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Risk Taking of Executives under Different Incentive Contracts: Experimental Evidence

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Abstract
Classic financial agency theory recommends compensation through stock options rather than shares to induce risk neutrality in otherwise risk averse agents. In an experiment, we find that subjects acting as executives do also take risks that are *excessive* from the perspective of shareholders if compensated through options. Compensation through restricted company stock reduces the uptake of excessive risks. Even under stock-ownership, however, experimental executives continue to take excessive risks—a result that cannot be accounted for by classic incentive theory. We develop a basic model in which such risk-taking behavior is explained based on a richer array of risk attitudes derived from Prospect Theory. We use the model to derive hypotheses on what may be driving excessive risk taking in the experiment. Testing those hypotheses, we find that most of them are indeed borne out by the data. We thus conclude that a prospect-theory-based model is more apt at explaining risk attitudes under different compensation regimes than traditional principal-agent models grounded in expected utility theory.

Keywords: prospect theory; expected utility theory; risk attitude; executive compensation; reference dependence; experimental finance;

JEL Classification: D03, G28, G32, J33, L22

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1. Introduction

A large part of the performance-contingent pay of executives today is delivered through stock-options. Traditionally, the compensation of executives through stock-options instead of company shares has been justified by the need of inducing some desirable risk appetite in otherwise risk-averse agents (Agrawal & Mandelker, 1987; Smith & Stulz, 1985). This argument however rests on the assumption of global risk aversion by executives (Wiseman & Gomez-Mejia, 1998). A wealth of evidence from the empirical literature points in the direction that risk attitudes depend on decision frames and aspiration levels as well as the source of the uncertainty, and may thus vary over the outcome and probability spaces (Abdellaoui, Baillon, Placido, & Wakker, 2010; Diecidue & van de Ven, 2008; Fiegenbaum & Thomas, 1988). We develop a simple model relaxing the assumption of global risk aversion. Assuming a richer array of risk attitudes based on prospect theory (Kahnemann & Tversky, 1979), we predict that some risk seeking may take place under stock compensation as well as under compensation through options. And this holds even when such risk taking is excessive from shareholders' point of view.

The long-standing postulate that linear incentive contracts result in risk aversion on the side of agents lacks empirical evidence. The availability of data on these issues is indeed limited, and often no clear-cut, causal conclusions can be drawn even where such data can be found. We thus investigate the effect of different compensation mechanisms experimentally. Experiments have the advantage of permitting controlled variations in one independent variable at the time, thus permitting the isolation of clear causal relationships. Experiments are common in finance for issues that are difficult to disentangle in the real world (e.g. Biais, Hilton, Mazurier, & Pouget, 2005; Gneezy, Kapteyn, & Potters, 2003; Haigh & List, 2005), and can significantly supplement results obtained from the analysis of real-world data. Furthermore, experimental investigation makes simplifications aimed at isolating fundamental causal relationship which closely resemble the simplifications made by theoretical models—and few people doubt the usefulness of theories because of the simplifications they entail.

We let experimental executives choose between two prospects into which to invest company assets, characterized by different volatility levels. In order to test the extent to which compensation through options may induce risk taking, the high volatility investment is also always inferior in terms of expected value, although to different degrees. Our results indicate that option-based compensation schemes can induce risk taking by executives that is excessive from shareholders' point of view. More importantly, even linear compensation through long-term stock-ownership plans results in high levels of suboptimal risk taking.

Classical accounts based on expected utility theory cannot explain such risk taking under linear incentive contracts. We thus find that executives' behavior is described much better by a prospect-theory-based model. In general, a majority of our experimental subjects exhibit prospect-theory-type risk preferences. Reference-point effects and overweighting of small probabilities are found to make executives take risks even when compensated through restricted company stock. When compensation takes the form of stock options, executives tend to take excessive risks especially when they hold options that are at- or out-of-the-money—a finding that cannot be explained by classical expected utility models. We thus argue that expanding incentive theory to allow for richer risk-attitudes as found in empirical investigations promises to greatly increase our understanding of the issues involved.

The present paper proceeds as follows. Section 2 presents a discussion of different compensation schemes and develops a simple model predicting choices based on expected utility theory. Section 3 presents the experiment and its main results. Section 4 expands the model developed in section 2 to take account of prospect-theory-type behavior, and tests the predictions thus derived on the data. Section 5 contains a general discussion of our findings, and section 6 concludes the paper.

2. Compensation schemes and investment behavior

2.1 Stock option compensation versus stock ownership

The importance of stock-option payments has increased dramatically over the last two decades and holds a prominent place in the overall compensation of executives (Core *et al.* 2003; Hall & Liebman, 1998). Traditionally, compensation through stock options has been explained as a solution to the agency problem inasmuch as it counteracts the natural risk aversion of executives (Agrawal & Mandelker, 1987; Feltham & Wu, 2001; Guay, 1999; Hall & Liebman, 1998; Smith & Stulz, 1985). Indeed, options shelter executives from potential losses since they do not have to be exercised in case of a decline in stock prices (Bebchuck & Fried, 2003; De Fusco, Johnson, & Zorn, 1990). The result that stock options may increase risk seeking when the latter is desirable is thus well established. It is less clear what will happen when any risk seeking is undesirable. We thus want to test the extent to which compensation through options can induce the uptake of risks that are sub-optimal for the company.

It is also generally accepted that paying executives in restricted company stock increases the linearity of the incentive instrument (Holden, 2005; Jensen & Murphy, 1990). Traditionally, this has mostly been seen as undesirable, since it may trigger excessive risk aversion on the side of executives. There is however a lack of empirical evidence on this point, and the conclusion holds true only as long as one assumes that executives maximize expected utility theory with a concave utility function, i.e. they are risk averse over the whole outcome space. Expected utility theory has however been shown time and again to have significant shortcomings as a descriptive theory of choice behavior (Starmer, 2000). Indeed, people's risk attitudes have been found to vary widely over the probability and outcome space—a finding that has also been shown to hold for large firms (Chou, Chou, & Ko, 2009; Fiegenbaum & Thomas, 1988) and for actual CEOs (List & Mason, 2010). Once one relaxes the assumption that executives are risk averse expected utility maximizers, it is no longer clear how much risk they will take when compensated through stock.

Arguably, a dimension that may be just as important as the fact whether executives are compensated through stock options or actual company stock is the time-horizon of the compensation scheme. In the present experiment, we compare stock-options with short vesting periods to long-term stock-ownership plans. This choice is driven by the aim of subjecting the hypothesis that there may be excessive risk taking even under stock compensation to as hard a test as possible: While it may sometimes be appealing to take a long shot if shares can be sold after each investment period, risk taking becomes clearly sub-optimal in our setting when such equity can be cashed only after multiple periods.

2.2 A simple model and some initial hypotheses

In this section we develop a model aimed at generating hypotheses for our empirical investigation. Though it easily generalizes to a wider class of compensation schemes, we will adopt the terminology of our experimental investigation to simplify exposition. Executives choose between investing into a low volatility (*LV*) investment project or a high volatility investment (*HV*) project. The expected value (*EV*) of the high volatility investment opportunity is always inferior to the one of the low volatility investment by design ($EV_{HV}<EV_{LV}$), since we want to test the conditions under which risk taking by executives may be *excessive*. As implicit in the designation, the standard deviation of the high volatility investment is always larger than the one of the low volatility investment: $\sigma_{HV} > \sigma_{LV}$.

In each period, the CEO has to make a choice between two investments. Such choices are repeated for T periods. CEOs are compensated either through stock-options or company shares. Under stock ownership, the executive is compensated through shares in the firm she manages that are not tradable until the end of the contract, *T*. Under a stock-options contract, the executive receives, each period, a grant of stock-options that become vested in the subsequent period, so that they can be exercised in any period until the end of the contract at *T*. These stock-options are emitted at-the-money at the exercise price $e_t = y_t$., where y_t represents the value of shares at the time t when the options are emitted. For simplicity we will assume that whenever an option is exercised, the shares thus called will be resold immediately, so that realized gains for options emitted at time t and sold at time i will be $y_i – e_t$, $y > e$ and i > t.

We assume that CEOs maximize their own payoff, and first solve the problem for an expected value maximizer (defined as an individual who maximizes the mathematical expectation of the payoff). For CEOs compensated through company stock the problem is trivial: since the expected value of the LV investment is always higher than for the HV investment, it is optimal to always choose the LV investment. When on the other hand a CEO is compensated through options, then her compensation varies linearly with the firm's share price only to the extent that the share price exceeds the exercise price. Hence the manager's payoff from an option emitted at time t is $max_i\{ y_i – e_t , 0\}$. Since the manager receives a grant of options in each period until T–1 , the CEO now chooses his investments so as to maximize the following expression:

$$\sum_{t=1}^{T-1}\left[\left(\max_{i}(0, y_i - e_t)\right)\right] \text{ with } t < i \leq T \tag{1}$$

Feltham and Wu (2001) showed that the value of an option increases monotonically with stock price variance. Under risk neutrality, it is thus easy to see that when compensated through stock options, the CEO will always prefer the riskier investment as long as the two investments have equal expected value. Smith and Stulz (1985) also showed that stock-options may induce risk-averse managers to choose investments with higher volatility. It is however far from clear that this result will carry over to our case, where the investment with a higher volatility is also inferior in terms of expected value. Indeed, Ross (2004) showed that this may not hold for a risk-averse executive. We have already seen that under stock compensation risk neutral executives will never take the HV investment since it is inferior in terms of expected value. Given that it also holds the higher risk, as measured by its volatility, this must be even more true under the assumption of risk aversion under expected utility theory. We thus derive the following hypothesis:

H1: Executives compensated through company stock will never take the high volatility investment.

While executives compensated through options are predicted to be more risk seeking, it is not quite clear to what extent this result will hold when the high volatility investment is inferior in terms of expected value:

> **H2**: When compensated through options, executives will invest into the HV investment at least in some cases; this also means that **a)** executives take more risks when compensated through options than when compensated through stock; and **b)** the extent of risk taking under option compensation will *decrease* in the expected value difference between the two investments.

3. The Experiment

3.1 Experimental Design

Subjects. 96 subjects were recruited from a list of experimental subjects maintained at GATE, University of Lyon, France, using the ORSEE software (Greiner, 2004). Groups of six subjects needed to be formed, so that all sessions were run with either 12 or 18 subjects each. Subjects had an average age of 22 years, and 55% of subjects were female. 63% were studying economics or business management, 31% mathematics or engineering and the rest is not specified.

