i}(K_{i1}, \ldots, K_{iS})$, agent $i$ earns in expected terms

$$\pi_i = \sum_{s=1}^{S} w_s \frac{K_{is}}{p_s} \quad \text{for } i = 1, \ldots, N.$$

Since agents invest their entire endowment $K_i$, each agent $i$ maximizes

$$\mathcal{L} = \pi_i + \lambda_i \left( K_i - K_{i1} - \ldots - K_{iS} \right).$$

Since $\partial p_s / \partial K_{is} = 1$, we obtain

$$\frac{\partial \mathcal{L}}{\partial K_{is}} = \frac{w_s}{p_s} - \frac{w_s}{p_s^2} K_{is} - \lambda_i = 0 \quad \text{for } s = 1, \ldots, S.$$

This requires for any two states $s, r, \in \{1, \ldots, S\}$

$$\frac{w_s}{p_s}\left(1 - \frac{K_{is}}{p_s}\right) = \frac{w_r}{p_r}\left(1 - \frac{K_{ir}}{p_r}\right). \tag{4}$$

Suppose now there exists an equilibrium allocation with

$$\frac{w_s}{p_s} \neq \frac{w_r}{p_r}$$

for some states $s$ and $r$. Of course, without loss of generality we can assume, e.g., $\frac{w_s}{p_s} < \frac{w_r}{p_r}$. Then, from (4), we get

$$\left(1 - \frac{K_{is}}{p_s}\right) > \left(1 - \frac{K_{ir}}{p_r}\right) \quad \Rightarrow \quad \frac{K_{is}}{p_s} < \frac{K_{ir}}{p_r} \quad \forall\, i \in \{1, \ldots, N\}. \tag{5}$$

Summing (5) for all $i$, we get an invalid statement $1 < 1$. Therefore, only allocations with $\frac{w_s}{p_s} = \frac{w_r}{p_r}$ can satisfy (4). Therefore, (assuming $w_s \neq 0\ \forall s$) we can divide (4) by $\frac{w_s}{p_s}$ to get

$$\frac{K_{is}}{p_s} = \frac{K_{ir}}{p_r} \quad \forall i\ \in \{1, \ldots, N\}.$$

We conclude that only allocations with

$$\frac{w_s}{p_s} = \frac{w_r}{p_r} \quad \text{and} \quad \frac{K_{ir}}{p_r} = \frac{K_{is}}{p_s} = \frac{K_i}{K} = K_i \tag{6}$$

satisfy the equilibrium condition (4). However, condition (6) corresponds to

$$\frac{w_s}{w_r} = \frac{p_s}{p_r} = \frac{K_{is}}{K_{ir}}$$

uniquely defining the evolutionary stable allocation $e_i = e^* = w$ for all $i = 1, \ldots, N$ of Blume and Easley (1992).

□

## 6.2 Instructions

### 6.2.1 Treatment 8+0

Welcome and thank you for participating in this experiment. Please read the instructions very carefully. From now on you have to remain calmly seated and refrain from communicating with other participants. If you have any questions, please raise your hand. We will answer your questions privately. It is very important that you obey these rules, otherwise we will be forced to exclude you from the experiment, and you will not receive any payoff.

**The situation**

This experiment comprises a number of phases smaller than 10. Each phase consists of 15 rounds. In each round you have to make a decision. You belong to a group of 8 players. All groups keep the same composition until the end of the experiment.

**The experiment**

At the beginning of **each** round each player receives a capital of 100 ECU[18]. There are three possible situations. Your task is to assign a share of your capital (in percent) to each of the three situations. Hereby you have to spend all your capital. After you make your investment decision, you will be informed which situation was randomly selected. Your payoff is given by the following equations:

Payoff = Investment in the situation that was randomly selected (in ECU) * Reward
Reward = (Sum of the initial capital of all players in your group)/(Sum of the investments of all players in your group in the randomly selected situation)

[18]Experimental Currency Units

**Your investments in situations that were not randomly selected are lost.**

The three situations are selected with different probabilities. These probabilities are the same within a phase. Across phases the probabilities differ. You will always be informed about the current probabilities.

**Sequence of events in chronological order**

The same procedure applies to all rounds. First, the players are informed about the current probabilities of the situations. Second, everyone makes their investment decisions. Third, a random device selects one situation. Last, the resulting payoffs are displayed.

