LaRGE

Laboratoire
de Recherche
en Gestion
& Economie

Working Paper

# Working Paper
2009-08

# Testing alternative theories of financial decision making: an experimental study with lottery bonds

**Patrick Roger**

May 2009

**Ecole de Management Strasbourg**
**Pôle Européen de Gestion et d'Economie**
61 avenue de la Forêt Noire
67085 Strasbourg Cedex

**Institut d'Etudes Politiques**
47 avenue de la Forêt Noire
67082 Strasbourg Cedex

http://ifs.u-strasbg.fr/large

UNIVERSITÉ DE STRASBOURG

IFS

# Testing alternative theories of financial decision making: an experimental study with lottery bonds

**Patrick ROGER**

**Strasbourg University**

**LARGE Research Center**

**EM Strasbourg Business School**

**61 avenue de la forêt noire**

**67085 STRASBOURG CEDEX, FRANCE**

**proger@unistra.fr**

**May 2009**

## Abstract

In this article, a simple paper-and-pencil experiment, based on lottery bonds, shows that financial decisions taken by participants are inconsistent with the traditional view of economic agents as risk averse expected utility maximizers. First, our results cast doubt on the relevance of variance as a measure of risk and put to light the importance of skewness in decision making. The decisions taken by participants are consistent with the optimal distortion of beliefs introduced in Brunnemeier and Parker (2005) and Brunnemeier *et al.* (2007). As a by-product of this study, we also illustrate the fact that people use heuristics when they choose numbers at random and have, in general, a poor opinion about the rationality of others.

JEL classification: D03, D81

Keywords: Lottery bonds, optimal beliefs, probability distortion, risk aversion

## Introduction

Lottery bonds are interesting assets to build an experimental study of investment choices and rationality for several reasons. First, these assets exist for more than two centuries in many countries and are, even today, very popular (Miller and Gentry, 1980, Lévy-Ullmann, 1896, Green and Rydqwist, 1997, Ridge and Young, 1998, Guillen and Tschoegl, 2002, Pfiffelmann and Roger, 2005). Second, contrary to the distribution of stock returns which is unknown, the distribution of lottery bond returns is perfectly known. Objective probabilities can be associated to the possible outcomes. Third, most people who never invested in lottery bonds easily understand how payoffs are defined because they bet, at least occasionally, on state lotteries like the lotto game. Fourth, some designs of payoffs introduce a pari-mutuel feature and people have to make assumptions about the rationality of others.

For almost 60 years, economic rationality is a concept most often understood in the framework of expected utility (henceforth EU) theory. Moreover, the utility function is assumed to be concave to take into account risk aversion. As soon as the word *expectation* is used, a probability space with states of nature, events, and at least a probability measure are referred to. Consequently, economic rationality also means that agents obey the rules of probability theory, especially the Bayes rule which states the way beliefs have to be changed when a new information is received (freely or costly)[1]. It then implicitly assumes that agents are able to manage all the information they receive, a maybe complicated task for professionals who receive a continuous information flow from all over the world.

To get a more tractable description of preferences, the "modern" theory of portfolio choice, starting with Markowitz (1952a), depicts investors as agents taking decisions in a mean-variance world. The utility of an investment is then an increasing function of its expected return and a decreasing function of the corresponding variance. It is one of the most simple ways to describe risk aversion. But in another paper published the same year, Markowitz (1952b) himself challenges this simple view, dealing with a question first addressed by Friedman and Savage (1948). The two papers deal with the puzzling fact that many individuals simultaneously buy insurance contracts and (unfair) lottery tickets, a behavior

[1] Rationality and compliance to Bayes rule give rise to the efficient market hypothesis (EMH) which means that prices fully and instantaneously reflect all available information (Fama, 1970).

inconsistent with risk aversion. The two papers refer to ranges of wealth where the utility function is convex to explain this kind of behavior.

Twenty five years later, Kahneman and Tversky (1979) proposed prospect theory which describes the individual behavior by means of a S-shape value function (the equivalent of the utility function) and an inverse S-shape probability weighting function. They base their proposition on multiple experiments which show that people violate the axioms of utility theory on several aspects. First, they value risky prospects by considering gains and losses with respect to a reference point. Second, losses loom larger than gains. Third, agents are risk averse in the domain of gains and risk seeking in the domain of losses. Finally, they distort probabilities, overweighting small probabilities of extreme outcomes and underweighting moderate and large probabilities. The probability weighting function was then improved in cumulative prospect theory (henceforth CPT) (Tversky and Kahneman, 1992), by borrowing the formulation of Quiggin (1982). It applies to the cumulative distribution of outcomes and no more to the probabilities of single outcomes

Overweighting small probabilities of extreme events is an intuitive and convenient way to explain why people play unfair state-lotteries. These lotteries generally offer large gains with very small probabilities. They then attract investors obeying cumulative prospect theory. Another way to characterize these lotteries is to remark that they are highly positively skewed. For a long time, research on state-lottery gambling and research in finance have been separated. But recently, Barberis and Huang (2008), Bali *et al.*(2009) and Kumar (2009) published papers focused on lottery-type stocks. Barberis and Huang (2008) show that stocks with positively skewed returns can be overpriced on markets populated by CPT investors. It is especially the case if the return on skewed securities is independent of the returns on other securities and if the supply of skewed stocks is small relative to the global market supply. Kumar (2009) shows the existence of significant links between investment behavior and lottery play behavior. He shows that investors used to play state-lotteries also prefer lottery-like stocks. This observation is reinforced during economic downturns. Finally, Bali *et al.* (2009) show that stocks exhibiting at least one very high return in the past month are overpriced. This effect is robust when controlling for idiosyncratic volatility.

To explain these stylized facts, one more step was done by Brunnermeier and Parker (2005) who introduced endogenous beliefs in the maximization of expected utility. Their basic idea is that distorting beliefs (in an optimistic way) generates more anticipatory utility but comes at a cost. The future utility based on distorted beliefs is lowered because investment decisions taken under distorted beliefs are not optimal. They show that there exist optimal beliefs which equalize the marginal gain of changing probabilities and the cost of investing in a non optimal way. The intuition behind this result is that a slight distortion in beliefs generates first-order gains when the consecutive loss coming from non optimal investment is a second-order one. In a portfolio choice framework, it has several implications; investors become overconfident and optimistic. Moreover, they prefer positively skewed securities. Brunnermeier *et al.* (2007) pursue in the same direction and show in a finite state-space framework that investors overvalue the probability of one state and undervalue the probability of all other states. It leads to highly skewed optimal portfolios. Roughly speaking, the optimal portfolio is a combination of the risk-free asset and the most skewed asset available on the market.

Less explicitly, most economic and financial models also assume that rationality of agents is common knowledge. Everybody is assumed rational, everybody knows that everybody is rational, everybody knows that everybody knows that everybody is rational, and so on (Aumann, 1976). It is a strong assumption and many examples show that it does not represent the way people are thinking. The most famous example is probably the beauty contest (first introduced by J.M. Keynes, 1936, chapter 12, p. 156[2]) which was translated by H. Moulin (1986) in numerical terms. Players have to choose a number between 0 and 100 and the winner is the one who chooses the number closest to a given percentage (say $a$) of the mean choice of players. The Nash equilibrium of the game is that everybody chooses 0 when $a < 1$[3]. However, all experiments show that most people are far from choosing 0 (Thaler, 1998, Nagel, 1995).

In this paper, we use two lottery bonds (specially designed for the study) to test three assumptions. First, people are not choosing numbers at random even when they are expected

---

[2] As stated by John Maynard Keynes (1936): "Or, to change the metaphor slightly, professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not a case of choosing those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practise the fourth, fifth and higher degrees."

[3] Some guessing games involve negative feedback. Players have to find the closest number to $100 - p \times mean$. For $p = 2/3$ it is easy to see that the equilibrium choice is 60 (see Sutan and Willinger, 2009)

to do so[4]. It means that they have common preferred numbers, a suboptimal feature in a pari mutuel game commonly observed in state lotteries (Farrell *et al.*, 2000, Roger and Broihanne, 2007). Second, when facing positively skewed distributions, investors do not behave like risk averse expected utility maximizers. In particular, they do not use a mean-variance criterion. Positive skewness is a highly weighted decision criterion and the probability of the highest possible outcome is overvalued. Finally, when the distribution of payoffs depends on the choices of others, people have a tendency to consider that others are not fully rational (and they seem right!).