Main Task. In the main part of the experiment, groups of six subjects are formed. The composition of the groups is kept fixed for the 15 periods, and subjects do not know whom they are matched with. At the outset of the experiment, each group member is assigned the role of CEO of one company. In their function of CEO of a company, subjects are confronted with a sequence of investment decisions over 15 periods. In each period, the CEO decides between two investment opportunities into which to invest the total stock of company assets (screenshots in appendix A). The initial stock value of the company is €100 ($150) for everyone. The final value of the company will be determined by the outcome of the 15 investment decisions[1]. At the same time, each group member also acts as shareholder in the five other companies managed by the five other subjects in her group. The shareholder role is a passive role, in the sense that it does not require any action on the part for the subject. However, it contributes towards final payoffs in the following way. Each subject is given one share with the initial value of €1 ($1.50) in each of the other five companies in her group. She is then paid the final value of that share (total company value divided by100) at the end of the 15 periods. Each CEO observes only the performance of her own company for the 15

[1]Please note that any change in share prices in our experimental model are generated purely by changes in the underlying value of the company assets as determined by investment outcomes—there is no market for shares.

periods of the experiment. The experiment was conducted using the REGATE software (Zeiliger, 2000).

Investment Decisions. In each period, the CEO has to choose between two investment opportunities in which to invest total company assets. The investment opportunities (*prospects*) are described in terms of percentage increases or decreases of the company's value. Investments are displayed graphically by means of pie-charts representing the probabilities of winning and losing in addition to a verbal description. The choice is always between a high volatility (*HV*) and a low volatility (*LV*) prospect. The LV prospect always offers a higher expected value than the HV prospect, so that any risk taking observed is excessive from the point of view of the company or the shareholders by definition, inasmuch as it delivers a lower expected value. Indeed, differences in expected value were such that consistently investing in the LV option would yield an expected final company value that was almost 30 percentage points higher than the one obtainable by consistently investing into the HV option. In the initial instructions, subjects were given a graphical overview of the general characteristics of the two investments as well as an example representing a choice between two 'typical investments'. This graphical display, as well as the instructions and a table showing the parameters of all prospect pairs can be found in the appendix.

Stock-Option Compensation. The stock-option treatment is our baseline treatment. Each CEO obtains five stock-options in each period, which are emitted at-the-money, i.e. giving the right to buy company stock at the current stock value. For example, the five options granted before period 1 investment decisions are made give each the right to buy one share of the company at €1 ($1.50). The options get vested in the subsequent period and remain exercisable until the end of the game, so that they can be 'cashed' at any time. While in reality the options give right to buy company stock which can then be either sold or kept, this decision was unified for simplicity. That is, exercising options in the experiment means buying stock and reselling it immediately, thus realizing the difference between current stock value and the exercise price of the option. This process seems to closely mimic real-world practices of "cashless exercise" (Heath, Huddart, & Lang, 1999). Thus, in every period after the first, the CEO is called upon to decide whether to cash her options after the results of the investment have become known (separately for options emitted in different periods). She will then obtain the new options and decide which investment to take for the subsequent period.

Stock-Ownership Plan. In the stock-ownership condition subjects obtain an initial endowment of

10% of the company stock, corresponding to an initial value of €10 ($15). At the end of the 15 periods, they are paid the final value of their shares. They cannot sell their stock before the end of the 15 periods. Their payment structure thus coincides with the one of shareholders, who also obtain the value of their shares at the end of the 15 periods. The compensation parameters were designed in such a way that the total amount to be earned on average should be roughly equal to the compensation in the stock-option condition (see results sections for a discussion).

Risk attitudes. Before the main part of the experiment described above, detailed risk attitudes were elicited. A detailed overview of the methodology and results will be given below.

3.2 Risk taking and company performance under alternative compensation regimes

As hypothesized, executives take risks that are excessive from the point of view of shareholders when compensated through stock-options. This is also reflected in company performance. Figure 1 shows the development of mean stock values by compensation type. It can clearly be seen that the mean stock value of companies managed by CEOs compensated through stock outperforms companies managed by CEOs compensated through stock-options. Indeed, the mean final value of companies managed by CEOs compensated through stock is over 10 percentage points higher than the mean final value of companies managed by CEOs compensated through options.

Figure 1: Average stock evolution in the option (OP) versus stock ownership (ST) treatment over the 15 periods.

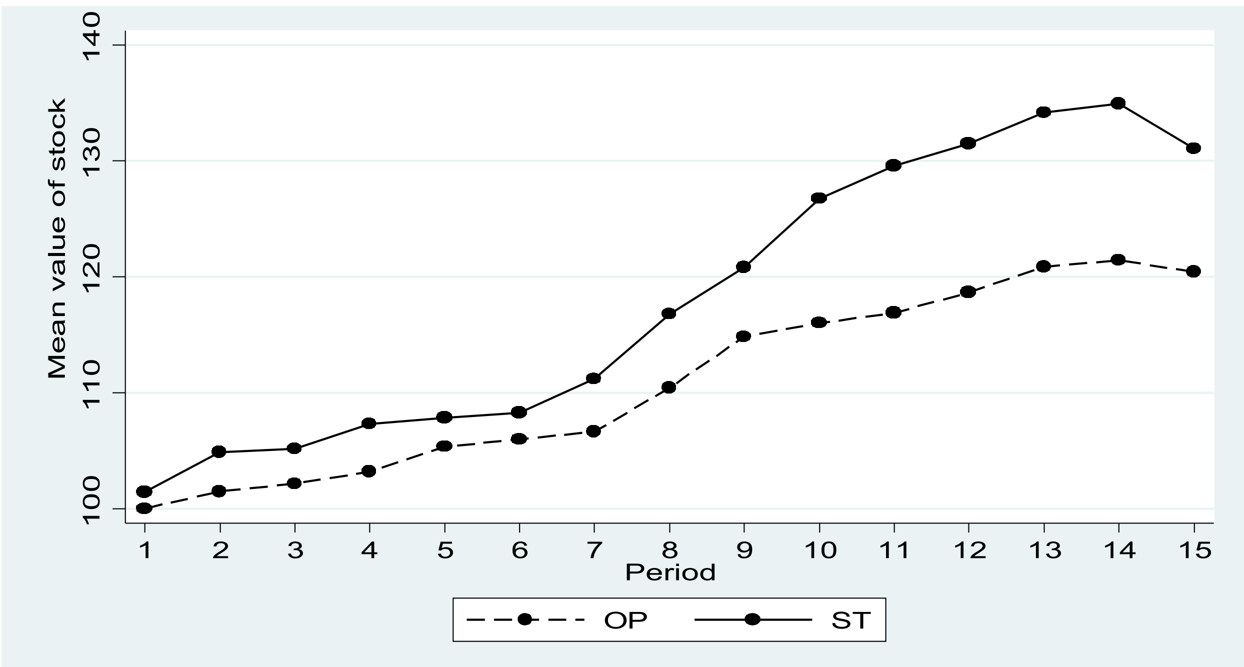
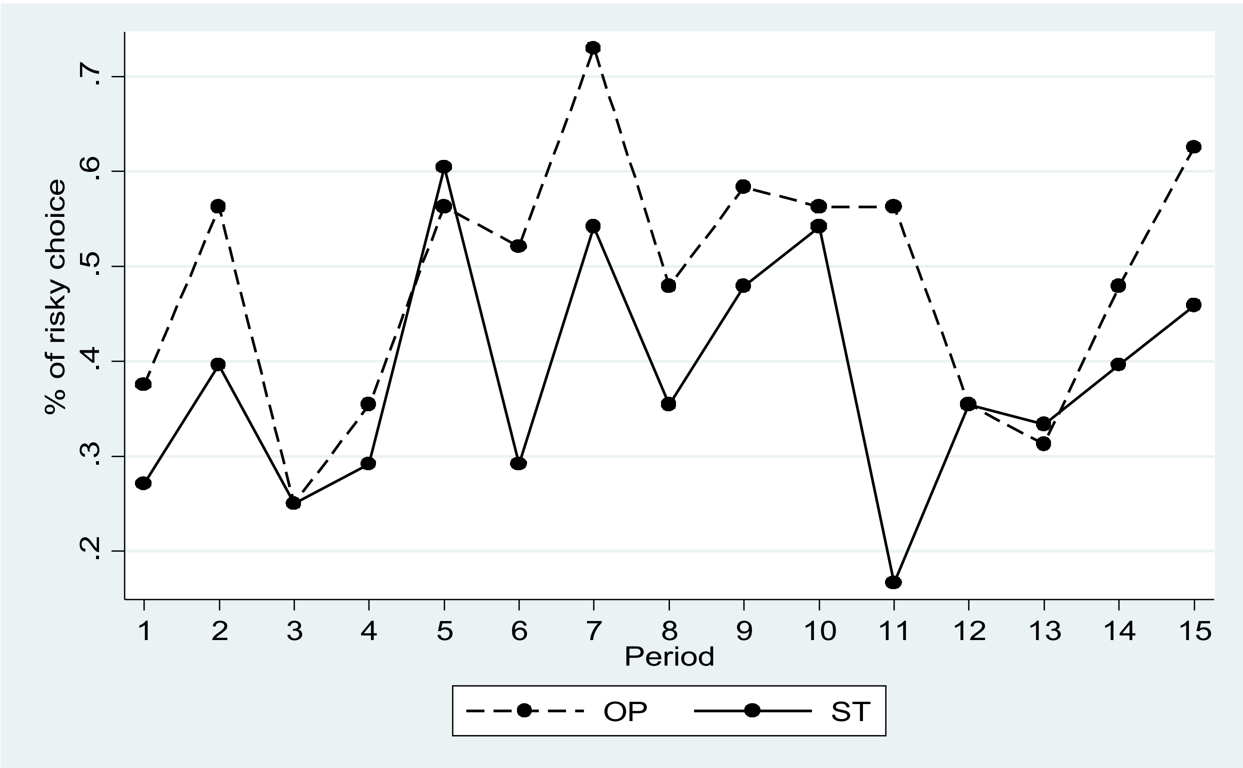


Figure 2 summarizes choice behavior over the 15 investment periods. Subjects choose the inferior high volatility investment quite often when compensated through options as predicted by hypothesis 2 (on average 48.8% of the time). They can also be seen to take significantly less risk on average when they hold stock in the company they manage compared to when they are compensated through options. Nevertheless, subjects compensated through stock still take significant amounts of risk (38.2% of the time on average), thus rejecting the prediction of zero risk taking put forth in hypothesis 1. Even from these first descriptive results, we can thus already conclude that hypotheses 2 is supported by the data, while hypothesis 1 is definitely rejected.

