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## Résumé

Cette thèse étudie le comportement des investisseurs au travers de leur performance et de leurs attentes durant les crises financières de 2008-2011 et de leurs croyances. Elle se compose de trois chapitres.

Dans le premier chapitre, nous faisons une revue de la littérature existante sur la performance des investisseurs individuels, leur biais comportementaux et leurs préférences. Nous montrons les principales lacunes en terme de performance des investisseurs individuels ainsi que leurs principaux biais comportementaux. Nous mettons également en lumière l'apport des neurosciences dans la compréhension du comportement des investisseurs individuels.

Dans le deuxième chapitre, nous étudions l'impact des crises financières de 2008-2011 sur la performance des investisseurs individuels et leurs attentes à l'égard de leurs intermédiaires financiers dans quatre différents pays : Allemagne, Belgique, Luxembourg, France. Nous établissons également une comparaison en fonction du niveau de richesse des investisseurs à l'intérieur de chaque pays mais aussi globalement. Nos données proviennent de questionnaires distribués à des gestionnaires d'actifs dans les plus grandes banques des pays pris en considération ainsi que des données de marché historiques pour chacun de ces pays. Nous montrons que les investisseurs les plus fortunés sont les moins réfractaires à la prise de risque que ce soit avant ou après les crises financières, quel que soit le pays pris en considération. Nous remarquons aussi que ces derniers adoptent les stratégies d'investissement les moins conservatrices. Enfin nous notons un important changement des attentes des investisseurs par rapport à leurs intermédiaires financiers, demandant plus de transparence et un meilleur service clientèle, quel que soit le niveau de richesse. Nous

montrons enfin que ces attentes peuvent être contradictoires notamment chez les investisseurs les moins fortunés.

Dans le troisième chapitre, nous fournissons un test expérimental sur la formation des croyances chez les investisseurs individuels d'après le modèle de Brunnermeier et Parker (2005). Nous utilisons à cet effet une expérimentation avec deux loteries identiques excepté leur skewness. Nous montrons que les participants à cette expérimentation ressentent des émotions par anticipation une fois qu'ils ont pris connaissance de la loterie à laquelle ils vont jouer. Ces émotions se forment à partir de la deuxième minute d'attente et restent stables jusqu'à ce qu'ils prennent connaissance de leurs gains. Par ailleurs, ces émotions par anticipation sont aussi fortes que celles ressenties une fois leurs gains connus. Enfin nous montrons que les sujets participants à la loterie avec une skewness positive présente moins de capacité d'auto régulation que les autres sujets. Les émotions qu'ils ressentent sont plus fortes et plus persistantes que chez les autres.

## **Abstract**

This thesis studies the investors behaviour through their performance and their expectations during the 2008-2011 financial crises as well as their beliefs formation. It consists of three chapters.

In the first chapter, we review the literature on individual investors performance, their behavioural biases and their preferences. We highlight their lack of performance on financial markets and their main behavioural biases. We also exhibit the contribution of neurosciences in the understanding of the investor's brain.

In the second chapter, we study the impacts of the 2008-2011 financial crises on individual investors returns and their expectations towards their financial intermediaries in four different countries: Belgium, France, Germany, Luxembourg. We also consider investors differences regarding their endowment, inside each country and globally. Our dataset is extracted from questionnaires administered to asset managers in the main banks in the countries considered as well as historical market data for each country. We show that wealthier investors are less risk averse and their level of risk aversion has not changed with financial crises whatever the country considered. Furthermore, these wealthier investors adopt less conservative investment strategies than retail ones. We notice an important shift regarding the investors' expectations towards their financial intermediaries, since the crises they ask for more transparency and more client services. We also show that these expectations may be contradictory a bit in retail investors.

In the third chapter, we provide an experimental test of investors beliefs formations according to Brunnermeier and Parker model (2005). For this purpose, we use a two identical lotteries design except in terms of skewness. We show that participants to this experiment feel anticipatory emotions once they have learned the lottery they will play. These emotions are formed from the second waiting minute and remain stable until they learn their gains. Besides, anticipatory emotions are as strong as emotions felt once the payoffs known. Finally, we demonstrate that subjects participating in the positively skewed lottery exhibit less self-regulation than other subjects. Hence, their emotions are stronger and more persistent.



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# General introduction

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## **1. Why are individual investors so naïve?**

Over the past decades, financial news has given many examples of injured individual investors by their investment decisions, especially during the 2008 financial crisis. None investors seem to be saved from investment mistakes, wealthy individuals, celebrities, banks, funds and small savers.

In this regards, the Madoff scandal offers a particularly good case study. For many years, individuals' investors as well as professional ones trusted Bernard Madoff and his above the average returns without asking themselves any questions with very few exceptions like the report submitted by Harry Markopolos to SEC, dated November 7, 2015 "The World's Largest Hedge Fund is a Fraud". When financial markets dropped in September 2008, several investors wanted to withdraw their investments, causing the fall of the system. Many kind of investors have lost money in the scandal from the wealthiest to the smallest. Some have even lost all their savings.

This scandal leads a question: why are investors so naïve while financial history is plenty of such scandals.