The paper is organized as follows. Section II describes the two lottery bonds used in the experimental study. This section is written in such a way that the reader can think about possible answers and then can "participate" to the experiment. Section III proposes a theoretical analysis of the bonds and explains what theoretical choices should be, especially for a risk averse expected utility maximizer. Section IV presents the experimental results and section V concludes.

## II Design of the lottery bonds

Lottery bonds are in general fixed-rate bonds issued by a state or a firm where the fixed rate applies to the global issue. If a firm issues $N$ one-year bonds, each with a face value of \$1, it repays $B = (1+r)N$ at the maturity date, where $r$ denotes the interest rate. A part of this amount is redistributed to subscribers by means of a lottery. For example, $B$ is divided in two parts such that:

$$B = B_1+B_2$$

$n < N$ bonds are drawn at random and their holders share $B_1$ (equally or not, depending on the design of the lottery). The remaining amount, $B_2$, is then shared equally among the $N$ subscribers or among the $N – n$ losers.

It is important to remind that, in most cases, the issuer bears no risk since it repays $B$ whatever happens in the random draw. The risk is entirely borne by subscribers. Lottery bonds are then unusual financial assets because they should not exist in a world populated by risk averse expected utility maximizers with objective beliefs.

In this section, we describe two kinds of lottery bonds which differ only by the way the amount paid by means of a lottery is defined. The structure of the two subsections is exactly

[4] For example, Boland and Pawitan (1999) show that people have difficulties to choose numbers randomly, even in very simple tasks.

the same and some of the sentences too, simply to make the reader think about the choices proposed at the end of each subsection (like in the following experiment). The theoretical analysis of the two bonds is reported in the following section.

**II-1 Lottery bond 1**

A bank, called Bank1, issues *N* units of a lottery bond (called bond1), each bond being sold $1. The subscriber of one bond has to choose a number between 1 and 10. At the maturity date, the bank pays an interest rate *r* on the global amount issued. However, the bank first draws one number at random between 1 and 10, say *j* (we say series *j* has been drawn). The issuer then pays $1 to each of the subscribers of series *j* and shares equally the remaining amount among **all** subscribers, including the winning ones. For example, table 1 shows the individual payoffs received by the subscribers, depending on the series they invested in and on the series which has been drawn. In this example, the number of bonds is 1 million and the interest rate paid by the bank is 5 %, so the bank will repay $1 050 000 at the maturity date. The first line (arbitrarily chosen) indicates the number of subscribers in each series and the first column identifies the possible states of nature (the series number drawn at random). There are then 10 states of nature. The following columns give the payoffs received by a subscriber of a given series in each state. For example, 1.95 is the final payoff obtained by a series-1 subscriber if 1 is drawn. As there are 100 000 subscribers in this series, each of them first receives $1 and the remaining $950 000 are shared equally among all the participants, so each subscriber receives $0.95. It explains the amounts appearing in the corresponding line. When number 2 is drawn, the series 1 subscriber receives $0.9 because there were 150 000 subscribers in series 2 so the remaining amount is $900 000 shared by the 1 000 000 subscribers. The same calculations justify the other amounts in the table.

**Table 1 around here**

The random payoffs can be formalized in the following way.

Let $X^i(j)$ the payoff received by a series-*i* subscriber when the number *j* is drawn and denote *N* the global number of subscribers. $N = \sum_{k=1}^{10} N_k$ where $N_k$ is the number of series-*k* subscribers (first line of table 1). The issuer globally repays $(1+r)N$ but, according to the preceding rule, the individual payoff $X^i$ is defined by:

$$X^i(j) = \begin{cases} (1+r) - \frac{N_j}{N} & \text{if } j \neq i \\ 2 + r - \frac{N_i}{N} & \text{if } j = i \end{cases} \tag{1}$$

Denote $Z_N$ the random variable defined on the ten states of nature by:

$$Z_N(k) = (1+r)\mathbf{1}_\Omega - \frac{N_k}{N}, k = 1,...,10$$

We then have $X^i = Z_N + \mathbf{1}_{\{i\}}$ where $\mathbf{1}_{\{i\}}$ is the indicator function of state $i$ and $\mathbf{1}_\Omega$ is the indicator function of the set of states of nature. This decomposition will be useful when we will study the moments of payoffs.

Suppose that you have to choose a series to invest in. Obviously, if the $N_j$ are unknown, we can reasonably expect indifference between the 10 series which all generate an expected payoff (1 + $r$) because the $\mathbf{1}_{\{i\}}$ all have the same probability distribution.

But what would be your choice if you were told the $N_j$ and if you were the last one-unit subscriber? For example, in table 1, would you choose series 8 with 50 000 subscribers or series 2 with 150 000? The detailed analysis is provided later on after the presentation of the second lottery bond.

**Lottery bond 2**

A bank, called Bank 2, issues $N$ units of a lottery bond (called bond2), each bond being sold \$1. The subscriber of one bond has to choose a number between 1 and 10. At the maturity date, the bank pays an interest rate $r$ on the global amount issued. However, Bank 2 first draws a number at random between 1 and 10, say $j$, and shares equally 10% of the global initial investment among the subscribers of series $j$. The remaining amount is shared equally among **all** subscribers, including the winning ones.

For example, table 2 shows the individual payoffs received by the subscribers, depending on the series they invested in and on the series which has been drawn. Table 2 is built as table 1, the number of subscribers in each series and the interest rate are the same. For example, 1.95 is the final payoff obtained by a series-1 subscriber if series 1 is drawn. As there are 100 000 subscribers in this series, each of them first receives \$1 and the remaining \$950 000 are shared equally among all the participants, so each subscriber receives \$0.95. It explains the amounts appearing in the corresponding line. When a different number is drawn, the series 1 subscriber receives \$0.95 because the remaining amount is \$950 000, shared among the 1 000 000 subscribers. One essential difference between the two bonds is that the payoff received by a "losing-series" subscriber doesn't depend on the number drawn for bond 2. In other words, each bond 2 pays only two different payoffs, a winning payoff or a losing payoff.

**Table 2 around here**

The random payoffs of bond 2 can, as before, be formalized in the following way.

Let $Y^i(j)$ the payoff received by a series-*i* subscriber when the number *j* is drawn and denote *N* the global number of subscribers. $N = \sum_{k=1}^{10} N_k$ where $N_k$ is the number of series-*k* subscribers (first line of table 1). The issuer globally repays $(1+r)N$ but, according to the preceding rule, the individual payoff $Y^i$ is defined

$$Y^i(j) = \begin{cases} 0.9 + r \ \text{ if } j \neq i \\ 0.9 + r + \dfrac{0.1N}{N_i} \ \text{ if } j = i \end{cases} \tag{2}$$

If $\mathbf{1}_\Omega$ denotes the constant random variable, $Y^i$ can be written as:

$$Y^i = (0.9 + r)\mathbf{1}_\Omega + \frac{0.1N}{N_i}\mathbf{1}_{\{i\}}.$$

Suppose you have to choose a series to invest in. If the number of subscribers $N_j$ are unknown, we can reasonably expect indifference between the 10 series which all generate an expected payoff 1 + *r*. But what would be your choice if you were told the $N_j$ and if you are the last one-unit subscriber?

## III Theoretical analysis of the lottery bonds

### III-1 Lottery bond 1

We remarked before that if the numbers $N_j$ are unknown, the potential subscribers should be indifferent between the series. What is changed when the information in table 1 becomes available? When I first asked this question to colleagues and students during informal discussions, most of them answered that they would choose series 8 with the lowest number of subscribers. Their intuitive argument was that, after receiving \$1 in the winning series, the remaining amount of money, shared among all participants, is higher when the number of subscribers is low in the winning series. Only one colleague chose the highest frequency series, saying that the probability of being in a losing series is much higher than the probability of being in the winning series. I have to mention that they were not shown tables 1 and 2 but only the number of bonds already sold in each series.