Fig. 2. Average choice of HV investment in the option treatment (OP) and the stock ownership treatment (ST)



3.3 Regression analysis of overall results: drivers of choice

Table 1 shows the results from a random effects Probit model regressing the choice of the HV investment on dummy variables indicating the treatments and a number of other variables. All specifications include period dummies as well as demographic variables such as age, gender and whether the participant is studying economics or business administration. In specification (1), we simply look at the effect of our main treatment variable—whether executives are compensated through options or stock. In addition, we include the difference in expected value between the LV and the HV investments. In specification (2), we add several measures of two other potentially important drivers of choice—past choices and general company performance. In order to investigate the possibility of path dependency or simply the effect of past events, we add the stock-value in the previous period as well as the growth rate of the stock value resulting from the last investment. We also add information on whether the participant chose a risky investment in the preceding period.

Table 1: Drivers of choice (Random-effects Probit model)

Dep. Variable: choice of the risky investment	(1)	(2)
Stock-ownership	–0.382** (0.148)	–0.426** (0.166)
Difference in expected value	–0.302** (0.118)	–0.289** (0.119)
Previous period stock value		–0.034 (0.165)
Growth rate		–0.008** (0.004)
Choice of risky in previous period		–0.321*** (0.092)
Gender (male=1)	0.026 (0.148)	–0.004 (0.166)
Econ/business studies	–0.261* (0.159)	–0.298* (0.178)
Constant	0.291 (0.449)	1.576*** (0.575)
Period effects	YES	YES
Nb observations	1440 (96 subjects)	1344 (96 subjects)
LL	–870	–811

Note: *** significant at the 1% level; ** at the 5% level and * at the 10% level. Standard errors in parentheses.

The compensation through stock instead of options significantly reduces risk taking by executives—an effect that is very stable across all specifications. This confirms hypothesis 2a. The fact that differences in expected value (actually: expected stock-value changes) are highly significant throughout goes to show that subjects carefully examine the parameters of the investment choices when making a decision. It also seems worth mentioning that the effect of the difference in expected value appears much more important in the stock-ownership condition than in the option condition. Indeed, it is highly significant in the former ($p<0.01$), while not significant in the latter ($p>0.1$), thus falsifying hypothesis 2b. The coefficient is almost twice as large for stock-owners (χ^2=6.78, p=0.033, Chow test). This makes indeed sense if one considers that the aim of maximizing own revenue is best achieved through expected value maximization if one is compensated through actual stock, while income in the option condition depends on stock-value change rather than expected value. It also provides an additional indication that when risk taking occurs in the stock-ownership condition it does so mostly for prospect pairs that are close in terms of expected value, and that it is thus relatively less harmful to shareholders than the more erratic risk-seeking embarked upon by executives compensated through options.

As to the general population variables, there is no main effect of gender or age. Interestingly however, field of study has a significant effect. Economics or business management students take less risk than the other subjects. In order to understand this finding better, we need to look at the effect for different compensation schemes in isolation. We find that economics and business students take significantly less risks than other subjects in the stock-ownership conditions ($p<0.01$). When compensated through stock options on the other hand, they take slightly more risks than other subjects (ns). This means that in a way they are better at maximizing their own payoff, which is linked to stock value in the stock-ownership conditions, but not in the stock-option conditions.

Finally, there remain to be discussed the effects of the growth rate and of a risky choice in the previous period. Both positive growth and a risky choice reduce risk seeking by executives. Underlying these effects are however complex interaction effects between compensation scheme, choice, outcome of the choice, and several other factors such as individual risk attitudes that we have not yet introduced. We thus postpone a discussion of those results to a later point, since they cannot be explained based on the simple model put forth above.

3.4 Discussion

Options are often hailed as the counterbalancing solution to undesirable risk aversion on the side of executives. Such an argument fundamentally relies on an assumption of uniform risk attitudes across the probability and outcome spaces. From our simple model developed above, we have seen that expected utility theory with concave utility, on which such predictions are usually based, predicts zero choices of the high volatility investment under stock compensation. Indeed, given that our high volatility investments do always have inferior expected value, even risk neutral executives should always choose the low volatility investment—something that at 38% of choices for the high volatility investment is clearly contradicted by our data.

This begs the question of what may lie behind such risk taking on the side of executives compensated through linear incentive contracts. Expected utility theory could only explain the data assuming that at least 38% of subjects were substantially risk seeking, i.e. displayed a strongly convex utility function, and the latter were responsible for all the choices of the HV investments (i.e., risk seekers would consistently choose HV and risk averters would consistently choose the LV investment). As we will discuss in more detail below, this explanation is not supported by our data. Indeed, even subjects who display risk aversion for gains, i.e. a concave utility function under expected utility theory, choose the HV investment when compensated through stock about 35% of the time. This fundamentally contradicts the hypothesis that all risk seeking in the stock treatment is driven by risk seekers in the expected utility sense, thus indicating that expected utility theory cannot account for the choices we observe.

A different hypothesis is the one that all choices of the inferior high volatility investment in the stock ownership condition are due to error, and thus reflect pure noise. While some choices, especially in the initial periods, may indeed be due to noise, such an explanation seems far-fetched as a whole. Subjects had to answer detailed questions about the functioning of the game and the calculation of their payoffs before the main part of the experiment. Only once they could answer all questions correctly were they allowed to participate. Also, subjects obtained feedback about the performance of their investment after each period, so that initial errors may be expected to quickly disappear.

This leaves us with one more possibility. Modern descriptive theories of decision making under risk indicate that risk attitudes are not generally constant, but rather depend on probability levels, reference points, or aspiration levels. Indeed, people have been found to be more risk seeking when they find themselves below a reference point or aspiration level (Abdellaoui, 2000; Diecidue & van de Ven, 2008). Also, non-linear probability weights as predicted by prospect theory may distort choices between the high volatility investment—in which the small probability of a large gain may be overweighted at the same time as the large probability of a loss is underweighted —and the low probability investment—in which the medium level probabilities are likely to be weighted close to linearity. Fortunately, our data allow us to test for this explanation. We thus proceed by expanding our previous model and applying prospect theory to it, thus deriving predictions that we can test on the data.

4. Allowing for Richer Risk Attitudes

4.1 Expanding the Model

We adopt a purely behavioral, and hence theory-neutral, definition of risk aversion. An agent is defined as risk averse whenever she weakly prefers the expected value of a prospect over the prospect itself. Similarly, she is defined as risk seeking whenever she weakly prefers the prospect over its mathematical expectation. Finally, she will be risk neutral if she is both risk averse and risk seeking (Wakker, 2010). This definition will allow us to adopt prospect theory as a descriptive theory of choice (Kahneman & Tversky, 1979)[2]. Prospect theory is descriptively superior to expected utility theory (Abdellaoui, 2000; Bleichrodt, Pinto, & Wakker, 2001), and it is increasingly used to explain issues in finance that were previously considered paradoxical (e.g., Bernartzi & Thaler, 1995; Fellner & Sutter, 2009; Gneezy & Potters, 1997). It has been found to hold not only for students but also for the general population (Booij, van Praag, & van de Kuilen, 2010) and influence the behavior of professional traders (Haigh & List, 2005) and executives (List & Mason, 2010). Furthermore, since prospect theory is more general then expected utility theory, the latter can be derived from it as a special case[3]. Finally, since we have measured our subjects' risk attitudes, we can say that a majority of subjects do indeed display the behavioral patterns predicted by prospect theory (see below).

One of the most important innovations of prospect theory is reference dependence—the idea that the evaluation of a given prospect or outcome depends on a reference point adopted by a subject. Reference dependence may give rise to different risk attitudes for gains versus losses as well as to loss aversion, a phenomenon by which people attribute more weight to losses than to monetarily equivalent gains which is thought to be the strongest component of risk aversion (Köbberling & Wakker, 2005). We will designate probability weighting for gains by w^+, and probability weighting for losses by w^-. $U(X)$ is taken to be utility over monetary gains X, and $U(-X) = -\lambda * U(X)$ is the utility over monetary losses, where λ is the loss aversion parameter. We will also designate gain percentages by α and loss percentages by β, so that for instance a gain in share value from a LV investment at time i can be written as $\alpha_{LV} * y_i$.

Let us again start with the simpler case of compensation through company stock. The problem is identical for all periods by design, so that we can look at one period in isolation. Assuming that the current stock value or status quo acts as a reference point, a CEO will thus choose the LV investment whenever

$$w^+(p_{LV}) * U(\alpha_{LV} * y_i) - \lambda * w^-(1 - p_{LV}) * U(\beta_{LV} * y_i) > w^+(p_{HV}) * U(\alpha_{HV} * y_i) - \lambda * w^-(1 - p_{HV}) * U(\beta_{HV} * y_i), \qquad (2)$$

where p represents the probability of a successful investment. This leads us the formulation of the following hypothesis:

[2] Given that we use only two-outcome prospects, we need not worry about rank dependence for outcomes.

[3] This is true in a technical sense, since expected utility theory can be derived from prospect theory by setting the loss aversion parameter equal to one and by assuming linear probability weights. From a more general scientific point of view this statement is however more problematic, as EUT makes other general assumptions that are incompatible with the worldview espoused in the prospect theory paradigm (see Kuhn, 1962, for a general discussion of conflicting research paradigms).