Academic research widely investigates individual investors performance in financial markets, biases, expectations, preferences and under diversification, leading to the fact that individual investor suffers from several biases at his expense.

## **2. Thesis organization**

The aim of this three-essays thesis is to investigate a particular aspect of the individual investors: how does he faces risk? This thesis is organized as follows

In the first chapter we draw a survey of the existing literature on investor behaviour. We first present his general performance on financial markets with cross countries and cross sectional differences. Then, we focus on the main behavioural biases he has to deal with, causing his poor performance on financial markets. We also look at his preferences in terms of risk and time and beliefs. Afterwards, we examine the new insight on investor's brain that neurosciences offer.

In the second chapter, we investigate the impacts of the 2008-2011 financial crises on individual investors across four countries (Belgium, France, Germany and Luxembourg) and two types of individual investors (high net worth and retail investors) with questionnaires submitted to asset managers and historical data on asset allocation. We show that wealthier investors are less risk averse than others, whatever the country considered. We also notice that wealthier investors adopt less conservative strategies. We exhibit the new expectations investors have towards their financial intermediaries.

In the third chapter we investigate the individual investors beliefs formation through the model of Brunnermeier and Parker (2005). We provide a two lotteries design with equal lotteries except for skewness. We show that investors form anticipatory emotions once they know the lottery they play from the second minute of the waiting interval until they learn their payoffs. Furthermore, this anticipatory emotion is as strong as the emotion felt when receiving the earnings. Finally, we show that subjects playing the skewed lottery exhibit less self-regulation than others. Their emotions are more robust and more persistent.

### **3. Contribution**

The different chapters of this thesis contribute differently to the academic research on investor's behaviour.

Far be it from us to pretend that our literature review may be considered as approaching the quality of the ones from Barberis and Thaler (2003) in Behavioural Finance or Sébastien Pouget (2000) in Experimental Finance. Nevertheless, we provide a corpus which try to gather all methods used in Finance (theoretical, empirical, experimental and neurological) in the aim of explaining the investors' behaviour across countries and across investors' characteristics.

In the second chapter we conduct a survey based study across four countries (Belgium, France, Germany and Luxembourg) and across two different types of individual investors (high net worth and retail investors). We analyse our questionnaires in two ways: qualitatively and quantitatively and compare the results with historical data in the same countries from

2008 to 2012. We show that wealthier investors are less risk averse than others before and after the crises, whatever the country considered. We also show that wealthier investors adopt less conservative investing strategies. Then, we exhibit changes in investors' expectations regarding their financial intermediaries. They wish more transparency and more client services whatever the type of investors considered.

In the third chapter, we provide a physiological test on the model of Brunnermeier and Parker (2005) with a two equivalent lotteries experiment except in terms of skewness. We show that participants experience anticipatory emotions regarding their future outcomes from the second minute of the waiting period once they know the lottery they play. This anticipatory emotion is as strong as the emotion felt once they learn their earnings. Finally, we highlight that subjects taking part in the skewed lottery exhibit less self-regulation than others. Their emotions are stronger and more persistent.

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# Chapter 1: Literature Review on Investor Behaviour

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## 1. Introduction

Following various scandals in financial markets over the last decades – the Madoff scandal being one of the famous regarding individual investors – evidence is acquired that individual investors suffer from several issues regarding their investment strategies.

The Madoff scandal is symptomatic of the lack of financial knowledge, naïve diversification and over-optimism of individual investors. Furthermore, the scandal affected wealthy investors as well as small savers all around the world. Another famous example, but less global was the Euro tunnel scandal. British government required private financing only. Hence, French and British governments called out private investors to purchase Euro tunnel stocks. Around 80% of purchasers were French small savers who found a good opportunity to save money for their retirement plan. Indeed, they were promised good and safe returns. Unfortunately, construction was delayed and the stock value of Euro tunnel dropped. Many investors lost most of their savings and the scandal made headlines in French newspapers and newscast late in the 80's.

One may ask himself how can individual investors remain so naïve about their asset allocation, when plenty of such examples exist through financial history?

The aim of this literature review is to address the following questions:

- How does individual investor perform on financial markets?
- What are the main drivers of this performance?
- How new fields in Science, especially neurosciences can help understanding individual investors behaviour?

## **2. Individual investor returns**

### **2.1. Long-term returns**

Barber and Odean (2000) analyse trading activity from 78,000 households in the US from 1991 to 1997 from the same discount brokerage firm. This dataset is innovative because it contains demographic data as well as positions and trading records. They show that, in their sample, households who managed their own portfolios earned gross returns on average 18.7% compared with the mean gross of an averaged value-weighted market (17.9%). However, when taking into account the net performance (after transaction costs and bid/ask spread), the average household earning was 16.7%, subpar the value-weighted market. In addition, the authors explain that investors who trade most actively earn less. They divide their sample into quintiles and show that the 20% of investors who trade most earn annually about 10% (net value) and the 20% of investors who trade least earn about 20%.