It is time to analyze investment in bond 1 with usual investment criteria, especially by looking at the first moments of the distribution of returns.

In the absence of information concerning frequencies, the expected return is 5 % for all series. The following proposition shows that it is the same if the distribution of frequencies is given.

**Proposition 1**

*The expected payoff of bond 1 is independent of the subscribers' choice and equal to 1+r*

**Proof**

Denote $E\left[X^i \middle| N\right]$ the expected payoff received by a subscriber of series *i* conditional on a given distribution of frequencies. We have:

$$E\left[X^i \middle| N\right] = E\left[Z_N + \mathbf{1}_{\{i\}}\right] = \frac{1}{10}\left[\sum_{j\neq i}\left(1+r-\frac{N_j}{N}\right)+2+r-\frac{N_i}{N}\right] = (1+r)$$

The first moment is independent of frequencies and is then not a criterion for a rational investor to decide. Consider now a mean-variance investor. We get the following proposition.

**Proposition 2**

1) *The variance of series-i return conditional on a distribution of bonds already sold is given by:*

$$V\left[X^i \middle| N\right] = \frac{1}{10}\left[\sum_{j=1}^{10}\left(\frac{N_j}{N}\right)^2 + \left(1-\frac{2N_i}{N}\right)\right] \tag{3}$$

**Proof**: see the appendix

Equation (3) shows that the variance of payoffs is lower in the series with the largest number of subscribers. In fact, if we note $V_{+1}\left[X^i \middle| N\right]$ the conditional variance of payoffs of series *i* when one more subscriber chooses this series, we get $\dfrac{V\left[X^i \middle| N\right]}{V_{+1}\left[X^i \middle| N\right]} = \left(\dfrac{N+1}{N}\right)^2$

Proposition 2 shows that the variance of returns on series *i* is a decreasing function of $N_i$. It implies that the usual mean-variance investor would choose to "play with the crowd", a not so intuitive result. However, if you imagine that all subscribers choose the same number, the issue becomes a risk-free asset paying 1 + *r* whatever is the number drawn by the bank.

**Proposition 3**

*Denote* $S\left[X^i \middle| N\right]$ *the skewness of payoffs. We get:*

$$S\left[X^i \middle| N\right] = \sqrt{10}\,\frac{-\sum_{j\neq i} N_j^3 + \left(N - N_i\right)^3}{\left[\sum_{j\neq i} N_j^2 + \left(N - N_i\right)^2\right]^{\frac{3}{2}}}$$

*Using the same notation as before, let* $S_{+1}\left[X^i \middle| N\right]$ *the skewness of series* $i$ *payoff when there is one more subscriber in the series. We obtain:*

$$S_{+1}\left[X^i \middle| N\right] = S\left[X^i \middle| N\right]$$

**Proof:** see the appendix

Proposition 3 means that the skewness of the payoffs of series *i* remains the same when a new subscriber chooses series *i*. However, it doesn't signify that the subscriber of one new unit is indifferent between series, simply because choosing a series changes the skewness of the other series!

Figure 1 illustrates the non monotonic link between the skewness of payoffs and the number of subscribers with the data of tables 1 and 2. A mean-variance investor would choose the series with the highest number of subscribers but, so doing, he would not choose the highest positive skewness.

**Figure 1 around here**

Suppose now that the investor is risk averse and denote *U* her utility function, assumed strictly increasing and strictly concave. The following proposition generalizes the preceding results and shows that this investor always chooses the most popular number, that is the one for which $N_i$ is maximum.

**Proposition 4**

*Let U denote a strictly increasing and strictly concave utility function. If $N_i < N_j$ then* $E\left[U(X^i)\right] < E\left[U(X^j)\right]$

**Proof**: see the appendix

The intuition behind proposition 4 is very simple when writing $X^i = Z_N + \mathbf{1}_{\{i\}}$ with

$$Z_N(k) = (1+r)\mathbf{1}_\Omega - \frac{N_k}{N}, k = 1,...,10$$

The investor prefers to add 1 to the lowest payoff of $Z_N$ simply because her marginal utility decreases with wealth. It is then optimal to add one unit of wealth on the worst state, that is the one for which $N_k$ is maximum. Proposition 4 indicates that risk averse expected utility maximizers should choose unambiguously n°2 if they face the distribution of frequencies of table 1.

### III-1 Lottery bond 2

The financial analysis of bond 2 is much more simple. We saw in equation (2) that:

$$Y^i(j) = (0.9+r)\mathbf{1}_\Omega + \frac{0.1N}{N_i}\mathbf{1}_{\{i\}} = \begin{cases} 0.9+r \text{ if } j \neq i \\ 0.9+r+\frac{0.1N}{N_i} \text{ if } j = i \end{cases}$$

Losing series generate the same payoff 0.9+*r* but the payoff of the winning series is inversely proportional to the number of subscribers of this series. Being given a distribution of frequencies, the optimal choice of the last subscriber of the issue is always the series with the lowest number of subscribers because the corresponding payoff dominates the others in the sense of first order stochastic dominance. Bond 2 is also a good example to show why variance is not always a good measure of risk. In fact, the expectation of series *i* payoffs is a decreasing function of $N_i$ but the variance of payoffs is also a decreasing function of $N_i$. In other words, no series is dominated in the mean-variance space. If we look more closely at two series *i* and *j* with frequencies $N_i$ and $N_j$ with $N_i < N_j$. The payoffs are 0.9+*r* with probability 0.9 but series *i* pays $0.1 \times N \times \left(\frac{1}{N_i} - \frac{1}{N_j}\right)$ more than series *j* with probability 0.1. It is as if you were given for free a lottery ticket paying this amount with probability 0.1. Whatever the preferences are (if they obey the first order stochastic dominance principle), it is reasonable to assume that you would accept the lottery ticket.

We can remark that the moments of $Y^i$ are given by:

$$E\left[Y^i \middle| N\right] = 0.9 + r + \frac{0.01 \times N}{N_i}$$

$$V\left[Y^i \middle| N\right] = 0.09\left(\frac{0.1 \times N}{N_i}\right)^2$$

It means that in the mean-variance space only, no bond dominates. This remark is an illustration of the lack of generality of the mean-variance criterion because first-order stochastic dominance leads to choose the highest variance. However, this remark has to be mitigated by the observation that the optimal choice is also the one with the highest Sharpe ratio.

## IV The experimental study

### IV-1 The questionnaire

The experiment was realized during different finance courses at the University of Strasbourg. The students involved in the study come from four different training programs summarized in table 3.

**Table 3 around here**

The participants had to answer 6 questions divided into three groups of 2 questions related to the lottery bonds presented in the preceding section. In each pair of questions the first one is related to bond 1 and the second to bond 2. The required answers were simply numbers between 1 and 10 corresponding to the choice of a series number.

For the first two questions, participants were only told the characteristics of the bonds without any other information, either on the table of payoffs or on the choice of former subscribers. The features of the two bonds provided to the participants were only the repayment process by the bank. Remember that the only difference between the two bonds is the amount devoted to the winning series. For bond 1, this amount is random since it is equal to the number of subscribers choosing this series. For bond 2, it is equal to 10 % of the global initial investment, that is $100 000.

Obviously, with no information other than the way payoffs are defined, investors should be indifferent between the series and we expect a random choice for the two first questions.

For the second group of two questions, we provided the distribution of choices of hypothetical former subscribers. The information given to respondents was the first line of tables 1 or 2 and we specified that respondents were about to buy the last bond of the issue. In other words, each rational respondent was able to infer the final distribution of payoffs after his/her own choice and to calculate figures appearing in tables 1 and 2. Participants had to answer questions 1 and 2 before getting the information related to questions 3 and 4.

Finally, in the third sequence of two questions, the rule was that participants had to choose a series number with the same information as in questions 3 and 4, but they were told that one million bonds were still to be sold to other subscribers after their own choice. Moreover, participants were also informed that the following subscribers would know the current distribution of sales at the time of their own purchase. It means that the first line in tables 1 and 2 would be updated after each transaction.