H3: Risk seeking will be observed whenever **a)** the share price is short of some reference point or aspiration level[4]; **b)** subjects exhibit strong probability weighting, such that the generally smaller probabilities of winning in the HV investment are overweighted; and **c)** subjects are relatively low in loss aversion*;*

We now move to the conceptually more interesting case of stock-option compensation. Because of reference dependence, we now need to explicitly take into account the asset position of the CEO. We thus start by looking at the problem in period zero or whenever all previously emitted stock-options have been sold, when a CEO holds only stock-options which are at-the-money. A CEO will now choose the HV investment over the LV investment if and only if

$$w^{+}(p_{HV})*U(\alpha_{HV}*y_i) > w^{+}(p_{LV})*U(\alpha_{LV}*y_i) \qquad (3)$$

This derives from the fact that while any increase in stock value can be cashed in, decreases in share value do not result in monetary losses since options need not be exercised. Although there may still be a loss in future earning potential given a stronger decrease in share price from a HV investment, this effect is likely to be secondary and the attention will be mostly focused on the gain side of the prospects. This means that the HV prospect will be chosen more often than in the situation depicted in equation 2. Moreover, choices of the HV investment will be reinforced by commonly found overweighting of small probabilities (Abdellaoui *et al.*, 2010; Wu & Gonzalez, 1996), given that the probability of a success is generally lower in the HV investment than in the LV investment.

Let us now take the case in which in addition to the options just emitted, the CEO holds one additional option bundle which is either in-the-money or out-of-the-money. Since one of the option bundles (the one just emitted) will always be at-the-money, equation 3 will still be relevant for the decision. In addition, however, for options that are in-the-money there is now the consideration that any currently existing value of the other option bundle, y_i-e_t, may be lost (either completely or in part, depending on the value of β_{HV}). Loss aversion over accumulated value will thus work against the risk-seeking tendency produced by newly emitted options. If on the other hand the additional option bundle is out-of-the-money, this will create additional incentives for risk seeking in order to push the share price above the exercising value of the out-of-the-money options. The exercise price of that bundle will thus act as an aspiration level (Carpenter, 2000; Diecidue & van de Ven, 2008). This risk-seeking tendency is further reinforced by the fact that no losses can be felt for options that are at- or out-of-the-money, so that loss aversion will not play a role for the decision. This intuition

[4] A discussion of what reference point may be appropriate will be provided in the results section below.

leads us to the formulation of the following hypothesis:

> **H4**: Under stock-option compensation, executives will display a propensity for taking risks that are suboptimal for shareholders since they are sheltered from losses and look mainly at the gain part; **a)** the extent of this risk taking will depend on the options held at the time of the decision so that the higher the value $\Sigma_t(y_i-e_t)$ of options held, the less likely subjects will be to choose the HV investment; more precisely **b)** subjects will be particularly risk seeking if all the options held at the moment of the decision are out-of-the-money; and **c)** subjects will be more averse to risks if all options currently held are in-the-money; also **d)** other things being equal, subjects who tend to overweight small probabilities will take more risks; and finally, **e)** the more loss averse subjects are, the sooner they will exercise their options.

4.2 Risk attitudes: overview

We used the method of Abdellaoui, Bleichrodt, & L'Haridon (2008), altering it only sightly to speed up the process (see instructions in appendix D), to elicit detailed risk attitudes. We elicited six certainty equivalents for pure gain prospects, six for pure loss prospects, and one for a mixed prospect. This allows us to derive utility functions over relevant amounts, which together with the estimation of probability weighting functions for gains and losses allow for the precise estimation of loss aversion (Abdellaoui*,* Bleichrodt, & Paraschiv, 2007; Schmidt & Zank, 2005). This was done before any treatment manipulations were introduced, so that the elicitation procedure was the same for all subjects. While one choice was selected for real pay in each domain (gains, losses, and mixed gambles), no information on payoffs was given until the very end of the experiment to avoid income effects. This part of the experiment lasted approximately 20 minutes.

Table 2 : Classification of subjects in terms of risk attitude

		LOSSES			
		Risk averse	Risk seeking	Mixed	Total
	Risk averse	18	24	10	52
GAINS	Risk seeking	5	15	6	26
	Mixed	4	10	4	18
	Total	27	49	20	96

Following Abdellaoui *et al.* (2008), we classified a subject as risk averse (seeking) within each domain, if she was risk averse (seeking) for at least 4 out of 6 prospects in said domain. If a subject had exactly three risk averse and three risk seeking answers in one domain, then she was classified in the mixed category. As can be seen from table 2, most of our 96 experimental subjects cannot be classified as universally risk averse or risk seeking. Indeed, only 18 out of 96 subjects (19%) conform to the traditional assumption of global risk aversion! The majority pattern is one of risk aversion for gains (54%) and risk seeking for losses (51%), and the combination of the two is also the modal pattern at the individual level. The average loss aversion coefficient was 1.94.

Beyond the general overview provided above, we can take a closer look at probability weighting and utility functions, both at the aggregate and at the individual level. Figure 5a and 5b represent the average probability weighting function and utility function respectively. We find the typical patterns predicted by prospect theory, with overweighting of small probabilities, underweighting of large probabilities, concave utility for gains and convex utility for losses, as well as loss aversion. Estimating the simple parametric functions introduced by Tversky & Kahnemann (1992), we find that utility for gains is indeed significantly different from linearity and concave (z = –8.697, p=0.000; one-sample median test), and utility for losses significantly different from linearity and convex (z = –10.009, p=0.000). Also, probability weighting is significantly different from linearity for both gains (z=10.800, p=0.000) and losses (z=10.773, p=0.000).

Fig. 5a: Average probability weighting function for gains (similar for losses)

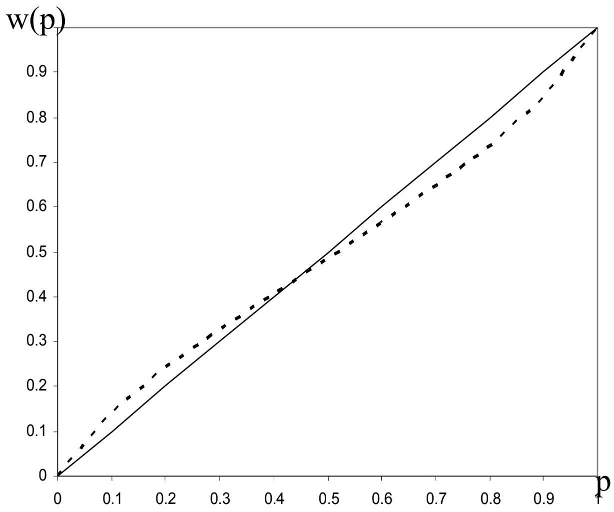
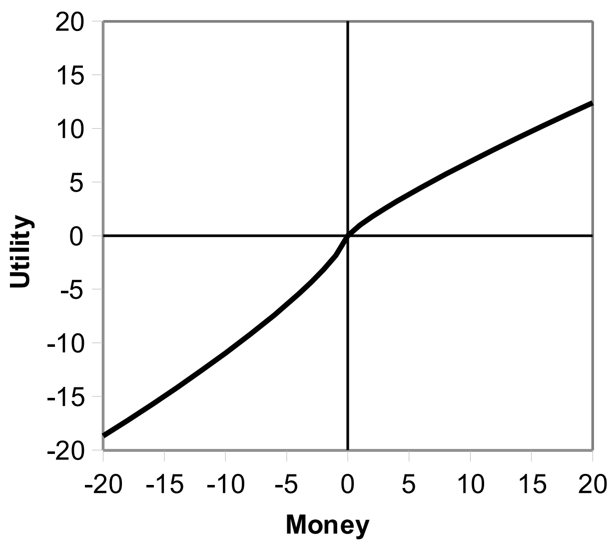
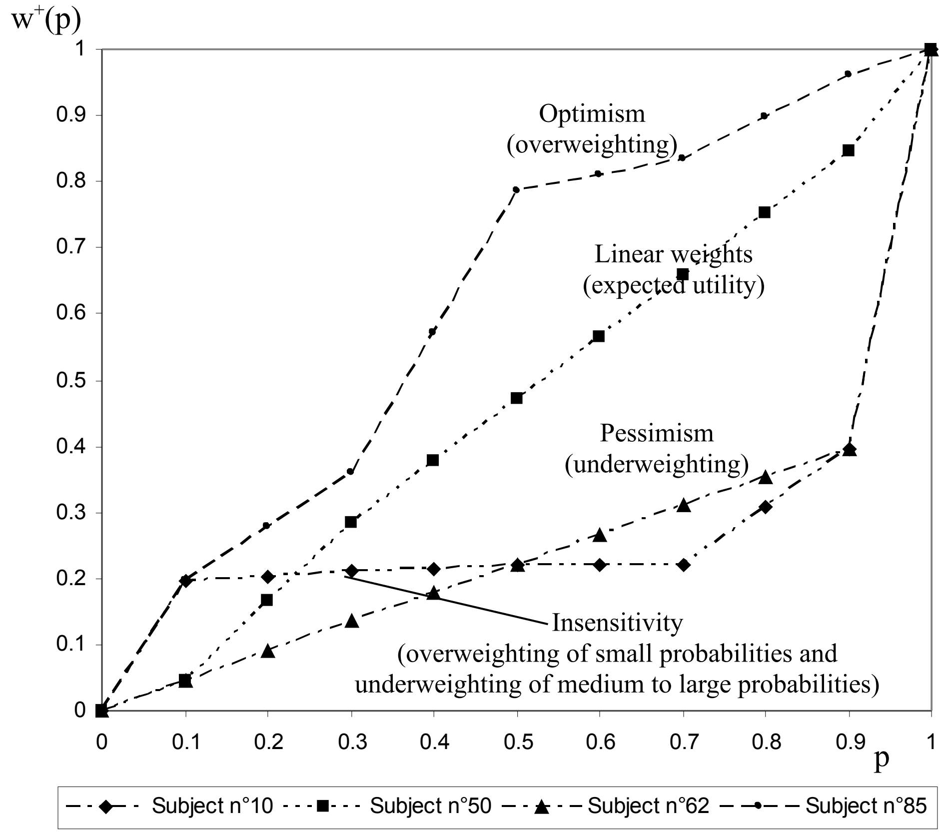


Fig. 5b: Average utility function



More interesting in the present context are however representations at the individual level. Figure 6 shows some typical non-parametric probability weighting functions at the individual level for gains (typical functions for losses are similar). Subject number 50 can be seen to have (approximately) linear probability weighting. Subjects 85 is optimistic, overweighting probabilities throughout, whereas subject 62 is pessimistic, underweighting probabilities throughout. Subject 10 on the other hand displays the typical inverse-S pattern that is found to be prevalent at the aggregate level: overweighting of small probabilities, probabilistic insensitivity for the medium range, and hence underweighting of medium to large probabilities. For a more thorough discussion of such attitudes at the individual level and how to classify them, see Abdellaoui, Baillon, Placido, & Wakker (2010).