This pattern is not specific to the US case. Grinblatt and Keloharju (2000) investigate the behaviour of foreign and domestic investors in the Finland market with a 2-years trading dataset. The authors calculate the investors performance on day  $t$  by the difference between the buy ratio of four stocks that future performance are in the top quartile minus the buy ratio

of the four stocks with future performance (from  $t+1$  to  $t+120$ ) in the lowest quartile. If the difference is positive, the buy ratio of future winning stocks is over the buy ratio of future losing stocks and thus the investor is a better performer. They find that the buy ratio for households is positive only 45% of the time. On the other hand, foreign investors and local financial companies have a positive ratio more than 55% of days. Thus, individual investors are buyers of weak performance stocks.

Barber et al. (2009) observe a similar pattern in Taiwan from 1995 to 1999. Their dataset allows them to compare all investors. They find that the aggregate portfolio of individual investors underperforms annually by 3.8%. The overall losses made by individual investors represent 2.2% of the Taiwan's GDP. In the same time the aggregate portfolio of institutional investors over perform by 1.5%.

Odean (1999) finds consistent results with individual records in the US, highlighting the poor performance of individual investors before trading costs. He uses trading records of individual investors from a large discount brokerage firm between 1987 and 1993. His findings show that the stocks bought by individual investors underperform the stocks sold in the year after the transaction.

## **2.2.Short-term returns**

Regarding short term returns outside the US (1 week or less), Barber et al. (2009) report that individual investors suffer from losses on both their short term and long term trades. They

construct a portfolio that mimic daily net purchases. They find negative earnings with monthly alphas of -10.97%, -3.27%, -1.91% for respectively 1 day, 10 days and 25 days.

Andrade et al. (2008) find the same results in Taiwan too with data from 1994 to 2002. Stocks bought heavily by individual investors perform poorly the following week, while those sold perform well.

In the US, individual investors appear to perform better. Using NYSE data between 2000 and 2003, Kaniel et al. (2008) demonstrate that the first decile of stocks heavily bought by individual investors has returns of 16 basis points over the next 20 trading days. With the same dataset they show (2011) that the aggregate stocks bought the 10 days before an earnings announcement over perform those sold in the 2 days around the announcement.

### **2.3.Order types**

Research is mixed about individual investors profits and market order types. The Taiwan Stock Exchange functions only with limit orders. Barber et al. (2009) categorize with their data trades as passive or aggressive. Aggressive trades are those with prices higher than the most recent unfilled limit order. Buy and sell orders are categorized in the same way. Individual investors loose on their aggressive trades on short and long term. However, they make profits from their passive trades at short horizons in the range of 1 to 10 days following.

Using data from the Finnish Stock Exchange, Linnainmaa (2010) finds that individual investors lose money on their trades regarding their limit orders they use vastly (about 75%).

This reason is not that other investors take advantage from their limit orders. He shows that individual investors limit orders decrease by more than 3% in the following 63 days. However, their market orders increase by more than 3.5% in the same time interval.

### **3. Factors influencing investor returns**

#### **3.1. Investors capacities**

Grinblatt et al. (2012) investigate the relation between IQ and the stock selection made by individual investors in Finland between 1995 and 2002. To measure IQ, they use the Finnish Armed Force Intelligence Assessment (FAF) distributed to males around age 20 to detect best candidates for mandatory military training. The test contains 120 questions divided in three domains: mathematical knowledge, verbal skills, logical skills. The global score for the test ranges from 1 to 9 (most intelligent). The authors define low IQ investors, investors with FAF score between 1 and 4 and high IQ those with FAF score of 9. Hence, 24% of their sample is low IQ while 8% is high IQ. They find that high IQ investors make better trades than low IQ with a better trade execution.

Other research comfort these results with inside the US. Korniotis and Kumar (2009a) demonstrate, using brokerage records from 1991 to 1996 that investors with higher cognitive abilities over perform the others by more than 3%. They also find that individual investors performance decreases with age.

Van Rooij et al. (2011) investigate the link between financial literacy and performance on financial markets in Netherlands. They exhibit that investors with higher level of financial literacy are more likely to participate in financial markets and make more profits.

Regarding 401(k) plans domain, Agnew and Szykman (2005) test whereas the investor's financial knowledge might influence his choices regarding saving plans. They conduct two experiments to test the information overload leading to adopt a default "saving plan". They compare the number of investment choices offered, the similarity of choices and the way choices are displayed, controlling for the financial knowledge of participants. Their results demonstrate that investors with a low level of financial capabilities invest more in the default plan (about 20%) than investors with high capabilities (2%). This behaviour is defined by Choi et al. (2002) as "the path of least resistance".

### **3.2. Gender differences**

In a paper investigating the gender overconfidence between men and women from 1991 to 1997, Barber and Odean (2001) find that men are more prone to overconfidence. Indeed, they trade 45% more than women. Even if both earn poor returns, men perform worse because of their excessive trading activity and the resulting trading costs.

Cervellati et al. (2011) find similar results in Italy with a data sample from a small cooperative bank between 2005 and 2007. They measure effects on age, gender as well as job position and incomes from online traders. They find no evidence about the effects of age on

trading behaviour but show that the number of trades increases when clients are men, self-employed, retired, or online traders.