**IV-2 Results**

**IV-2-1 Analysis of the complete sample**

The answers to the 6 questions are summarized in table 4. We deleted two questionnaires for which students have chosen the same number (neither 2 or 8) for the 6 questions, casting doubt on their motivation to participate in the experiment. Moreover, one student didn't answer question 2. It explains why the total of column Q2 in table 2 is only 110 instead of 111.

For Q1 and Q2 where random choices were expected, we cumulated the corresponding frequencies in the last column of table 4 to test for a random distribution of answers. The theoretical frequency for a uniform distribution is 22.1 when cumulating Q1 and Q2. We observe that some numbers are preferred, especially numbers 1, 3 and 7. A $\chi^2$ test rejects the uniform distribution assumption at the 1% level. It is not really surprising if we compare these results to the choices of French lotto players. In this game, players have to choose 5 numbers between 1 and 49 and (independently) a lucky number between 1 and 10. The sponsor of the game draws at random the winning combination and the lucky number. Since the start of the game in October 2008, number 7 has been drawn 8 times[5]. For these particular draws, the proportion of winners of the lucky number was between 15.75% and 17.10% when 10% were expected if players choose their numbers at random[6]. In our experiment, 16.3% of the participants choose number 7 in the first two questions.

**Table 4 around here**

[5] For the 93 first draws up to 05/09/2009.

[6] The data on French lotto draws are provided on www.fdjeux.com and the percentage of lucky number winners is reported on www.sojah.com.

The analysis of the preceding section shows that answers to questions 3 and 4 should be different if students decide according to the mean-variance model or, more generally, if they are risk averse expected utility maximizers. For question 4, they should choose number 8 because it dominates the other choices according to first-order stochastic dominance. 82 students out of 111 made this choice, that is 73.89%. A more "surprising" result is that 66 students also selected the lowest frequency for question 3 and only 12 chose the highest frequency corresponding to the optimal mean-variance choice. It means that more than one-half of the participants preferred the series with the highest variance. A part of the explanation may be found on figure 1. Choosing number 8 implies a preference for the highest skewness or, at least, for the highest outcome. Preference for positive skewness has been recognized in several papers (Kraus and Litzenberger, 1976, Harvey and Siddique, 2000, Mitton and Vorkink, 2007, Bali *et al.*, 2009). In particular, Bali *et al.* (2009) show that investors are willing to pay more for stocks that exhibit past extreme positive returns (in the preceding months). They observe that these stocks have lower returns in the future.

A possible explanation to this choice is the overweighting of the probability of winning. As mentioned before, choosing number 8 leads to a greater gain if this series number is drawn by the bank because the remaining amount shared among all participants is higher. Obviously, it also generates greater losses if another number is drawn. The most frequent answer selected by respondents, namely n°8, also corresponds to the choice of agents obeying the theory of optimal beliefs developed in Brunnemeier and Parker (2005) and Brunnemeier *et al.* (2007). They consider an economy in which agents search for optimal beliefs, realizing a tradeoff between the immediate perceived gain of utility when beliefs are distorted, and the cost of a suboptimal investment. They show that the probability of only one state is biased upward, the other probabilities being biased downward. When the states are equally likely, the upward biased state is the one with the lowest price-probability ratio. In our context, it corresponds to the state with the highest payoff.

Figure 2 illustrates this point. It represents the three-dimensional histogram of the pair (Q3-Q4). The two horizontal axes correspond to the possible choices from 1 to 10 and the vertical axis gives the frequency of the 100 possible pairs of answers. It appears that the area peaks at (8,8), corresponding to the lowest number of subscribers.

The answers to questions 5 and 6 show results that may appear surprising at a first glance. In fact, we observe a dramatic decrease of answer n°8 associated to a large increase of answer n°2. Questions 5 and 6 introduce a kind of Keynesian beauty contest since respondents have to infer what next subscribers will choose. Moreover, participants were told that their successors would have a complete and updated information about the subscription process. As we didn't expect such a switching phenomenon, we didn't formally introduce a question about the reason of switching. However, for three of the four groups of students we asked to switching students (in an informal discussion after the end of the experiment) the reasons of their choice. The answer was always the same. They were expecting that successors would choose answer n°8 (their own choice in Q3 and Q4) leading to an increase in the frequency of this answer and a decrease in perceived gains for themselves. This way of reasoning is not compatible with the assumption that rationality is common knowledge. To get more insights on this point, we restricted the analysis to the sample of participants whose answers obey first-order stochastic dominance, that is those who chose n°8 in question 4.

**IV-2-2 Analysis of the sample of "rational" participants**

The minimum requirement for a theoretical model of decision making under risk to be accepted by the scientific community is compliance to the first-order stochastic dominance rule. It is the reason why Prospect Theory (Kahneman and Tversky, 1979) was improved in Cumulative Prospect Theory (Tversky and Kahneman, 1992). The first version was not consistent with first-order stochastic dominance.

In our study, the design of bond 2 was devoted to test the compliance to the first-order stochastic dominance principle. Question Q4 may be seen as a benchmark for this minimum requirement. In fact, answer n°8 dominates the others because the payoff of series 8 is greater if the winning series is n°8 and equal if another number is drawn. Consequently, we focus now our comments on the 82 "rational" participants who chose series n°8 in Q4. The results for this subsample are given in table 5.

**Table 5 around here**

The first remark is that answers to questions 1 and 2 are not random and the bias in favor of n°7 remains present; it is even reinforced. The second observation is that the answer to Q3 is still concentrated on n°8 but those who don't choose this number are dispersed among the nine other numbers. The most interesting observation on this table is the change between Q3-Q4 and Q5-Q6. We observe that a large proportion of these "rational" players switches to other answers and especially to n°2. Concerning Q6, if participants were thinking that other subscribers are rational they should be indifferent between all solutions for which the number of subscribers is lower than 200 000. To explain why it is the case, assume that all investors are rational and rationality is common knowledge. As the number of bonds of the issue is now 2 millions, the subscription should end with 200 000 bonds in each series. The reason is simple. It is suboptimal to choose a series with more than 200 000 bonds already purchased because such a situation implies that there is at least another series with a lower number of subscribers and hence dominating payoffs.

However, if you assume that other subscribers are not completely rational and have a "one-step" reasoning, it appears optimal to play with the crowd, expecting that the others will choose the low frequency series. This switching behavior of the "rational" subsample also shows that participants have difficulties to integrate the information related to the future updating of information for the next subscribers. In fact, if a large number of players chooses series 2, it will obviously become a high frequency series and future subscribers will change their choices. Then, even with individuals that only obey the first-order stochastic dominance rule, the choice process should lead to equal frequencies in the end.

**V Conclusion**

In this paper, we analyzed the way people manage a simple financial decision making problem based on lottery bonds. These assets are interesting for such an experiment because they are popular on markets where they are traded and their features are close to the ones of state-lotteries. The abovementioned literature has shown that investors may be ready to pay a high price for positively skewed securities. In our experiment, all possible choices were skewed securities and in this framework we observed that a large part of respondents was choosing the highest skewness, even when it was associated to the largest variance. But the highest skewness also corresponds to the security with the highest return in the winning state. This result is then consistent with the theoretical analysis of Brunnemeier *et al.* (2007) and with the empirical study of Bali *et al.* (2009).

We also showed that people use heuristics to choose numbers at random, leading in fact to non random choices at the aggregate level. The number 7 is especially popular among respondents and it comes with no surprise. For example, Roger and Broihanne (2007) already showed that this number is the most popular among the 49 numbers of the French lotto game.

Finally, by introducing a kind of beauty contest in the experiment, we observed that respondents don't assume that rationality is common knowledge, either because they recognize their own limited rationality or because they consider that other are not fully rational.

The limitations of this paper lie essentially in the small sample considered here. 111 respondents are probably insufficient to get definitive results and this study has to be extended to larger samples in different contexts, not limited to a population of students but extended to different categories of investors. However, it may be easily replicated and we hope it will be.

## References


Aumann, R. (1976) Agreeing to Disagree, *Annals of Statistics* 4(6): 1236–1239.

Bali, T.G., Cakici, N. and Whitelaw, R.F. (2009), Maxing Out: Stocks as Lotteries and the Cross-Section of Expected Returns, NBER Working Papers 14804.