Fig. 6: typical probability weighting functions at the individual level, non-parametric



4.3 Regression analysis of risk attitudes

We have now seen that risk attitudes in our sample are typically not well described by expected utility theory, and tend to rather follow the pattern predicted by prospect theory. At this point it remains to be seen whether the individual risk parameters help predicting choices between the investments in the main task according to the hypotheses derived above. In order to test hypothesis 3, we look at some possible reference points, loss aversion, and at the overweighting of small probabilities and the underweighting of large probabilities.

Table 3 shows the results of a random effects Probit regression for the stock ownership condition. As already anticipated above, differences in expected value play an important role, with choices of the HV investment diminishing as said difference increases. We next look at potential reference points. One problem with reference points is that the true reference points of subjects are generally unknown, which holds especially true in a dynamic environment such as this one. We follow Baucells, Weber, & Welfens (2011) in assuming that a combination of past values may act as such a reference point. Since we cannot directly estimate the reference point as they do, we use a simple average of past stock prices. The effect of that reference point can be seen to be highly significant in the regression. Indeed, if the share price plunges below the past average price, risk seeking increases markedly. This confirms our hypothesis 3a.

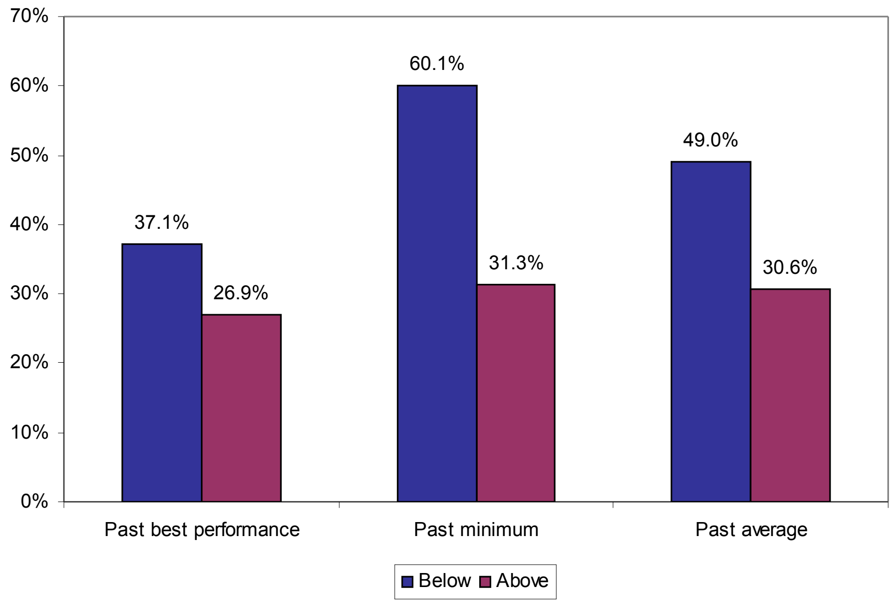
Table 3: Risk attitudes in the stock-ownership condition (random-effect probit model)

Dep. Variable: choice of the risky investment	**(1)**	**(2)**
Difference in expected value	–0.370** (0.169)	–0.408** (0.169)
Stock value	0.178 (0.227)	0.155 (0.221)
Stock below the past average	0.443*** (0.143)	0.452*** (0.142)
Overweighting of small probabilities (CE/EV|p=0.1)		0.598*** (0.155)
Underweighting of large probabilities (1–CE/EV|p=0.7)		–0.292 (0.270)
Loss aversion		0.007 (0.032)
Constant	0.643 (0.583)	0.877 (0.542)
Nb observations	672 (48 subjects)	672 (48 subjects)
LL	–389	–381

Note: All specifications include period effects and control for gender, age and field of study.*** significant at the 1% level; ** at the 5% level and * at the 10% level. Standard errors in parentheses.

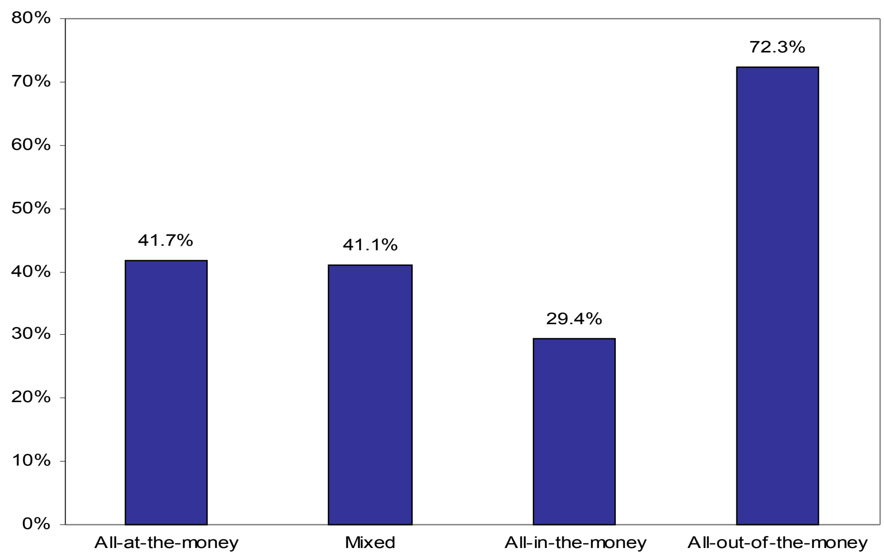
Obviously, such a linear combination of past prices is not the only conceivable reference point. Current share price per se can be seen from the regression not to play a role. We have entered no further reference points in the regression because of multi-collinearity issues with the average reported. If instead of the average level we use other salient reference points, we also find strong effects, with risk seeking increasing markedly for instance when the price plunges below the minimum price observed in the past ($p<0.01$) or below the best performance in the past ($p<0.10$). Figure 7 represents the effect of these reference points graphically. It directly compares the level of risk taking when current share prices are below the different reference points to the level of risk seeking observed when the share prices lie above those same reference points. The differences are indeed remarkable, showing that the reference points play an important part in explaining choice behavior.

Figure 7: Percentage of risky choices by reference point, stock compensation



Beyond and in addition to reference points, we hypothesized that probability weighting and loss aversion may also influence choices. From specification 2 of the regression we can see that subjects who overweigh small probabilities do indeed take the HV investment significantly more often. This confirms our hypothesis 3b. Finally, loss aversion does not explain a significant proportion of variance, so that there is no support in the data for hypothesis 3c.

Fig. 8: percentage of risky choices conditional on asset situation, option compensation



We next take a closer look at hypothesis 4. Figure 8 displays levels of choices of the HV investment in the option treatment separated by asset position. The basic level of risk taking when all options are at-the-money is relatively high at 42%, which is similar to the level of risk taking observed when executives hold a mixed bundle containing both options that are in- and out-of-the-money. Choices of the HV investment are reduced to 29% when CEOs hold options that are in-the-money. When all the options held are out-of-the-money, however, subjects choose the HV investment fully 72% of the time.

Table 4: Risk attitudes in the stock-options condition (random-effect Probit model)

Dep. Variable: choice of the risky investment	**(1)**	**(2)**	**(3)**
Difference in expected value	–0.197 (0.165)	–0.199 (0.165)	–0.215 (0.168)
Stock value	0.331 (0.245)	0.321 (0.244)	0.390 (0.272)
Total value of options held	–0.197*** (0.066)	–0.197*** (0.066)	–0.032 (0.069)
All options in-the-money			–0.454*** (0.174)
All options out-the-money			0.718*** (0.153)
All options at-the-money			–0.416 (0.255)
Overweighting of small probabilities (CE/EV|p=0.1)		0.173 (0.171)	0.129 (0.172)
Underweighting of large probabilities (1–CE/EV|p=0.7)		0.098 (0.318)	0.181 (0.321)
Nb observations	672 (48 subjects)	672 (48 subjects)	672 (48 subjects)
LL	–405	–405	–381

Note: All specifications inculde period effects and control for gender, age and field of study.*** significant at the 1% level; ** at the 5% level and * at the 10% level. Standard errors in parentheses.

Table 4 tests hypothesis 4 statistically through a random effects Probit regression. The difference in expected value between the HV and the LV investment now plays no role in explaining choices. It further clearly emerges that risk taking decreases in the total value of options held, thus confirming our hypothesis 4a. To test our hypotheses 4b and 4c, we need to disentangle the options held by the CEO. Regression (3) thus introduces three dummies indicating that all options held (except the bundle just emitted, which is always at-the-money by definition) are in-, at-, or out-of-the-money, with the effect being measured against the forth possible case in which the CEO holds a mix of options, some of which are in- and some out-of-the-money. Holding only options that are in-the-money significantly reduces risk taking. When on the other hand all options held are out-of-the-money, risk taking increases dramatically. This confirms hypotheses 4c and 4b respectively.

This leaves us with probability weighting to be examined. In the regressions reported in table 4 probability weighting is not significant. That is however somewhat misleading, since we have seen above that we would expect it to be important only in cases where all options are at the money, and may expect it to be overwhelmed by reference dependence under different asset positions. When options holdings are either mixed or purely at the money, overweighing of small probabilities indeed increases risk taking as predicted ($p<0.1$). In that case, the underweighting of large probabilities is also marginally significant ($p<0.1$), and negative as predicted.

We next take a look at executives' option selling behavior in order to test hypothesis 4e. Table 5 presents a Probit analysis regressing option selling decisions on a number of potential explanatory variables. We take as dependent variable the selling decision (1 if sold, 0 if kept) for each bundle of five options. Option bundles are thus followed from their emission period through the selling period, and may be included in the regression between 1 and 15 times, depending on when they are emitted and when they are sold. This results in a total of 3275 observations.

Table 5: **Decisions to exercise options**

Dep. Var: exercising option	**(1)**	**(2)**
Loss aversion		0.346*** (0.029)
Potential gain from selling	0.171*** (0.033)	0.149*** (0.034)
Nb options held	0.434*** (0.027)	0.205*** (0.009)
Nb options sold	0.687*** (0.040)	0.337*** (0.013)
Cumulated gains	–0.087*** (0.033)	–0.102*** (0.014)
Peak price	1.377*** (0.219)	1.253*** (0.154)
Stock value (t-1)	1.174*** (0.652)	0.698*** (0.294)
Constant	–36.561*** (4.391)	–18.193* (1.712)
Nb observations	3275	3275
LL	–650	–701

Note: The dependent variable is the decision to exercise options or not. *** significant at the 1% level; ** at the 5% level and * at the 10% level. Standard errors in parentheses. All specifications include period effects and control for gender, age and field of study.