### **3.3. Day trading**

Barber et al. (2013) investigate the performance of day traders from 1992 to 2006. They choose a country where day trading is a common habit: Taiwan. Day traders represent about 17% of all trading volume exchanged in the Taiwan Stock Exchange and are over 300,000. The author rank day traders regarding their returns in a year  $y$  and measure their performance in year  $y+1$ . Only the 1% of day traders (about 4,000) the most profitable the prior year earn positive returns net of transaction costs the following year. The top 500 day traders earn gross returns of 61 basis points on their day trading portfolio compared with the thousands of traders with intraday returns of -11.5 bps per day. This research show that day traders outperform other traders that trade less frequently. This suggest a kind of performance persistence over time. Coval et al. (2005) show persistence in the performance of individual investors. They classify investors in deciles according to their performance during the first half of their sample and compare it with performance of the same investors during the second half of their sample. The earning spread between the top and the bottom decile is around 5 basis point per day. Per year, investors in the top decile beat investors in the bottom decile by 8% per year.

## **4. Behavioural biases as an explanation of bad individual investor performance**

In the previous section we show that individual investors have poor performance in average and that performance is dependent of cross sectional aspects such age, gender or skills. The underperformance of individual investors is even worst when taking into account trading



costs. One of the reasons is the bad security selection made by investors (Agnew & Szykman 2005). In the following section we investigate the main biases leading to these bad investment performances.

## **4.1.Overconfidence**

Overconfidence is one of the most behavioural biases studied in Finance. Literature on the topic is numerous with many literature reviews already existing (Moore and Healy 2008). Overconfidence can take many aspects such as miscalibration, better-than-average effect and self-attribution bias.

### **4.1.1. Miscalibration**

Miscalibration is defined as the tendency that have individuals to overestimate the precision of their information. This bias is often measured through answers to difficult questions, one is asked to provide confidence intervals to these questions such that the correct answer lies in this interval with a 90% probability. People well calibrated usually provide intervals containing the correct answer more than 90% of the time.

Most theoretical papers based on overconfidence such as Daniel et al. (1998) or Gervais and Odean (2001), use miscalibration. Extension from Kyle (1985) or Grossman and Stiglitz (1980) assume that investors are prone to miscalibration, overestimating the precision of their private signals. This behaviour leads those investors to trade too much.

Biais et al. (2005) make an experimental test of miscalibration following Plott and Sunder (1988) experimental market with pre experiment questionnaires to value participants miscalibration. However, they add short sales possibility and a call auction in addition to continuous auction. In their setup one single risky asset is traded and this asset pays a liquidating dividend of 490, 240 or 50 francs with equal probability at the end of the game. Before the experiment starts, each participant receives a private and imperfect signal about the asset's dividend. For instance, when the final value is 50 francs, half players knows that the dividend will not be 490 francs and the other half knows that the dividend will not be 290 francs. If traders are miscalibrated they will overestimate their private information about the final dividend. The authors find a clear negative correlation between miscalibration and trading profits make by participants. The average return of the 25% least miscalibrated traders was about 131.36 and the average return of 25% most miscalibrated was about -147.67.

Grinblatt and Keloharju (2009) study overconfidence as well and sensation seeking in the Finnish stock market. They show that overconfident investors tend to trade more than others.

#### **4.1.2. Better-than-average effect**

The second type of overconfidence is the tendency one may have to believe himself better than a median individual. Glaser and Weber (2007) test several behavioural biases such as miscalibration, better-than-average, unrealistic optimism and illusion of control of 215 German investors who responded to a questionnaire. They find no evidence of the effect of miscalibration on trading volume. However, investors who think themselves better-than-

average regarding their investment abilities and past performance in financial markets trade more.

### **4.1.3. Self-attribution**

The self-attribution bias is defined as the tendency investors have to attribute their successes to their own competence and their failures to bad luck. Barber and Odean (2002) investigate the behaviour of more than 1,600 investors who have switched from phone to online trading between 1991 and 1996. They find that investors who switched to online trading performed better before switching, beating the market by 2% annually on average. But, after trading online, they start trading more and make less profits, performing under the market by 3% annually. The authors explain this drop in performance by self-attribution and overconfidence.

## **4.2. Gambling motivation**

Kumar (2009) analyse data from a US discount brokerage between 1991 and 1996 to find whereas sociological and psychological factors that are known to encourage lottery purchases influence investments in lottery type assets. They show that people investing more in lottery type assets have a lower mean performance. They also find that some sociological factors that impact lottery purchases have the same influence on lottery type assets purchasing. Indeed,

investors poor, young, living downtown, tending to vote Republican, belonging to specific minorities, invest more in lottery type assets.

Grinblatt and Keloharju (2009) test sensation seeking (gambling motivation) and overconfidence as factors leading to excessive trading activity in Finland. They measure overconfidence with data from a questionnaire administered to enter the Finnish Army which measures respondents' true and perceived abilities. They use traffic tickets as a proxy for gambling motivation making the assumption that investors speeding are sensation seekers. Overall, gambling motivations and overconfidence lead investors to trade more.