Barberis, N. and Huang M. (2008), Stocks as Lotteries: The Implications of Probability Weighting for Security Prices, *American Economic Review*, 98(5), 2066-2100.

Boland, P.J. and Pawitan, Y. (1999), Trying to be random in selecting numbers for Lotto, *Journal of Statistics Education*, 7(3).

Brunnemeier, M.K., Gollier, C. and Parker, J.A. (2007), Optimal Beliefs, Asset Prices, and the Preference for Skewed Returns, *American Economic Review*, 97(2), 159-165.

Brunnermeier, M.K. and Parker, J.A. (2005), Optimal Expectations, *American Economic Review*, 95(4), 1092-1118.

Fama, E. F. (1970), Efficient Capital Markets: a Review of Theory and Empirical Work, *Journal of Finance*, 25(2), 383-417.

Farrell, L., Hartley, R., Lanot, G. and Walker, I. (2000), The Demand for Lotto: the Role of Conscious Selection, *Journal of Business & Economic Statistics*, 18(2), pp. 228–241.

Friedman, M. and Savage, L. J. (1948), The Utility Analysis of Choices Involving Risk, *Journal of Political Economy*, 56, 279-304.

Green, R. C. and Rydqvist K. (1997), The Valuation of Non-Systematic Risks and the Pricing of Swedish Lottery Bonds, *Review of Financial Studies*, 10, 447-480.

Guillen, M. F. and Tschoegl, A. E. (2002), Banking on Gambling: Banks and Lottery-Linked Deposit Accounts, *Journal of Financial Services Research*, 21(3), 219-231.

Harvey, C. and Siddique, A. (2000), Conditional skewness in asset pricing tests, *Journal of Finance*, 55, 1263-1295.

Kahneman, D. and Tversky, A. (1979), Prospect Theory: An Analysis of Decision under Risk, *Econometrica*, 47, 263-291.

Keynes, J. M. (1936), *The General Theory of Employment, Interest and Money*, Harcourt Brace and Co.

Kraus, A. and Litzenberger, R.H. (1976), Skewness preference and the valuation of risk assets, *Journal of Finance* 31, 1085-1100.

Kumar, A. (2009), Who Gambles on the Stock Market?, *Journal of Finance*, forthcoming.

Lévy-Ullmann, H. (1896), Lottery Bonds in France and in the Principal Countries of Europe, *Harvard Law Review*, 9, 386-405.

Markowitz, H. (1952a). Portfolio Selection, *Journal of Finance*, 7 (1), 77-91.

Markowitz, H. (1952b), The Utility of Wealth, *Journal of Political Economy*, 60, 151-158.

Millar, J.R. and Gentry J.A. (1980), The Soviet Experiment with Domestic Lottery Bonds, *Financial Management*, Winter, 21-29.

Mitton, T. and Vorkink, K. (2007), Equilibrium Underdiversification and the Preference for Skewness, *Review of Financial Studies*, 20, 1255-1288.

Moulin, H. (1986), *Game Theory for the Social Sciences*, 2nd Ed., NYU Press.

Nagel, R. (1995), Unraveling in Guessing Games: An Experimental Study, *American Economic Review* 85, 1313-1326.

Pfiffelmann, M. and Roger, P. (2005), Les comptes d'épargne associés à des loteries : approche comportementale et étude de cas, *Banque et Marchés*, 78, septembre-octobre, 1-8.

Quiggin, J. (1982), A Theory of Anticipated Utility, *Journal of Economic Behavior and Organization*, 8, 641-645.

Ridge, J. and Young, M. (1998), Innovations in Savings Schemes: The Bonus Bonds Trust in New Zealand, *Financial Services Review*, 7(2), 73-81.

Roger, P. and Broihanne, M.H. (2007), Efficiency of Betting Markets and Rationality of Players: Evidence from the French 6/49 Lotto, *Journal of Applied Statistics*, 34(6), 645-662.

Sutan, A. and Willinger, M. (2009), Guessing with Negative Feedback: An Experiment, *Journal of Economic Dynamics and Control*, 33, 1123-1133.

Thaler, R. (1998), Giving Markets a Human Dimension, in *The Complete Finance Companion*, Financial Times/Prentice Hall.

Tversky, A. and Kahneman, D. (1992), "Advances in Prospect Theory: Cumulative Representation of Uncertainty", *Journal of Risk and Uncertainty*, 12, 297-323.

## APPENDIX

**Proof of proposition 2**

The result is immediately obtained by writing:

$$V\left[X^i \middle| N\right]=\frac{1}{10}\left[\sum_{j\neq i}\left(-\frac{N_j}{N}\right)^2+\left(1-\frac{N_i}{N}\right)^2\right]$$
$$=\frac{1}{10}\left[\sum_{j=1}^{10}\left(\frac{N_j}{N}\right)^2+\left(1-\frac{2N_i}{N}\right)\right]$$

**Proof of proposition 3**

The skewness of a distribution of payoffs $(x_i;p_i), i=1,...,n$ is given by:

$$S\left[x\right]=\frac{\sum_{i=1}^{n}(x_i-E(x))^3}{\left(\sum_{i=1}^{n}(x_i-E(x))^2\right)^{\frac{3}{2}}}$$

In our case, the return is always 1+$r$ so we get:

$$S\left[X^i \middle| N\right]=\sqrt{10}\,\frac{\sum_{j\neq i}\left(-\frac{N_j}{N}\right)^3+\left(1-\frac{N_i}{N}\right)^3}{\left[\sum_{j\neq i}\left(-\frac{N_j}{N}\right)^2+\left(1-\frac{N_i}{N}\right)^2\right]^{\frac{3}{2}}}=\sqrt{10}\,\frac{-\sum_{j\neq i}N_j^3+\left(N-N_i\right)^3}{\left[\sum_{j\neq i}N_j^2+\left(N-N_i\right)^2\right]^{\frac{3}{2}}}$$

It is easily seen that if $N$ becomes $N$+1 and $N_i$ becomes $N_i+1$ the skewness doesn't change.

**Proof of proposition 4**

$$X^i=Z_N+\mathbf{1}_{\{i\}}$$

Assume without loss of generality that the values of $Z_N$ are ranked in increasing order, corresponding to a ranking of the $N_i$ in decreasing order. We know that $X^i(i)$ is the maximum possible value of $X^i$. It means that selecting a number when buying a bond transfers the $i$-th outcome of $Z_N$ at the right tail of the probability distribution (winning always generates a better outcome than losing!). It implies that transferring the lowest outcome to the right tail by a given amount is always preferred by a risk averse agent because the marginal utility is decreasing when the utility function is strictly increasing and strictly concave. But as the lowest value of $Z_N$ corresponds to the highest value of $N_i$, we get that a risk averse investor always prefer to bet with the crowd.

**Table 1:** Payoffs of bond 1

The "series*K*" column contains the payoffs received at the maturity date by a subscriber of series *K* when the number drawn at random is the one appearing in the first column and the same line.

| | Series1 | Series2 | Series3 | Series4 | Series5 | Series6 | Series7 | Series8 | Series9 | Series10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100000 | 150000 | 80000 | 120000 | 60000 | 140000 | 70000 | 50000 | 130000 | 100000 |
| 1 | 1,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 |
| 2 | 0,9 | 1,9 | 0,9 | 0,9 | 0,9 | 0,9 | 0,9 | 0,9 | 0,9 | 0,9 |
| 3 | 0,97 | 0,97 | 1,97 | 0,97 | 0,97 | 0,97 | 0,97 | 0,97 | 0,97 | 0,97 |
| 4 | 0,93 | 0,93 | 0,93 | 1,93 | 0,93 | 0,93 | 0,93 | 0,93 | 0,93 | 0,93 |
| 5 | 0,99 | 0,99 | 0,99 | 0,99 | 1,99 | 0,99 | 0,99 | 0,99 | 0,99 | 0,99 |
| 6 | 0,91 | 0,91 | 0,91 | 0,91 | 0,91 | 1,91 | 0,91 | 0,91 | 0,91 | 0,91 |
| 7 | 0,98 | 0,98 | 0,98 | 0,98 | 0,98 | 0,98 | 1,98 | 0,98 | 0,98 | 0,98 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| 9 | 0,92 | 0,92 | 0,92 | 0,92 | 0,92 | 0,92 | 0,92 | 0,92 | 1,92 | 0,92 |
| 10 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 1,95 |