From a normative point of view, people should not exercise options before they expire because the market value of a “live” option exceeds the proceeds from exercise (Heath, Huddart, & Lang, 1999). We find that subjects sell their options on average after holding them for three periods. The main reason for selling stock options are liquidity considerations, which do obviously not apply in our experiment. In addition, stock-options provide subjects with a sure amount in the current period and an uncertain amount of cash in the future. Subjects may thus sell their options too early if they are loss averse, thus exhibiting a sort of myopic loss aversion (Fellner & Sutter, 2009; Gneezy & Potters, 1997). We find a highly significant effect of loss aversion. Loss averse individuals are much more likely to sell their stock in any given period, thus foregoing potential future gains due to their fear of losing already available gains. This confirms our hypothesis 4e.

Reassuringly, the potential gain that can be realized by selling a package of options influences decisions. This goes to show that the overall majority of subjects understood the payoff mechanism quite well. Quite naturally, holding a larger amount of options makes selling them more likely. Furthermore, the number of options already sold also makes it more likely that options will be sold in any given period. The latter finding could be due to several factors, including a general positive trend in stock-price, a different investment strategy, or the perpetuation of an initial selling strategy (e.g. 'sell as soon as a positive gain can be realized').

We also find an income effect for selling (exercising) decisions. Indeed, a higher accumulated income makes it less likely that options are sold in any given period, indicating a higher acceptance of the risk deriving from keeping the options longer-term. This agrees with general findings on income effects in the literature (Lee, 2008; Thaler & Johnson, 1990). We also find a highly significant peak price effect, i.e. subjects are much more likely to sell their options when the current share price is above the highest price observed in the past. This finding is in line with past studies on option exercising decision (Core & Guay, 2001; Heath, Huddart, & Lang, 1999). It has been explained by the fact that, when the share price reaches its peak, it is automatically above the reference point for all individuals when reference points are formed as some kind of combination of past share prices (Baucells, Weber, & Welfens, 2011).

5. Discussion

We find that compensating executives trough options induces risk taking by executives not only when such risk taking is optimal for shareholders or the company, but also when such risk-taking is sub-optimal. While paying executives in restricted company stock reduces such risk seeking, the level of risk seeking that remains is still very high.

The results that significant risk seeking remains even when subjects are compensated through long-term stock ownership plans rather than stock options with short vesting periods is indeed surprising. Linear compensation mechanisms have generally been assumed to result in excessive *risk aversion*, and traditional models based on expected value or expected utility maximization cannot account for these data. On the other hand, we have shown that a prospect-theory-based model explains such choices quite well. Once one takes into account probability weighting and reference points, one can thus explain why there is remaining risk seeking when executives are compensated through stock, as well as being able to predict under what conditions executives compensated through options will be particularly risk-prone.

A bit less surprising, though still important, is the finding that risk taking under compensation though options takes place even when such risk taking is excessive for the shareholders and the company. This finding is indeed driven by two main factors. On the one hand, reference points as described by current asset holdings strongly influence choice behavior, thus inducing risk taking beyond the levels predicted purely by the non-linearity of the incentive instrument. This is nicely shown in our model and later confirmed in the data. On the other hand, we have also seen that differences in expected value do not influence choices under option compensation, thus extending the generality of earlier findings. Obviously, this is also a matter of degree: expected values in our setup are always non-negative, so that extreme cases are excluded. It seems rather clear that by making the HV investment extremely negative in terms of expected value will eventually lead to zero choices of that investment—no matter how high its volatility.

One important criticism that could be brought to our result is that by using relatively low stakes it underestimates risk aversion. We have seen that in our data risk attitude is mostly driven by probability weighting and loss aversion while utility for gains was found to be only slightly concave. Given that under prospect theory risk attitudes are determined by a combination of these three elements, a more extreme shape of the utility function may well counteract the probability weighting we have found to drive results. Notice, however, how the convex utility function in the loss domain may actually increase risk seeking when decisions take place in the loss domain. When decisions take place in the gain domain, a more concave utility function as typically found for higher stakes may well increase risk aversion. Taken together, however, this does not show a clear direction in which decision making might change. Existing studies from the management literature do indeed indicate that the typical pattern of risk attitudes predicted by prospect theory persist for large-scale decisions (Fiegenbaum & Thomas, 1988; Jegers, 1991).

The nature of the compensation scheme is not the only difference between our option and stock-ownership treatments. One characteristic of the stock-ownership plan that seems rather fundamental is the long-term nature of the stock compensation, which is contrasted to the short-term structure of option compensation. In reality, stock-ownership often provides short-term incentives as well, and may in such a case produce investment behavior that is closer to the one observed for options (Bebchuk, Cohen, & Spamann, 2009). Given the main purpose of our study—testing whether the prediction of zero risk tolerance under linear compensation contracts stands the empirical test—a longer time horizon such as the one implemented in our experiment does indeed constitute a stronger test. Any excessive risk taking that we have found can thus be expected to increase under shorter-term compensation structures.

There is however also an opposite case to be made—that increasing the vesting periods of options may reduce risk taking. This however may or may not be true. The evidence from our experiment points in the direction that risk taking under option compensation strongly depends on asset positions. This in turn indicates that risk taking under longer vesting periods may well decrease as long as any options held are in-the-money. If on the other hand they should be out-of-the-money after a decrease in stock prices, longer vesting periods may increase risk seeking even when such risk seeking is sub-optimal for the company and shareholders. The exact effect will thus depend on the specific circumstance and is ultimately an empirical question.

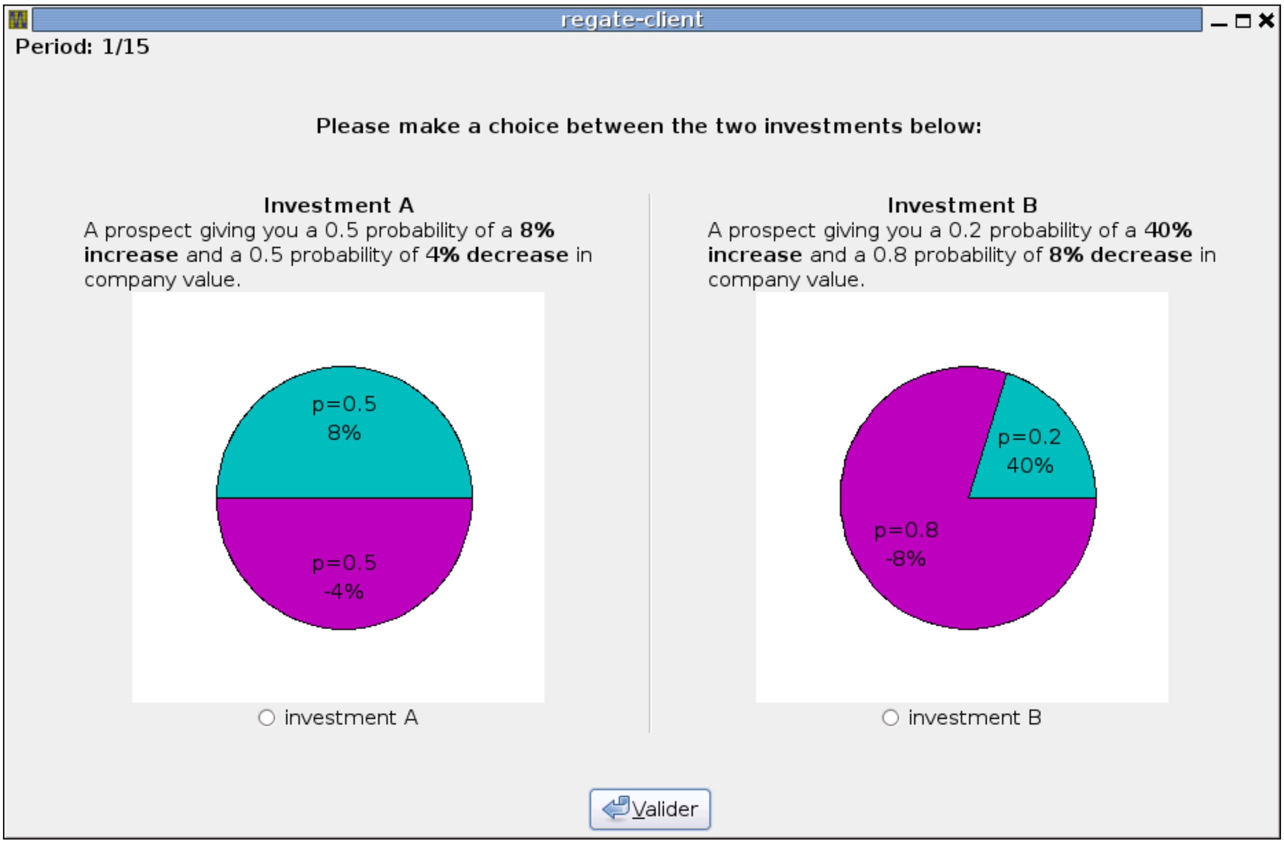
At this point, we also need to address potential subject pool effects. We have already seen in the results section how economic and business students seem to take more rational decisions than others. This may well derive from their better understanding of the issues at hand. It is however often alleged that using students as experimental subjects may reduce the external validity of any results obtained. The fact that the overwhelming proportion of our subjects are economic and business students from French elite schools—and that future CEOs can be expected to be drawn from that pool to a large extent—seems to reduce such concerns. Furthermore, alleged subject pool effects need not always go in the expected direction. For instance, Haigh & List (2005) found that myopic loss aversion is actually *accentuated* by using professional traders instead of students in an experiment—the opposite of what the authors had expected. One could thus argue that having more experience with the kind of decisions subjects are called upon to take in our experiment may if anything accentuate their tendency to increase their own profits, even if this works to the detriment of shareholders.