Dorn and Sengmueller (2009) find similar results using trading and survey data from 1,000 German investors. Investors who claim themselves as "enjoying investing" or gambling turn over their portfolios 100% more than other investors. The authors highlight that the gambling motivation itself explain the investors' excess trading and balance the decrease in performance.

### **4.3. Familiarity and local biases**

The effects of the local bias about investors' behaviour is unclear. Some research show that they have an informational advantage when investing in companies close to them or in companies in the same industry as they are employed in and this informational advantage leads to higher returns. Other research argue that individuals overinvest in companies they are familiar with, leading to under diversification and lower returns.

Massa and Simonov (2006) study familiarity as an information driver on Swedish investors. They show that investors invest more in stocks closely related to them either geographically or professionally. They argue that this familiarity investment strategy allows investors to earn higher returns. Ivkovic and Weisbenner (2005) demonstrate the same advantage of investing in closely related firms. In their sample from 1991 to 1996, households earned superior returns of more than 3% on their local stocks compared with their foreign stocks. However, using the same dataset, Seasholes and Zhu (2010) find contrary results and show that individual investors investing in local stocks do not earn abnormal excess return.

#### **4.4.Mood**

Some factors like weather have an impact on peoples' mood. Hirshleifer and Shumway (2003) find evidence that sunny weather influence trading activity. They use daily market returns data from 26 countries between 1982 and 1997. The authors find that sunshine is strongly correlated

with daily stock returns but find no relation between stock returns and other weather conditions such snowing or raining. This weather strategy implies very frequent trading, thus only investors with low transaction costs can take benefit from such strategy.

Edmans et al. (2007) investigate market reactions induced by investors' changes in mood. They use soccer, cricket, rugby and baseball outcomes as proxies of investors' mood. They find a strong correlation between bad sports outcomes and market decline. A loss in the World Cup elimination stage leads to an abnormal stock return of -49 basis points the next trading day. This effect is stronger in small markets and with the most popular games.

## 4.5. Disposition effect

The disposition effect is known as the propensity individual investors have to hold stocks that has decreased in value and sell stocks that has increased in value relative to their purchase price (Shefrin & Statman, 1985).

Several papers have confirmed the presence of the disposition effect. Weber and Camerer (1998) conduct an experiment to test the disposition effect. In their study, participants make portfolio decisions with six risky assets before 14 periods. Probabilities of increase vary across stocks but not across rounds. Subjects know the probability distribution but not which stock will increase (or decrease) the most. They find that that 60% of sales are winners sales while 40% of sales are losers sales.

Odean (1998) uses 10,000 trading records from an US discount brokerage between 1987 and 1993 to compare the investors rate of selling winners (realized gains) and losers (realized losses) with the opportunities to sell winners and losers. He demonstrates that the rate of realized gains is 50% higher than the rate of realized losses.

Feng and Seasholes (2005) find that individual investors in China learn to avoid the disposition effect. Investor sophistication and experience (time since the first trade) reduce the disposition effect by 37%, but fails to eliminate it.

Barberis and Xiong (2009) have modelled the trading behaviour of investors with prospect theories preferences. Their findings suggest that when investors' performances are evaluated

on an annual basis, the prospect theory preferences do not lead to disposition effect. Indeed, investors seem to realize more losses than gains.

Summers and Duxbury (2007) experimentally investigate the involvement of emotions in the disposition effect with two experiments. During the first experiment, participants are endowed with an asset they have not chosen in period 1. They are then informed of the current value of the asset and the history of price movements of this asset during the previous period. The asset value in period 1 is then revealed to subjects. Hence, they are not responsible for the gains or losses they experienced in this period. Next, they are allowed to trade the asset and the final price is revealed in period 2. In the second experiment, half of the subjects are passive investors endowed with a fictive company stock. The others are endowed with an equivalent amount of cash and need to actively choose to hold stocks, contrary to experiment 1. The authors show that the disposition effect does not exist when participants do not actively choose the assets in their portfolios. If they do not feel themselves responsible for the investment decisions leading to gains or losses, they are not more prone to sell winners more than losers. Therefore, emotional regret and pride lead to the disposition effect.

Weber and Welfens (2011) experimentally analyse the purchase-repurchasing behaviour linked with regrets. They specifically investigate the investors' preference for purchasing additional shares of a stock that has declined previously and the tendency to repurchase stocks they have previously sold at a higher price. They find that participants are more likely to purchase stocks if the price of the stock declines following a purchase in the previous period only when they are responsible for the original sale; otherwise, subjects refrain from repurchasing stocks at a higher price than their prior sale price to avoid admitting a wrong decision and regret.

Strahilevitz et al. (2004) find similar results about emotional regret with empirical data about household between 1991 and 1999. They show that households are more likely to repurchase stocks they have previously sold if the price dropped since the previous transaction.

#### **4.6.Path dependence**

The simplest definition of learning is to repeat actions that procured pleasure and avoid actions that procure pain or disappointment. Several studies demonstrate that investors are particularly sensitive to past successes. Learning reinforcement is also defined as path-dependence.

Choi et al. (1009) document this learning intensification pattern with a dataset from 1998 to 2000. They show that individual investors extrapolate too much regarding their savings decisions. Those who experienced previous greater outcomes or lower variance in their 401(k) plans tend to invest more in these plans than investors who have experienced less pleasuring experiences.