**Hint on probabilities**

Imagine an urn with 100 balls. Some of them are red, others green and the remaining yellow. The colors represent the situations. In the beginning of each phase you will be informed about the number of red, green, and yellow balls. The number of e.g. green balls divided by 100 represents the probability to draw one green ball when performing a single draw. At the end of each round one ball is randomly drawn. The color of the ball represents the situation that is randomly selected. Within a phase, the contents of the urn do not change. After each random draw at the end of each round, the ball is put back into the urn. The contents of the urn change only at the beginning of a new phase.

**Information at the end of each round**

At the end of each round, every player is informed about her payoff in this round.

**Payoff at the end of the experiment**

Your overall payoff equals the sum of your payoffs from all rounds. At the end of the experiment this accumulated amount will be converted into euros according to the exchange rate 300 ECU = 1 euro and will be paid to you in cash.

**Questionnaire and test rounds**

After reading these instructions, you will receive the opportunity to become acquainted with the experiment during four test rounds. The payoffs from these test rounds do not count for your final payoff. Afterwards, we will ask you to answer a questionnaire. The questions that you do not answer correctly will be repeated until you find the correct answers. The 24 players who make the fewest mistakes will participate in the experiment. The others will receive 5 euros and will have to leave the room.

### 6.2.2 Treatment 0+8

Like T 8+0

**The situation**

Like T 8+0

**The experiment**

Like T 8+0

The three situations are selected with different probabilities. These probabilities are the same within a phase. Across phases they differ. You will not be informed about these probabilities. We will only inform you when the probabilities change.

**Sequence of events in chronological order**

The same procedure applies to all rounds. First, everyone makes their investment decisions. Then, a random device selects one situation. Last, the resulting payoffs are displayed. At the beginning of each new phase players will be reminded that the probabilities have changed with respect to the previous phase.

**Hint on probabilities**

Imagine an urn with 100 balls. Some of them are red, others green and the remaining yellow. The colors represent the situations. A random device selects the number of red, green and yellow balls. The number of e.g. green balls divided by 100 ... Like T 8+0

**Information at the end of each round**

Like T 8+0

**Payoff at the end of the experiment**

Like T 8+0

**Questionnaire and test rounds**

Like T 8+0

#### 6.2.3 Treatment 1+7

Like T 8+0

**The situation**

Like T 8+0

In each group there are one expert and seven nonexperts. One of these roles will be randomly assigned to you. You will keep your role until the end of the experiment.

**The experiment**

Like T 8+0

The three situations are selected with different probabilities. These probabilities are the same within a phase. The expert in your group will always be informed about the current probabilities. In contrast, the nonexperts will not be informed about the probabilities of the situations.

Before making a decision, a nonexpert can take advice from an expert. This advice is a recommendation concerning the share of capital to be assigned to each situation. If a nonexpert wishes to receive advice, she has to state her willingness to pay for the advice (in ECU). At the same time, the expert announces the fee she requires for her recommendation. Whenever the willingness to pay of a nonexpert exceeds the fee of an expert, the nonexpert receives advice and pays the fee. If the fee exceeds the willingness to pay of a given nonexpert, this nonexpert will not receive advice.

The fee is due **only once in the first round of a phase** and is paid before the decisions in this round are made. This means that each nonexpert, who receives advice e.g. in phase three, disposes in the first round of phase three of her initial capital minus the advisor's fee. In contrast, the advisor has her initial capital plus the fee at her disposal before making her decision in the first round of phase three. Herewith, the nonexpert buys the right to be advised by the expert in each round until the end of the phase. Advisors are obliged to invest according to their recommendations. Experts as well as nonexperts can refuse to give or take advice. Only those, who paid for advice, are entitled to be advised.

**Sequence of events in chronological order**

The following events always take place in the first round of a phase:

1. Only the expert is informed about the probabilities of the situations.
2. The nonexperts who are willing to take advice, state their willingness to pay. At the same time, the expert states her fee.
3. The capital of those nonexperts, whose willingness to pay exceeds the expert's fee, is reduced by the respective fee. The advisor's capital is respectively increased. Nonexperts who do not want to be advised or cannot be advised because of their too low willingness to pay and/or a too high fee do not pay a fee and do not receive advice.
4. The expert communicates her recommendation to the nonexpert(s).
5. Each player individually makes her investment decision.
6. The players are informed about which situation was randomly selected and their resulting payoffs.

In the following rounds (2 to 15) of a phase, only recommendations are communicated and decisions are made (points 4, 5, and 6). Only in the first round of a new phase the full game with stages 1 to 6 is played.