6. Conclusion

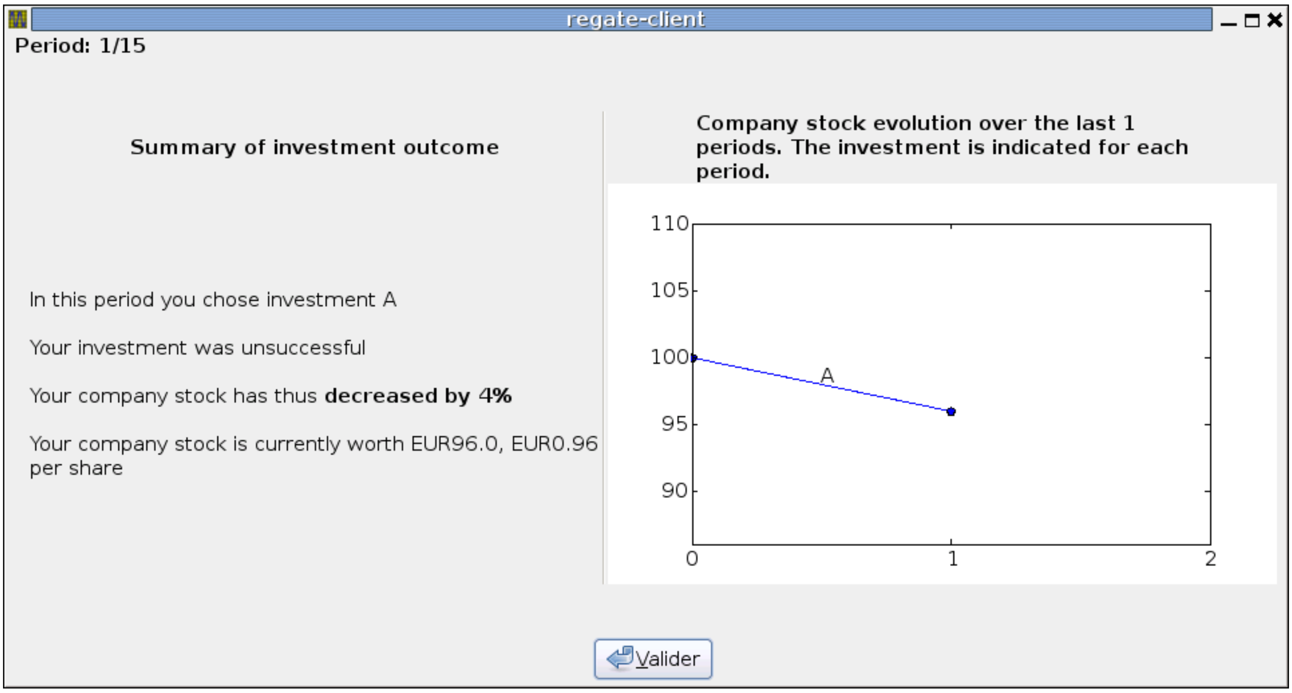
Traditional theories propose to link pay to performance by compensating executives through options rather than company shares, in order to avoid the excessive risk aversion triggered by linear incentive contracts. We found that not only do executives take risks that are excessive from shareholders' point of view when compensated through stock-options, but they do so even when compensated through restricted company stock, even though to a lesser degree. This is explained through a model that abandons the classical agency theory assumption of global risk aversion in favor of a richer, behaviorally founded, model of risk attitudes. Taking into account asset positions as well as compensation mechanisms, we find that risk-taking is strongly influenced by reference points, non-linear probability weighting, and loss aversion. It thus seems at the time to incorporate such richer risk attitudes into incentive theory in order to gain a deeper understanding of the incentive effects of different contract provisions.

Appendix A: Decision Screens, Main Experiment

i) Investment screen



ii) feedback screen



iii) option selling decision (option compensation only)

Appendix B: Instructions main experiment (option payment)

In this part of the experiment you will be asked to take repeated decisions over 15 rounds. You have **two roles** in this part, one as CEO of a company, and one as stockholder in 5 other companies managed by five other people in your group. Groups are randomly formed at the beginning of part 2 and stay the same for all 15 rounds. Just as you are a shareholder in the 5 companies managed by the other 5 people in your group, the other 5 people in your group are shareholders in your company and part of their payoff thus depends on your company's performance.

Please notice that your decisions are **completely anonymous**, and that neither the experimenter nor any of the shareholders in your company (the other 5 people in your group) can trace any decisions or outcomes back to you. As a matter of fact, neither you nor the other people taking part in the experiment will know who of the others in the experiment was in their group of 6.

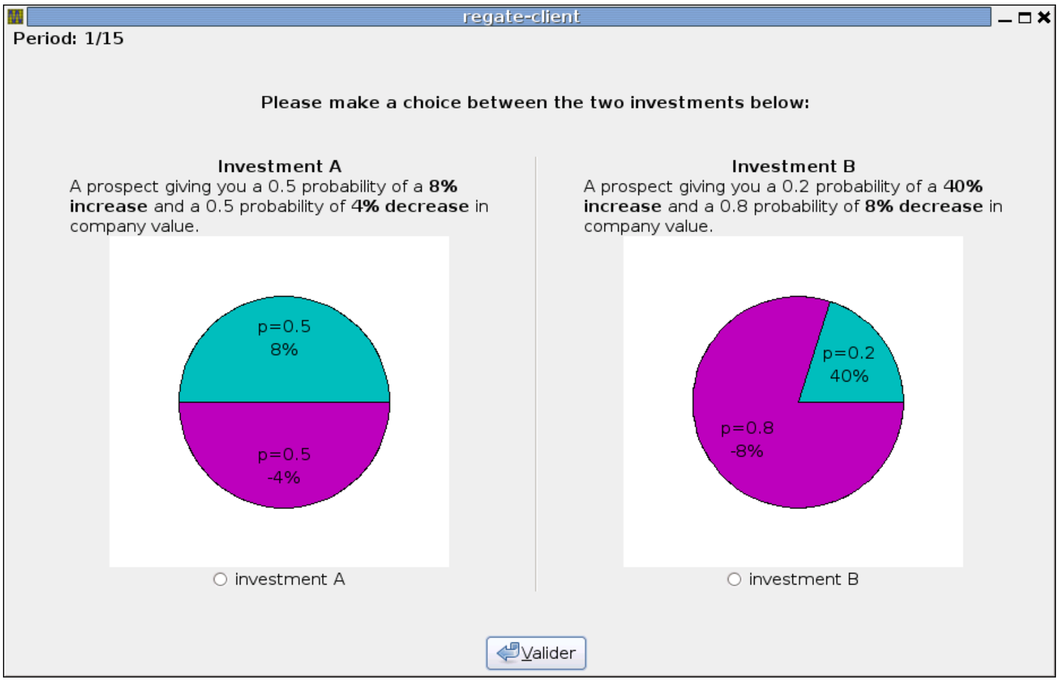
In your function as CEO, you are managing a company. Your company has an initial value of 100 euros, corresponding to 100 shares of the value of 1 euro each. Your main decision will be to choose in each period **which of two investment projects you want to invest the assets of your company in**: investment A or investment B. You will have to make a choice between these two options, and you have to invest the total value of your company in every period. Each investment will be described for each period, and is characterized by its outcomes and its probabilities. Outcomes are given in percentage changes of company value, which can be either positive, negative or zero.

Example:

A typical choice is shown in the screen below. In the example shown, you are called upon to decide between two investments for your company assets:

- *investment A*, which gives you a 50% chance that the company assets will *increase* by 8% and a 50% chance that they will *decrease* by 4%
- *investment B*, which gives you a 20% chance that the company assets will *increase* by 40%, and an 80% chance that the value of your company assets will *decrease* by 8%

Imagine that you are facing the first investment decision (period 1), and that the company you manage is thus worth 100 euros. Imagine now you choose investment A and your investment is successful. Your company is now worth 108 euros, which corresponds to a value of 1.08 euros per share. This will be your starting value for period 2. There are 15 periods of investment in total.



Payoffs:

Contrary to part 1, **all your decisions will now count** towards your final payoff. Your payoffs are determined as follows. Before each investment period, you will obtain **5 stock options** that give you the right to buy company stock in any future period for the exercise price indicated on the option. Options will be emitted at company value and will become vested (that is, cashable) in the subsequent period. You can then decide separately for options obtained in different periods whether you want to: 1) cash the options, thus obtaining the difference between the current stock price and the emission value of the option (times 5 since you have five options); or 2) keep the options and preserve the right to exercise them in a later period.

Example (continued):

Following the example given above, this means that before your first investment decision you have obtained 5 stock options with an exercise price of 1 euro each (the company value divided by 100). Imagine again that you chose option A and that your investment was successful, so that your share value increased to 1.08 euros per share. You will now be asked whether you want to sell your options (*actually*: buy company stock and resell the stock, but the decision is only one and incorporates the two steps) or whether you want to keep the options.

If you decide to sell your options, in the example above you now gain 0.08 euros (8cents) on each of them for a total of 40 cents (the current stock value minus the exercise price for the five shares you can buy). If you decide to keep them, you obtain no money but preserve the right to sell them at a later point. Whatever your decision, at this point 5 new options will be emitted at an emission value of 1.08 euros each and you will start round 2. Once again, you will choose an investment, become feedback on whether the investment was successful or not, and you will again be asked whether you want to exercise your stock options. In case you have not yet sold your period 1 options, you will now be asked separately whether you want to sell your period 1 options and whether you want to sell your period 2 options.

Your Role as Shareholder:

In addition to your role as CEO, you are also a **shareholder in the 5 companies** managed by the other 5 people in your group (just as those other 5 people are shareholders in your company). This is a passive role, inasmuch as it does not require you to take any decisions. However, the shares you hold in the other companies will contribute towards your final payoffs as follows. In each of the 5 companies, you initially hold one share worth 1 euro. At the end of the 15 rounds, you will be paid out the total value of the shares you own in the different companies. For instance, if the final value of company 4 is 103 euros and the final value of company 6 is 187 euros, you will obtain 1.03 euros from your share in company 4, and 1.87 euros from the share you own in company 6 (plus whatever your shares in the other 3 companies are worth).