Strahilevitz et al. (2004) show that investors are more likely to repurchase an asset they have previously sold for a profit rather than an asset they previously sold for a loss.

De et al. (2010) show that investors are more sensitive to the intensity than to the magnitude of a stimulus. They demonstrate that investors trade more actively when their past recent trades were successful and the influence of the success or failure is stronger than the amount gained or lost. Overall trading according to past success leads to a decrease in investors' profits.



## 4.7.Limited attention

Investors limited attention has two effects. On one side dedicating too little attention to information may result in delayed reaction to this information. On the other side, dedicating too much attention to information can lead to overreaction.

Barber and Odean (2008) find that attention influences investors purchase decisions. Indeed, they face searching problems when looking for stocks to buy. They do not systematically search. Many investors consider stocks that grab their attention in news or in terms or price movements.

Hirshleifer et al. (2008) demonstrate that market reactions to earnings surprises are smaller for companies announcing earning the same days where other firms announce theirs and post-earnings drifts are bigger similarly, because many companies compete to grab investors' attention in this pattern.

Seasholes and Wu (2007) examine attention buying side in the Shanghai stock market. They show that stocks that hit upper price limits grab attention of individual investors. Even individuals who have never owned a stock before are sensitive to this attention grabbing event. The upper price limit event coincides with an initial price increase and a mean reversion the following week. Hence, rational traders profit from this attention-based buying.

Several papers investigate the relationship between media and investors' attention. Engelberg et al. (2012) study overnight market reactions following Mad Money's recommendations. They find that market reactions are immediate after the recommendations. The abnormal overnight return is over 3% on their sample and the price movements are higher for wealthy

investors who watch the shows than for low income households. Moreover, the overnight return of the first buy recommendation is greater than the first time sell recommendation.

Engelberg and Parsons (2011) study the impact of events reported in newspapers on trading activity. They find that investors are more likely to trade an S&P 500 stock after an earnings announcement if this announcement was covered by local newspapers.

#### **4.8. Affect based trading**

Cooper et al. (2001) investigate stock price movements in reaction to the announcement of a company which changes its name into a dotcom name in the US. Between 1998 and 1999. They find a strong increase in stock prices with cumulative abnormal returns about 74% prior and after the changing name announcement. They also find that the premium investors apply to changing names companies does not depend on their level of involvement in the sector.

In another study, Frieder and Subrahmanyam (2005) test the effect of brand perception on investors and their willingness to hold stocks of firms with high brand recognition. They find strong correlation between brand visibility and stock holding of this firm. The authors argue that individual investors prefer investing in companies in which they think they have more information as it is more visible.

## 4.9. Naïve and insufficient diversification

Many papers prove evidence that individual investors do not hold diversified portfolios and therefore do not behave like risk averse investors, minimizing their idiosyncratic risk. Those who invest in stocks of their own company or the company they work in are particularly exposed, like Enron employees. Poterba (2003) study the 20 largest contribution plans managed by companies and find that over 45% of these plans are invested in company stocks.

Bernartzi and Thaler (2001) demonstrate naïve diversification with  $1/n$  heuristic. In one of their survey based experiments they ask participants to allocate their wealth between two funds (A and B) with three conditions. In the first condition, fund A is invested in stocks and fund B in bonds. In the second condition, fund A is still invested in stocks and fund B is a balanced fund with half stocks and half bonds. In the last condition, fund A is the balanced fund and fund B is the bond fund. The authors find that the final asset allocation chosen by participants mostly depends on the funds offered. Subjects use naïve diversification with  $1/n$  heuristic, they divide their money over the alternatives offered. When more stock funds are presented to them, they increase their allocation in equities. When more bond funds are presented the same happens with their fixed income allocation.

Huberman and Jiang (2006) test the robustness of this finding with 500,000 records about 401(k) plans data. They do not find the same influence of funds offered over investment decisions. They show that household tend to allocate their wealth uniformly across the funds they use. On average they used between 3 and 4 funds and this is not sensitive to the number of funds that may be offered. Finally, they argue that the inclination an investor has to allocate

his contribution to equity funds is not sensitive to the ratio of equity funds proposed over all funds.

On average individual investors hold very few stocks. According to Barber and Odean (2000) individual investors only hold about four stocks. Goetzmann and Kumar (2008) show that individual investors on average hold under-diversified portfolios. The level of under-diversification greatly depends on the age, the income, the education level and the level of sophistication. Hence, Under-diversification is greater amongst younger, low income, uneducated, and less sophisticated investors. Furthermore, they document that under-diversification is correlated with over-weighting stocks with high volatility and high skewness. These results are in line with Grinblatt et al. (2011) who show that Finnish investors with higher IQ hold a larger number of stocks and mutual funds.

Campbell (2006) portrays the household investment behaviour. He shows that many households solve the complex investment problem adequately. However, some households, typically poorer and less educated ones, make investment mistakes such as under-diversification amongst others. He documents that about 50% of the volatility in retail portfolios is due to a lack of diversification.