**Hint on probabilities**

Imagine an urn with 100 balls. Some of them are red, others green and the remaining yellow. The colors represent the situations. In the beginning of each phase the expert will be informed about the number of red, green, and yellow balls.
Like T 8+0

**Information at the end of a period**

Like T 8+0

**Payoff at the end of the experiment**

Like T 8+0

**Questionnaire and test rounds**

Like T 8+0

### 6.2.4 Treatment 3+5

Like T 8+0

**The situation**

Like T 8+0

In each group there are three experts and five nonexperts. One of these roles will be randomly assigned to you. You will keep your role until the end of the experiment.

**The experiment**

Like T 8+0

The three situations are selected with different probabilities. These probabilities are the same within a phase. The experts in your group will always be informed about the current probabilities. In contrast, the nonexperts will not be informed about the probabilities of the situations.

Before making a decision, a nonexpert can take advice from an expert. This advice is a recommendation concerning the share of capital to be assigned to each situation. The nonexperts who need advice, announce their willingness to pay (in ECU). The experts who want to advise, announce their fees. Each nonexpert sees only those fees which are smaller or equal to her willingness to pay. Given the fees, each nonexpert chooses one expert whose advice she wants to take. If the fees of all three experts exceed the willingness to pay of a nonexpert, this nonexpert does not receive any advice.

The fee is due... same as T 1+7

**Sequence of events in chronological order**

The following events always take place in the first round of a phase:

1. Only the experts are informed about the probabilities of the situations.
2. The nonexperts who are willing to take advice, state their willingness to pay. At the same time, the experts state their fees.
3. The nonexperts are informed about those fees which do not exceed their willingness to pay. Given this information they choose an advisor.
4. Nonexperts who do not want to be advised or cannot be advised because of their too low willingness to pay and/or too high fees do not pay a fee and do not receive advice.
5. The experts communicate their recommendations to the nonexperts.
6. Each player individually makes her investment decision.
7. Players are informed about which situation was randomly selected and their resulting payoffs.

In the following rounds (2 to 15) of a phase, only recommendations are communicated and decisions are made (points 5, 6, and 7). Only in the first round of a new phase the full game with stages 1 to 7 is played.

**Hint on probabilities**

Like T 1+7

**Information at the end of a period**

Like T 8+0

**Payoff at the end of the experiment**

Like T 8+0

**Questionnaire and test periods**

Like T 8+0

## 6.3 Questionnaire

A selection of these questions was used depending on the specific features of each treatment.

1. My capital amounts to 100 ECU. I assigned

    - 50% to situation 1,
    - 10% to situation 2 and
    - 40% to situation 3.

    Situation 3 is randomly selected. Hence, my payoff in this round is

- 10% of 100 ECU * reward
- 40% of 100 ECU * reward
- 100% of 100 ECU * reward
- 0
- None of the answers is correct.

2. The group consists of three players. Player 1 assigned 40 ECU to the situation that was randomly selected, player 2 - 10 ECU and player 3 - 50 ECU. Each player has an initial capital of 100 ECU. How large is the reward?

   - 300/100 ECU
   - 300 ECU
   - 100/300 ECU
   - None of the answers is correct.

3. The group consists of three players. Player 1 assigned 40 ECU to the situation that was randomly selected, player 2 - 10 ECU and player 3 - 50 ECU. Each player has an initial capital of 100 ECU. How large is the payoff of each player?

   - $40 \cdot 3 = 120$; $10 \cdot 3 = 30$; $50 \cdot 3 = 150$
   - $40 \cdot (1/3) = 40/3$; $10 \cdot (1/3) = 10/3$; $50 \cdot (1/3) = 50/3$
   - $40 \cdot 300$; $10 \cdot 300$; $50 \cdot 300$

4. The capital shares, assigned to the situations that were not randomly selected,

   - will be given back to me at the beginning of the next round.
   - will be given back to me at the end of the experiment.
   - are lost.

- will be distributed among the other players of my group.
- None of the answers is correct.

5. The probabilities of the situations do not change for the duration of
   - one phase
   - one round
   - 11 rounds
   - the whole experiment
6. The probabilities of the situations are determined
   - in every period
   - in the first period of each phase
   - once at the beginning of the experiment
7. Which statement is correct? The experts...
   - know which situation will be randomly selected.
   - know the probability of each situation.
   - do not know the probability of each situation.
8. Nonexpert A is willing to pay 50 ECU for advice by expert B. Expert B requires a fee of 30 ECU.
   - A will not receive advice since she offers too little.
   - A will have to pay 50 ECU to receive advice.
   - A will have to pay a random price between 30 and 50 ECU to receive advice.
   - A will have to pay 30 ECU to receive advice.