**Table 2:** Payoffs of bond 2

The "series*K*" column contains the payoffs received at the maturity date by a subscriber of series *K* when the number drawn at random is the one appearing in the first column and the same line.

| | Series1 | Series2 | Series3 | Series4 | Series5 | Series6 | Series7 | Series8 | Series9 | Series10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100000 | 150000 | 80000 | 120000 | 60000 | 140000 | 70000 | 50000 | 130000 | 100000 |
| 1 | 1,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 |
| 2 | 0,95 | 1,62 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 |
| 3 | 0,95 | 0,95 | 2,20 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 |
| 4 | 0,95 | 0,95 | 0,95 | 1,78 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 |
| 5 | 0,95 | 0,95 | 0,95 | 0,95 | 2,62 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 |
| 6 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 1,66 | 0,95 | 0,95 | 0,95 | 0,95 |
| 7 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 2,38 | 0,95 | 0,95 | 0,95 |
| 8 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 2,95 | 0,95 | 0,95 |
| 9 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 1,72 | 0,95 |
| 10 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 0,95 | 1,95 |

**Table 3: Origin of participants**

| Program | Number of students |
|---|---|
| EM Strasbourg Business School | 40 |
| Master in Finance (second year) | 20 |
| Master in Actuarial Studies | 20 |
| Master in Finance (first year) | 33 |
| TOTAL | 113 |

**Table 4: Results of the experiment: complete sample**

Column 1 gives the series number. Column 2 provides the information about the choices of former subscribers (relevant for questions 3 to 6). Columns 3 to 8 report the numbers of students choosing the corresponding series number in the first column. The last column adds the frequencies of questions 1 and 2 where random choices are expected.

| SERIES NUMBER | BONDS BOUGHT | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q1+Q2 |
|---|---|---|---|---|---|---|---|---|
| 1 | 100000 | 18 | 12 | 7 | 1 | 13 | 2 | 30 |
| 2 | 150000 | 15 | 11 | 12 | 13 | 33 | 41 | 26 |
| 3 | 80000 | 17 | 13 | 6 | 2 | 9 | 9 | 30 |
| 4 | 120000 | 8 | 8 | 3 | 3 | 4 | 3 | 16 |
| 5 | 60000 | 12 | 16 | 5 | 6 | 8 | 3 | 28 |
| 6 | 140000 | 4 | 4 | 5 | 3 | 4 | 9 | 8 |
| 7 | 70000 | 17 | 19 | 5 | 0 | 9 | 8 | 36 |
| 8 | 50000 | 6 | 9 | 66 | 82 | 23 | 22 | 15 |
| 9 | 130000 | 5 | 3 | 1 | 0 | 4 | 5 | 8 |
| 10 | 100000 | 9 | 15 | 1 | 1 | 4 | 9 | 24 |

### Table 5: Results of the experiment: "rational" sample

This table gives the results of the subsample of respondents having chosen n°8 to question 4. Column 1 gives the series number. Column 2 provides the information about the choices of former subscribers (relevant for questions 3 to 6). Columns 3 to 8 report the numbers of students choosing the corresponding series number in the first column. The last column adds the frequencies of questions 1 and 2 where random choices are expected.

| SERIES NUMBER | BONDS BOUGHT | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q1+Q2 |
|---|---|---|---|---|---|---|---|---|
| 1 | 100000 | 12 | 8 | 4 | 0 | 7 | 1 | 20 |
| 2 | 150000 | 11 | 10 | 7 | 0 | 26 | 29 | 21 |
| 3 | 80000 | 11 | 8 | 3 | 0 | 8 | 7 | 19 |
| 4 | 120000 | 6 | 5 | 1 | 0 | 3 | 2 | 11 |
| 5 | 60000 | 8 | 10 | 3 | 0 | 4 | 1 | 18 |
| 6 | 140000 | 3 | 3 | 4 | 0 | 4 | 6 | 6 |
| 7 | 70000 | 13 | 17 | 3 | 0 | 7 | 8 | 30 |
| 8 | 50000 | 5 | 7 | 56 | 82 | 16 | 19 | 12 |
| 9 | 130000 | 5 | 3 | 0 | 0 | 3 | 3 | 8 |
| 10 | 100000 | 8 | 11 | 1 | 0 | 4 | 6 | 19 |

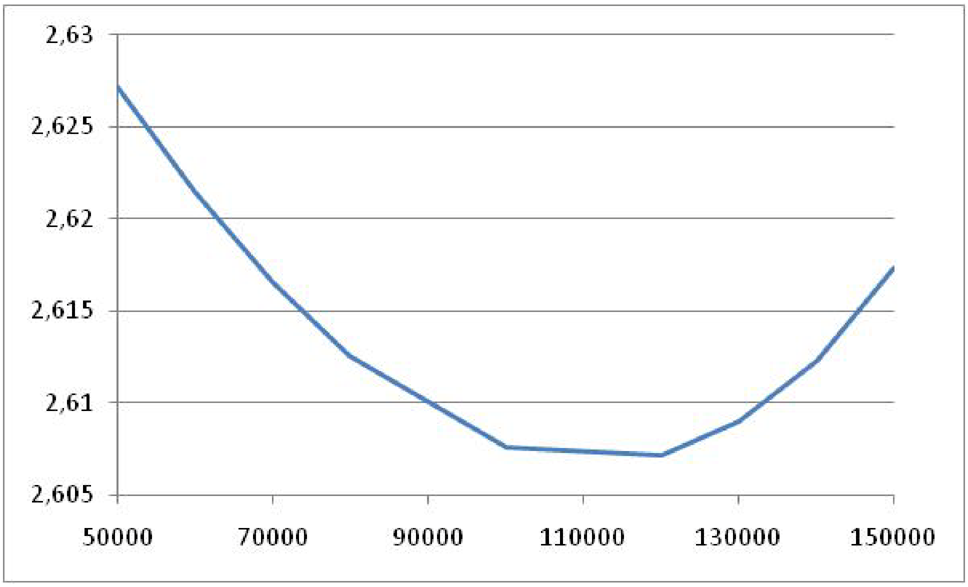

**Figure 1: Skewness of payoffs of bond 1 as a function of the number of subscribers (data of table 1)**

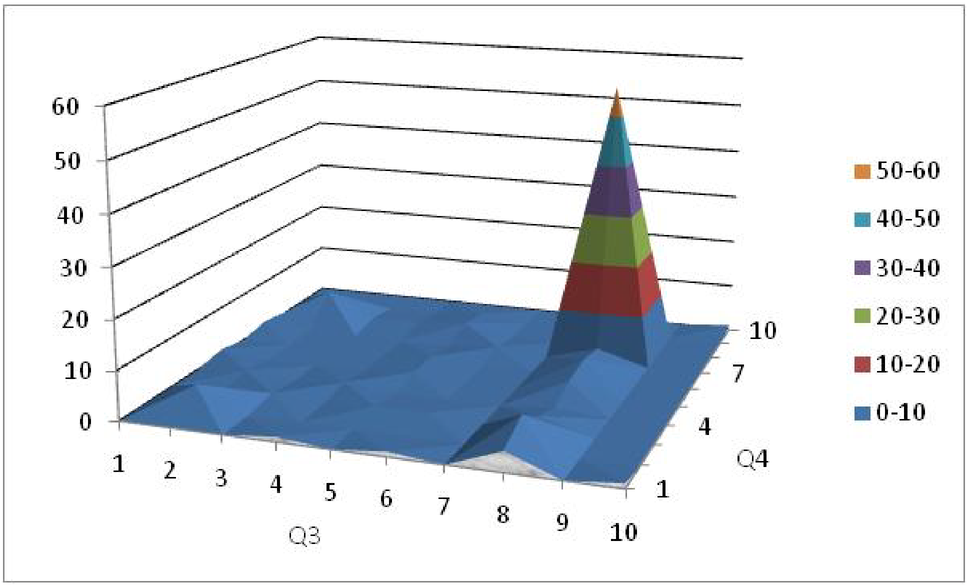

**Figure 2: 3-dimensional histogram of answers to questions 3 and 4**

# Working Papers

## Laboratoire de Recherche en Gestion & Economie

______

D.R. n° 1 "Bertrand Oligopoly with decreasing returns to scale", J. Thépot, décembre 1993