The home bias is a strong phenomenon, investors prefer familiar and local companies and stocks though this trend is decreasing. French (2008) reports that the average U.S. investor portfolio allocated to foreign stocks grow from 2% in 1980 to 8.5% in 1990 and more than 27% in 2007. Huberman (2001) study the geographic bias through regional phone companies. He shows that investors prefer investing in a local rather than a distant phone company.

## **5. Investor preferences**

### **5.1. Optimistic beliefs and the preference for skewed returns**

Several papers have investigated optimistic beliefs among individual investors. One of the most popular models is the Optimal Expectations framework from Brunnermeier and Parker (2005). In this model economic agents are forward looking. Believing that an asset they invest in will pay well make them better off.

Hence, this behaviour generates first order gain with the increase in anticipatory utility and a second order loss because of the distort behaviour. Moreover, agents may choose not to distort beliefs when large amounts are at stake.

In a subsequent paper (2007) the authors show that as the cost of holding biased beliefs is second order, agents hold biased judgments about probability distributions. Therefore, they under diversify their portfolios and exhibit a preference for skewed assets that allow greater first order anticipatory pleasure. The rising demand for skewed assets lead to a lowering of their incomes.

### **5.2. Delayed earnings**

One may desire to postpone possible bad outcomes because it makes him better off. Several papers investigate this possibility with medical testing. Oster et al. (2011). They use a dataset containing people at risk with Huntington disease (HD) who report their subjective belief

about having the disease. The authors rank patients in 5 categories. Patients with low risk profile to carry HD (they exhibit no signs but have one of their parents affected), people with less than 50% of having HD, patients with a risk between 50 and 89% of having HD, patients with probabilities of having HD between 90 to 98% and patients surely affected by the disease. Overall they find that untested individuals are over optimistic about their chances not to carry HD. Indeed, people with clear signs of HD do not have a significantly higher testing rate than those with less signs. Only patients with non-ignorable signs report the highest testing rate.

In another survey based experiment, Sieff and Loewenstein (1999) test reactions about HIV test results. They find that those who learnt they were positive to HIV experienced greater distress compared with others. However, regarding the anticipatory response provided by participants with post results responses the authors show that the anticipatory distress was higher than the actual distress felt by respondents.

Delayed consumption also apply to positive outcomes. Loewenstein (1987) asked students in a survey based experiment the amount of money they would be willing to pay to receive or avoid certain outcomes. Among the possible outcomes several are pleasurable (movie star kiss) and others very unpleasant like an electric shock. He shows that participants are more willing to pay to delay very pleasurable outcomes to enjoy from some anticipation about this future outcome. Likewise, they are more willing to pay more to avoid unpleasant outcomes (see Figure 1 for a description of the experiment).

Fig. 1 summarises results from a survey in which 30 undergraduates were asked to specify the 'most you would pay now' to obtain (avoid) each of five outcomes, immediately, and following five different time delays. The outcomes were: (1) obtain four dollars; (2) avoid losing four dollars; (3) avoid losing one thousand

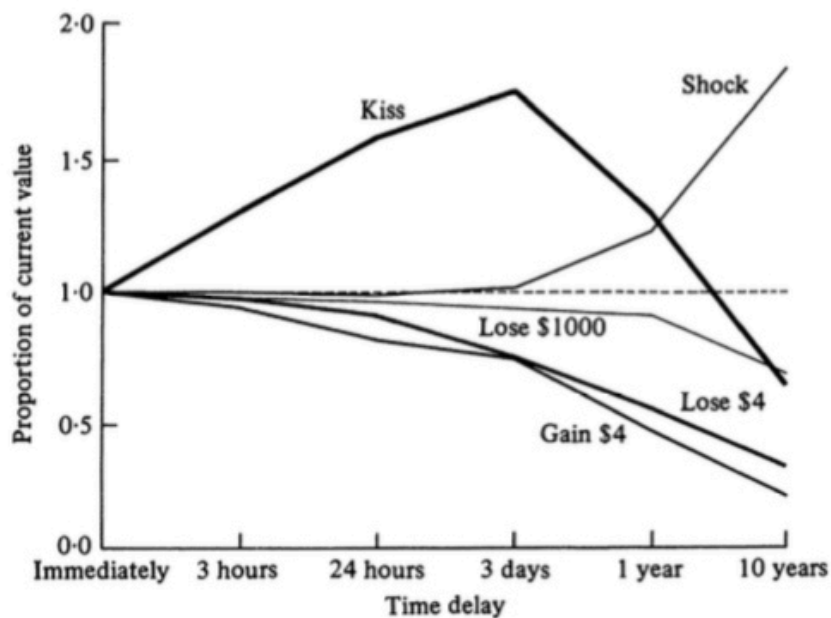


Figure 1. Description of the experiment made by Loewenstein in 1987. Extracted from Loewenstein (1987)

### 5.3. Valuation

Rottenstreich and Hsee investigate in two different papers subjective valuation. They find that investors valuating by feelings are very sensitive to extreme probabilities and less to their variations. People valuating by calculation however, present sensitivity on the entire range of probabilities (see Figure 1).