- None of the answers is correct.

9. Which statement is correct?

   The advisors...

   - do not have to invest according to their own recommendation.
   - have to invest according to their own recommendation.
   - may communicate different recommendations in each round.
   - have to communicate the same recommendation in each round.
   - have to communicate different recommendations in each round.
   - 2 and 3.
   - None of the answers is correct.

10. The fee has to be paid

    - in the last round of each phase.
    - in each round.
    - once per phase, in the first round.
    - only once, at the beginning of the experiment.
    - only once, at the end of the experiment.

## 6.4 Tables and figures

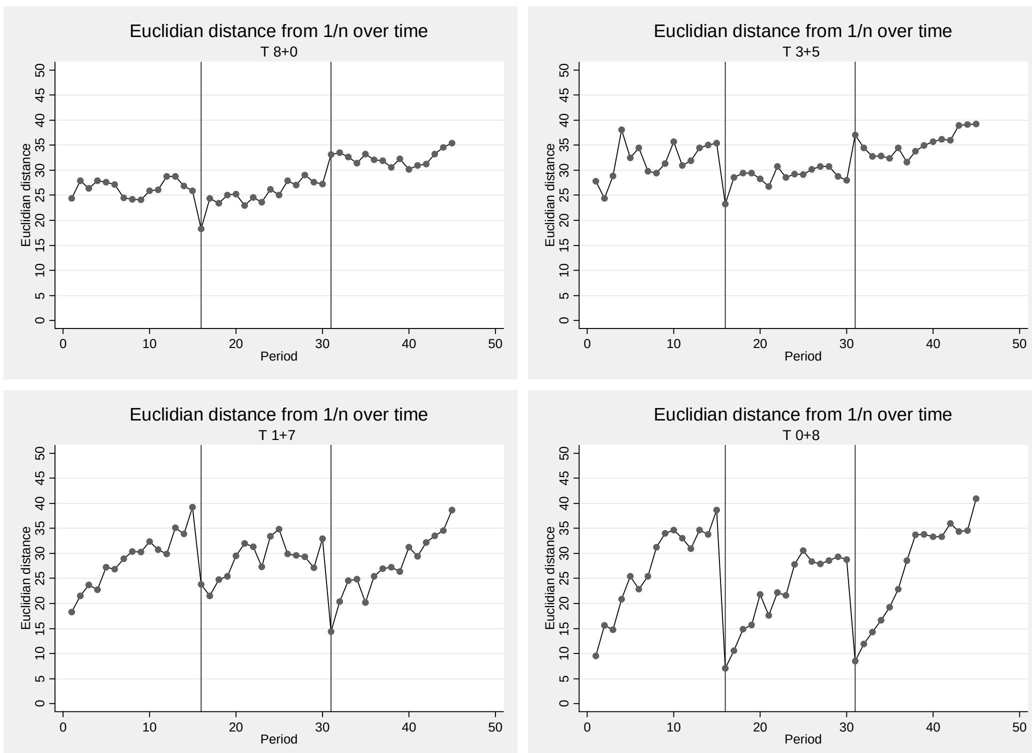


Figure 2: Euclidean distance from the $1/n$ portfolio by treatment over time

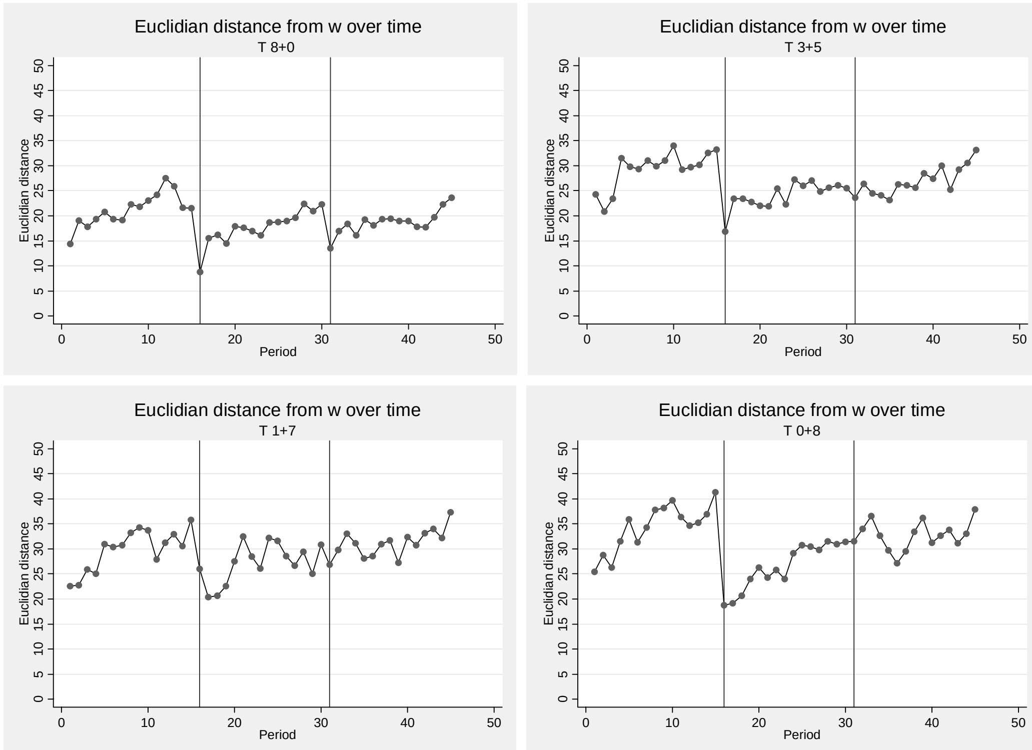


Figure 3: Euclidean distance from the $w$-portfolio by treatment over time