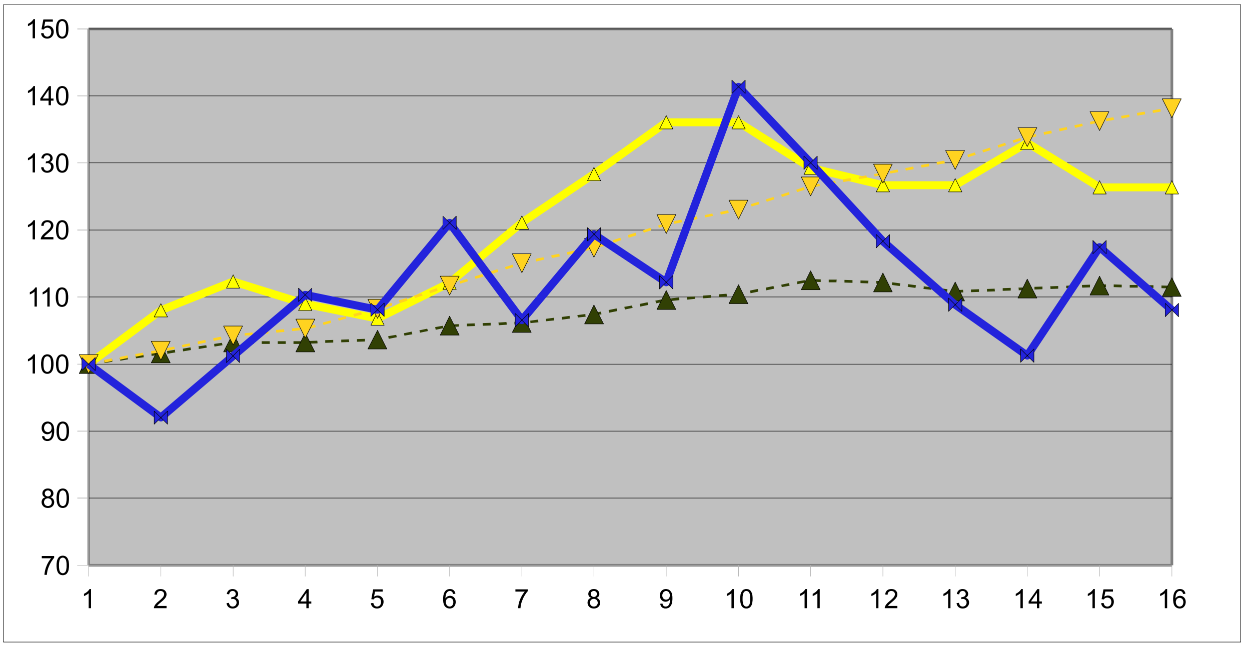
Typical Properties of Investments:

Finally we include a graphical display of the **typical properties of investments A and B**, derived from a simulation of investments with very similar characteristics. Please notice that the changes displayed in the graphs below are not the ones that will obtain in the experiment, but that they represent only random realizations from the same type of investment that have obtained in the past. However, the general trends that are indicated reflect the two types of investment that you will face. This means that the graphical display should not be seen as a substitute for careful considerations of probabilities and outcomes, but only as **an indication of the general average characteristics of the different investment types**.

Graph 1 below displays the evolution of typical investments A and B in 15 periods in the past (thick solid lines, with the light line representing investment A and the dark line representing investment B). Graph 1 also shows the long-term average returns of the two investment types (thin dashed lines, with the light line representing investment A and the dark line representing investment B).

Those average returns are what results from observing investment types A and B over thousands of trials and averaging the outcomes.

Graph 2 shows the same data in a different way. While graph 1 shows the evolution of company stock as you will also see it during the experiment, graph 2 shows absolute percentage changes on the previous period (not taking base values into account). The data are the same as in graph 1, but they are displayed in a different way to show changes period per period.



Graph 1: Solid lines indicate the evolution of investments A and B over 15 periods in the past; the dashed lines indicate long-time trends of the two investment types; light grey lines indicate investment type A, dark grey lines investment type B.

Appendix C: Investment Pairs

	HV prospect		**LV prospect**	
	Prob. (loss, gain)	% change	Prob.(loss, gain)	% change
Pair 1	(0.8, 0.2)	(-8, 40)	(0.5, 0.5)	(-4, 8)
Pair 2	(0.6, 0.4)	(-4, 10)	(0.3, 0.7)	(-2, 4)
Pair 3	(0.6, 0.4)	(-6 ,9)	(0.6, 0.4)	(-1, 7)
Pair 4	(0.9, 0.1)	(-2, 22)	(0.2, 0.8)	(-2, 4)
Pair 5	(0.5, 0.5)	(-8, 12)	(0.3, 0.7)	(-4, 5)
Pair 6	(0.6, 0.4)	(-12 ,19)	(0.5, 0.5)	(-2, 8)
Pair 7	(0.4, 0.6)	(-15 ,12)	(0.5, 0.5)	(-2, 6)
Pair 8	(0.8, 0.2)	(-6, 34)	(0.2, 0.8)	(-6, 6)
Pair 9	(0.7, 0.3)	(-10 ,26)	(0.7, 0.3)	(-0, 6)
Pair 10	(0.5, 0.5)	(-8, 13)	(0.4, 0.6)	(-5, 8)
Pair 11	(0.7, 0.3)	(-9, 20)	(0.5, 0.5)	(-2, 5)
Pair 12	(0.9, 0.1)	(-8, 60)	(0.6, 0.4)	(-0, 4)
Pair 13	(0.8, 0.2)	(-7, 30)	(0.3, 0.7)	(-3, 5)
Pair 14	(0.6, 0.4)	(-10, 16)	(0.6, 0.4)	(-5, 12)
Pair 15	(0.9, 0.1)	(-8, 70)	(0.8, 0.2)	(0, 7)

Appendix D: Instructions Risk Elicitation

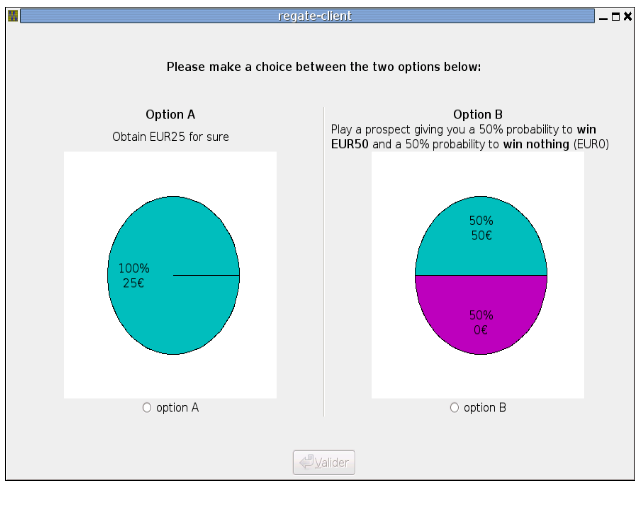
Part 1 of the experiment consists in choices between lotteries. All the choices you make are **completely confidential** and cannot be traced back to you personally. Please consider each decision problem carefully before you indicate your decision, as your final payoff will depend on your choices in addition to chance.

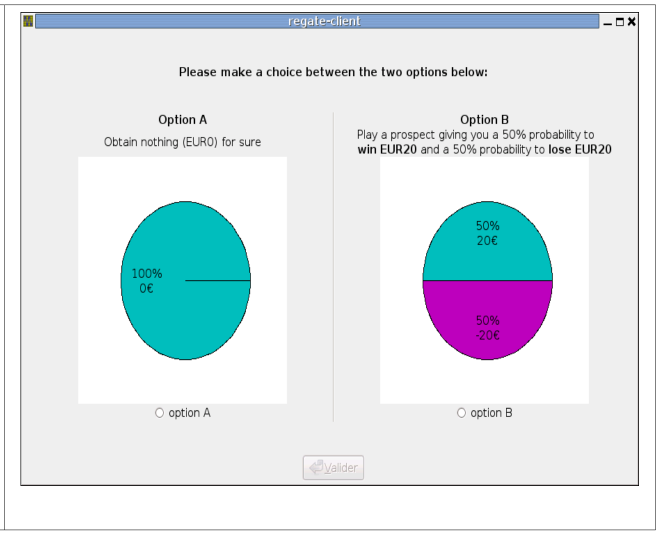
In the choice pairs involved in part 1, you will be called upon to make repeated choices between a sure amount of money and a lottery with two outcomes. As to the outcomes of the lottery, there are three basic types of lotteries: 1) lotteries giving you a certain probability to win an amount of money, and a complementary probability of winning nothing (*pure gain lottery*); 2) lotteries giving you a certain probability to lose an amount of money, and a complementary probability of losing nothing (*pure loss lottery*); and 3) lotteries giving you a probability of winning a certain amount of money and a complementary probability of losing a certain amount of money (*mixed lottery*). All the information necessary for you to take a decision will be displayed on the computer screen.

Given this setup of the lotteries, and given that the parameters of a decision change for each decision problem that is presented to you, it is crucial that you **pay close attention to both outcomes and probabilities**. Also, pay attention to the sign of the outcome as it may be positive or negative! While you can incur losses in this part of the experiment, the payoffs are calibrated in such a way that it is extremely unlikely for you to lose money over the course of the whole experiment.

For pure gain or pure loss lotteries, you will be asked to choose repeatedly between any given lottery and different certain amounts. According to your choices, the certain amount will be adjusted upwards or downwards for the subsequent decision. You will then be asked again to choose between the new certain amount and the lottery. After five choices, you will pass on to the next lottery.

For mixed lotteries, a procedure analogous to the one described above is used. The only difference is that for these lotteries what changes in subsequent iterations is not the sure amount of money (which now stays always at 0), but rather the amount to be lost in the lottery. Below you find an example of a choice for a pure gain lottery and for a mixed lottery.





We next describe how your payoffs for this part of the experiment will be determined. Only some of the choices you make will be randomly drawn and played for real money. While the exact procedure is described in detail below, the most important thing for you to know is that **you will perform best if you make each decision as if it were the only one to be played for real**. In other words, there does not exist any way in which you can outsmart the system by choosing according to some predetermined strategy.

Three choices will be extracted for real play from the lotteries presented to you in part 1—one choice involving a pure gain lottery, one choice involving a mixed lottery, and one choice involving a pure loss lottery. All choices within the given domain have the same probability of being extracted.

Whatever choices are extracted will then be played out at the end of the experiment. If in the choice that is extracted you have chosen the sure amount, that amount will be added to (or subtracted from for loss lotteries) your total payoff. If you have chosen the lottery, a random draw will determine whether you have won or lost, and the corresponding amount will be added or subtracted from your total payoffs.

The payoff will only be determined once the whole experiment is finished. When you are done with the questions in part 1, please wait for the other people in the experiment to finish as well. As soon as everybody has completed the first part, we will proceed to distributing the instructions for part 2.

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