D.R. n° 2 "Sur quelques méthodes d'estimation directe de la structure par terme des taux d'intérêt", P. Roger - N. Rossiensky, janvier 1994

D.R. n° 3 "Towards a Monopoly Theory in a Managerial Perspective", J. Thépot, mai 1993

D.R. n° 4 "Bounded Rationality in Microeconomics", J. Thépot, mai 1993

D.R. n° 5 "Apprentissage Théorique et Expérience Professionnelle", J. Thépot, décembre 1993

D.R. n° 6 "Strategic Consumers in a Duable-Goods Monopoly", J. Thépot, avril 1994

D.R. n° 7 "Vendre ou louer ; un apport de la théorie des jeux", J. Thépot, avril 1994

D.R. n° 8 "Default Risk Insurance and Incomplete Markets", Ph. Artzner - FF. Delbaen, juin 1994

D.R. n° 9 "Les actions à réinvestissement optionnel du dividende", C. Marie-Jeanne - P. Roger, janvier 1995

D.R. n° 10 "Forme optimale des contrats d'assurance en présence de coûts administratifs pour l'assureur", S. Spaeter, février 1995

D.R. n° 11 "Une procédure de codage numérique des articles", J. Jeunet, février 1995

D.R. n° 12 "Stabilité d'un diagnostic concurrentiel fondé sur une approche markovienne du comportement de rachat du consommateur", N. Schall, octobre 1995

D.R. n° 13 "A direct proof of the coase conjecture", J. Thépot, octobre 1995

D.R. n° 14 "Invitation à la stratégie", J. Thépot, décembre 1995

D.R. n° 15 "Charity and economic efficiency", J. Thépot, mai 1996

D.R. n° 16 "Pricing anomalies in financial markets and non linear pricing rules", P. Roger, mars 1996

D.R. n° 17 "Non linéarité des coûts de l'assureur, comportement de prudence de l'assuré et contrats optimaux", S. Spaeter, avril 1996

D.R. n° 18 "La valeur ajoutée d'un partage de risque et l'optimum de Pareto : une note", L. Eeckhoudt - P. Roger, juin 1996

D.R. n° 19 "Evaluation of Lot-Sizing Techniques : A robustess and Cost Effectiveness Analysis", J. Jeunet, mars 1996

D.R. n° 20 "Entry accommodation with idle capacity", J. Thépot, septembre 1996

D.R. n° 21 "Différences culturelles et satisfaction des vendeurs : Une comparaison internationale", E. Vauquois-Mathevet - J.Cl. Usunier, novembre 1996

D.R. n° 22 "Evaluation des obligations convertibles et options d'échange", Schmitt - F. Home, décembre 1996

D.R n° 23 "Réduction d'un programme d'optimisation globale des coûts et diminution du temps de calcul, J. Jeunet, décembre 1996

D.R. n° 24 "Incertitude, vérifiabilité et observabilité : Une relecture de la théorie de l'agence", J. Thépot, janvier 1997

D.R. n° 25 "Financement par augmentation de capital avec asymétrie d'information : l'apport du paiement du dividende en actions", C. Marie-Jeanne, février 1997

D.R. n° 26 "Paiement du dividende en actions et théorie du signal", C. Marie-Jeanne, février 1997

D.R. n° 27 "Risk aversion and the bid-ask spread", L. Eeckhoudt - P. Roger, avril 1997

D.R. n° 28 "De l'utilité de la contrainte d'assurance dans les modèles à un risque et à deux risques", S. Spaeter, septembre 1997

D.R. n° 29 "Robustness and cost-effectiveness of lot-sizing techniques under revised demand forecasts", J. Jeunet, juillet 1997

D.R. n° 30 "Efficience du marché et comparaison de produits à l'aide des méthodes d'enveloppe (Data envelopment analysis)", S. Chabi, septembre 1997

D.R. n° 31 "Qualités de la main-d'œuvre et subventions à l'emploi : Approche microéconomique", J. Calaza - P. Roger, février 1998

D.R n° 32 "Probabilité de défaut et spread de taux : Etude empirique du marché français", M. Merli - P. Roger, février 1998

D.R. n° 33 "Confiance et Performance : La thèse de Fukuyama", J.Cl. Usunier - P. Roger, avril 1998

D.R. n° 34 "Measuring the performance of lot-sizing techniques in uncertain environments", J. Jeunet - N. Jonard, janvier 1998

D.R. n° 35 "Mobilité et décison de consommation : premiers résultas dans un cadre monopolistique", Ph. Lapp, octobre 1998

D.R. n° 36 "Impact du paiement du dividende en actions sur le transfert de richesse et la dilution du bénéfice par action", C. Marie-Jeanne, octobre 1998

D.R. n° 37 "Maximum resale-price-maintenance as Nash condition", J. Thépot, novembre 1998

D.R. n° 38 "Properties of bid and ask prices in the rank dependent expected utility model", P. Roger, décembre 1998

D.R. n° 39 "Sur la structure par termes des spreads de défaut des obligations », Maxime Merli / Patrick Roger, septembre 1998

D.R. n° 40 "Le risque de défaut des obligations : un modèle de défaut temporaire de l'émetteur", Maxime Merli, octobre 1998

D.R. n° 41 "The Economics of Doping in Sports", Nicolas Eber / Jacques Thépot, février 1999

D.R. n° 42 "Solving large unconstrained multilevel lot-sizing problems using a hybrid genetic algorithm", Jully Jeunet, mars 1999

D.R n° 43 "Niveau général des taux et spreads de rendement", Maxime Merli, mars 1999

D.R. n° 44 "Doping in Sport and Competition Design", Nicolas Eber / Jacques Thépot, septembre 1999

D.R. n° 45 "Interactions dans les canaux de distribution", Jacques Thépot, novembre 1999

D.R. n° 46 "What sort of balanced scorecard for hospital", Thierry Nobre, novembre 1999

D.R. n° 47 "Le contrôle de gestion dans les PME", Thierry Nobre, mars 2000

D.R. n° 48 ″Stock timing using genetic algorithms", Jerzy Korczak – Patrick Roger, avril 2000

D.R. n° 49 "On the long run risk in stocks : A west-side story", Patrick Roger, mai 2000

D.R. n° 50 "Estimation des coûts de transaction sur un marché gouverné par les ordres : Le cas des composantes du CAC40", Laurent Deville, avril 2001

D.R. n° 51 "Sur une mesure d'efficience relative dans la théorie du portefeuille de Markowitz", Patrick Roger / Maxime Merli, septembre 2001

D.R. n° 52 "Impact de l'introduction du tracker Master Share CAC 40 sur la relation de parité call-put", Laurent Deville, mars 2002

D.R. n° 53 "Market-making, inventories and martingale pricing", Patrick Roger / Christian At / Laurent Flochel, mai 2002

D.R. n° 54 "Tarification au coût complet en concurrence imparfaite", Jean-Luc Netzer / Jacques Thépot, juillet 2002

D.R. n° 55 "Is time-diversification efficient for a loss averse investor ?", Patrick Roger, janvier 2003

D.R. n° 56 "Dégradations de notations du leader et effets de contagion", Maxime Merli / Alain Schatt, avril 2003

D.R. n° 57 "Subjective evaluation, ambiguity and relational contracts", Brigitte Godbillon, juillet 2003

D.R. n° 58 "A View of the European Union as an Evolving Country Portfolio", Pierre-Guillaume Méon / Laurent Weill, juillet 2003

D.R. n° 59 "Can Mergers in Europe Help Banks Hedge Against Macroeconomic Risk ?", Pierre-Guillaume Méon / Laurent Weill, septembre 2003

D.R. n° 60 "Monetary policy in the presence of asymmetric wage indexation", Giuseppe Diana / Pierre-Guillaume Méon, juillet 2003

D.R. n° 61 "Concurrence bancaire et taille des conventions de services", Corentine Le Roy, novembre 2003