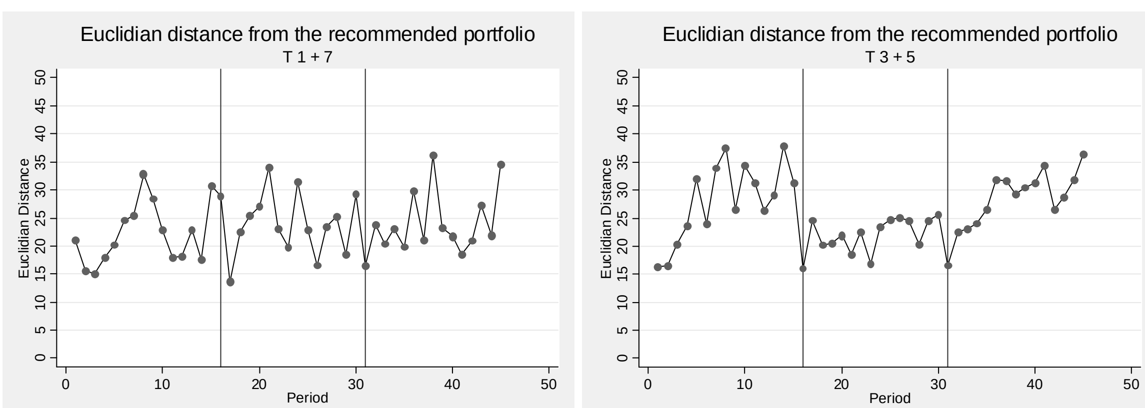


Figure 4: Euclidean distance from the recommended portfolio by treatment over time

| Independent variable | Investment in state A | Investment in state B |
|---|---|---|
| Investment in state B | -0.586***(0.11) | |
| $w_A$ | 0.0705(0.12) | |
| $w_A$ * T 8+0 | 0.305***( -0.048) | |
| Past realiz A | -1.150**(0.47) | |
| Past realiz A * T 8+0 | -1.970***(0.67) | |
| Investment in state A | | -0.383***(0.12) |
| $w_B$ | | -0.207(0.35) |
| $w_B$ * T 8+0 | | 0.300*(0.17) |
| Past realiz B | | -0.543(0.52) |
| Past realiz B * T 8+0 | | -2.351***(0.7) |
| Phase1 * period | -0.311***(0.084) | 0.0159(0.1) |
| Phase2 * period | 0.000762(0.075) | -0.0769(0.077) |
| Phase3 * period | -0.218***(0.042) | -0.0846(0.062) |
| N | 4224 | 4224 |
| R-squared | 0.43 | 0.37 |

Table 10: 3 SLS regression explaining investment in T 0+8 and T 8+0, standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$