D.R. n° 62 "Le petit monde du CAC 40", Sylvie Chabi / Jérôme Maati

D.R. n° 63 "Are Athletes Different ? An Experimental Study Based on the Ultimatum Game", Nicolas Eber / Marc Willinger

D.R. n° 64 "Le rôle de l'environnement réglementaire, légal et institutionnel dans la défaillance des banques : Le cas des pays émergents", Christophe Godlewski, janvier 2004

D.R. n° 65 "Etude de la cohérence des ratings de banques avec la probabilité de défaillance bancaire dans les pays émergents", Christophe Godlewski, Mars 2004

D.R. n° 66 "Le comportement des étudiants sur le marché du téléphone mobile : Inertie, captivité ou fidélité ?", Corentine Le Roy, Mai 2004

D.R. n° 67 "Insurance and Financial Hedging of Oil Pollution Risks", André Schmitt / Sandrine Spaeter, September, 2004

D.R. n° 68 “On the Backwardness in Macroeconomic Performance of European Socialist Economies”, Laurent Weill, September, 2004

D.R. n° 69 “Majority voting with stochastic preferences : The whims of a committee are smaller than the whims of its members”, Pierre-Guillaume Méon, September, 2004

D.R. n° 70 “Modélisation de la prévision de défaillance de la banque : Une application aux banques des pays émergents”, Christophe J. Godlewski, octobre 2004

D.R. n° 71 “Can bankruptcy law discriminate between heterogeneous firms when information is incomplete ? The case of legal sanctions”, Régis Blazy, october 2004

D.R. n° 72 “La performance économique et financière des jeunes entreprises”, Régis Blazy/Bertrand Chopard, octobre 2004

D.R. n° 73 “*Ex Post* Efficiency of bankruptcy procedures : A general normative framework”, Régis Blazy / Bertrand Chopard, novembre 2004

D.R. n° 74 “Full cost pricing and organizational structure”, Jacques Thépot, décembre 2004

D.R. n° 75 “Prices as strategic substitutes in the Hotelling duopoly”, Jacques Thépot, décembre 2004

D.R. n° 76 “Réflexions sur l’extension récente de la statistique de prix et de production à la santé et à l’enseignement”, Damien Broussolle, mars 2005

D. R. n° 77 “Gestion du risque de crédit dans la banque : Information hard, information soft et manipulation ”, Brigitte Godbillon-Camus / Christophe J. Godlewski

D.R. n° 78 “Which Optimal Design For LLDAs”, Marie Pfiffelmann

D.R. n° 79 “Jensen and Meckling 30 years after : A game theoretic view”, Jacques Thépot

D.R. n° 80 “Organisation artistique et dépendance à l’égard des ressources”, Odile Paulus, novembre 2006

D.R. n° 81 “Does collateral help mitigate adverse selection ? A cross-country analysis”, Laurent Weill –Christophe J. Godlewski, novembre 2006

D.R. n° 82 “Why do banks ask for collateral and which ones ?”, Régis Blazy - Laurent Weill, décembre 2006

D.R. n° 83 “The peace of work agreement : The emergence and enforcement of a swiss labour market institution”, D. Broussolle, janvier 2006.

D.R. n° 84 “The new approach to international trade in services in view of services specificities : Economic and regulation issues”, D. Broussolle, septembre 2006.

D.R. n° 85 “Does the consciousness of the disposition effect increase the equity premium” ?, P. Roger, juin 2007

D.R. n° 86 “Les déterminants de la décision de syndication bancaire en France”, Ch. J. Godlewski

D.R. n° 87 “Syndicated loans in emerging markets”, Ch. J. Godlewski / L. Weill, mars 2007

D.R. n° 88 “Hawks and loves in segmented markets : A formal approach to competitive aggressiveness”, Claude d’Aspremont / R. Dos Santos Ferreira / J. Thépot, mai 2007

D.R. n° 89 “On the optimality of the full cost pricing”, J. Thépot, février 2007

D.R. n° 90 “SME’s main bank choice and organizational structure : Evidence from France”, H. El Hajj Chehade / L. Vigneron, octobre 2007

D.R n° 91 "How to solve St Petersburg Paradox in Rank-Dependent Models" ?, M. Pfiffelmann, octobre 2007

D.R. n° 92 "Full market opening in the postal services facing the social and territorial cohesion goal in France", D. Broussolle, novembre 2007

D.R. n° 2008-01 A behavioural Approach to financial puzzles, M.H. Broihanne, M. Merli, P. Roger, janvier 2008

D.R. n° 2008-02 What drives the arrangement timetable of bank loan syndication ?, Ch. J. Godlewski, février 2008

D.R. n° 2008-03 Financial intermediation and macroeconomic efficiency, Y. Kuhry, L. Weill, février 2008

D.R. n° 2008-04 The effects of concentration on competition and efficiency : Some evidence from the french audit market, G. Broye, L. Weill, février 2008

D.R. n° 2008-05 Does financial intermediation matter for macroeconomic efficiency?, P.G. Méon, L. Weill, février 2008

D.R. n° 2008-06 Is corruption an efficient grease ?, P.G. Méon, L. Weill, février 2008

D.R. n° 2008-07 Convergence in banking efficiency across european countries, L. Weill, février 2008

D.R. n° 2008-08 Banking environment, agency costs, and loan syndication : A cross-country analysis, Ch. J. Godlewski, mars 2008

D.R. n° 2008-09 Are French individual investors reluctant to realize their losses ?, Sh. Boolell-Gunesh / M.H. Broihanne / M. Merli, avril 2008

D.R. n° 2008-10 Collateral and adverse selection in transition countries, Ch. J. Godlewski / L. Weill, avril 2008

D.R. n° 2008-11 How many banks does it take to lend ? Empirical evidence from Europe, Ch. J. Godlewski, avril 2008.

D.R. n° 2008-12 Un portrait de l'investisseur individuel français, Sh. Boolell-Gunesh, avril 2008

D.R. n° 2008-13 La déclaration de mission, une revue de la littérature, Odile Paulus, juin 2008

D.R. n° 2008-14 Performance et risque des entreprises appartenant à des groupes de PME, Anaïs Hamelin, juin 2008

D.R. n° 2008-15 Are private banks more efficient than public banks ? Evidence from Russia, Alexei Karas / Koen Schoors / Laurent Weill, septembre 2008

D.R. n° 2008-16 Capital protected notes for loss averse investors : A counterintuitive result, Patrick Roger, septembre 2008

D.R. n° 2008-17 Mixed risk aversion and preference for risk disaggregation, Patrick Roger, octobre 2008

D.R. n° 2008-18 Que peut-on attendre de la directive services ?, Damien Broussolle, octobre 2008

D.R. n° 2008-19 Bank competition and collateral : Theory and Evidence, Christa Hainz / Laurent Weill / Christophe J. Godlewski, octobre 2008

D.R. n° 2008-20 Duration of syndication process and syndicate organization, Ch. J. Godlewski, novembre 2008

D.R. n° 2008-21 How corruption affects bank lending in Russia, L. Weill, novembre 2008

D.R. n° 2008-22 On several economic consequences of the full market opening in the postal service in the European Union, D. Broussolle, novembre 2008.

D.R. n° 2009-01 Asymmetric Information and Loan Spreads in Russia: Evidence from Syndicated Loans, Z. Fungacova, C.J. Godlewski, L. Weill

D.R. n° 2009-02 Do Islamic Banks Have Greater Market Power **?**, L. Weill

D.R. n° 2009-03 CEO Compensation: Too Much is not Enough!, N. Couderc & L. Weill

D.R. n° 2009-04 La cannibalisation des produits à prix aléatoires : L'Euromillions a-t-il tué le loto français?, P. Roger & S. Chabi

D.R. n° 2009-05 The demand for Euromillions lottery tickets: An international comparison, P. Roger

D.R. n° 2009-06 Concentration in corporate bank loans What do we learn from European comparisons?, C.J. Godlewski & Y. Ziane

D.R. n° 2009-07 Le mariage efficace de l'épargne et du jeu : une approche historique, M. Pfiffelmann

D.R. n° 2009-08 Testing alternative theories of financial decision making:an experimental study with lottery bonds, P. Roger