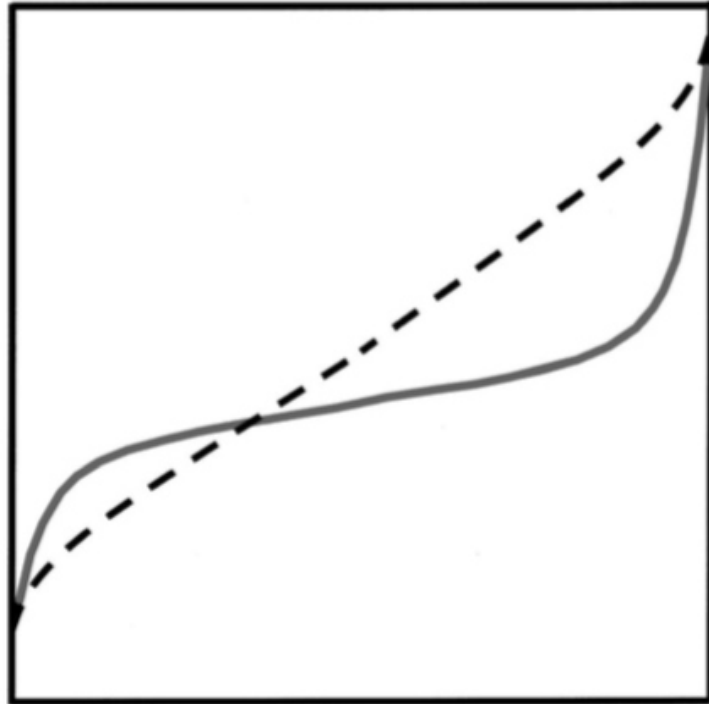


Figure 2. Probability weighting based on calculation (dot line) and feelings (continuous line). Extracted from Hsee and Rottenstreich (2004)

In 2004 they conducted several survey based experiments. In the first experiment the authors manipulate the valuation process with a prior task. In the calculation condition subjects are asked to calculate some probabilities and in the feeling condition they are asked to answer their feeling about personalities. Then participants need to answer how much they are willing to pay for a set of Madonna CDs (5 or 10 depending on the version). In the feeling condition subjects are insensitive to the number of CDs in the bundle whereas they value more the 10 CDs bundle in the calculation condition. They also find a “crossover” (participants value more the 5 CDs bundle in the feeling condition compared with the calculation condition and value less the 10 CDs bundle in the feeling condition compared with the calculation one) suggesting that feelings engendered by Madonna are affect poor.

In another experiment they test affect rich and affect poor items to find whereas affect-rich items encourage feeling-valuation. Participants need to imagine that pandas have been



discovered and they are asked some donation. In one treatment only one panda has been discovered and in the other four pandas have been found. In the affect rich condition, pandas are presented with cute pictures whereas they are presented with dots (1 or 4 dots) in the affect poor condition. Donations lie between 0 and 50 dollars with 10 dollar increments. Overall donations were higher for saving four pandas than for one. But, insensitivity is extreme for the affect rich condition without any differences in donations between one and four pandas. The authors find the same crossover as in the the previous experiment. Subjects are more willing to donate to save one panda in the affect-rich condition than in the affect-poor.

In the last experiment, Hsee and Rottenstreich test the valuation sensitivity with negative affect-rich items. Participants are asked to pronounce jail penalty for up to 10 years for an individual accused of mugging. The two conditions are empathy (affect-rich) and no empathy (affect-poor). In the empathy condition subjects are asked to put themselves in the position of the victim. According to the authors' predictions, sentences were less sensitive to scope than in the no empathy condition with a crossover.

## **6. Investor behaviour through Neurofinance**

In the last section, we have seen that a large amount of financial literature investigates the individual investor behaviour, his performance, the way he forms his preferences and manage his portfolio allocation. Several findings are puzzling in the sense that they are not reconcilable with classic models of rational behaviour. This issue has been challenged in three ways. New models of investor behaviour have emerged taking into account different

behavioural biases inherent influencing financial decisions (Kahneman and Tversky 1979) and several empirical studies using field data support (or invalidate) these theories (Barber and Odean 2001). Another set of studies uses experiments to allow more control over the environment have also challenged these theories (Biais et al. 2005, Weber and Camerer 1998 among others).

Since late 1990's another field is growing in Finance: Neurofinance. It adds to traditional experiments physiological measures such as fMRI or heart beat to test theories of the investor behaviour. These procedures allow researchers to have a direct access to the brain functioning during financial decision. Hence, many empirical and experimental studies have already challenged the standard economic view which assumes that investors decide maximizing their utility under the assumption that they behave in a rational way. Many questions about investor behaviour and deviations from rationality remain open, but several papers demonstrate that deviating from rationality may be optimal, allowing instantaneous well-being (Brunnermeier and Parker 2005), or maximization is impossible (Simon, 1959). Therefore, investors are satisfying rather than maximizing (Cohen, 2005).

In the following section, we will discuss the neural foundation of decision making under uncertainty and the main behavioural biases through Neurofinance.

## 6.1. Quick insight on the different brain regions and their involvement in human behaviour

### 6.1.1. The cortex

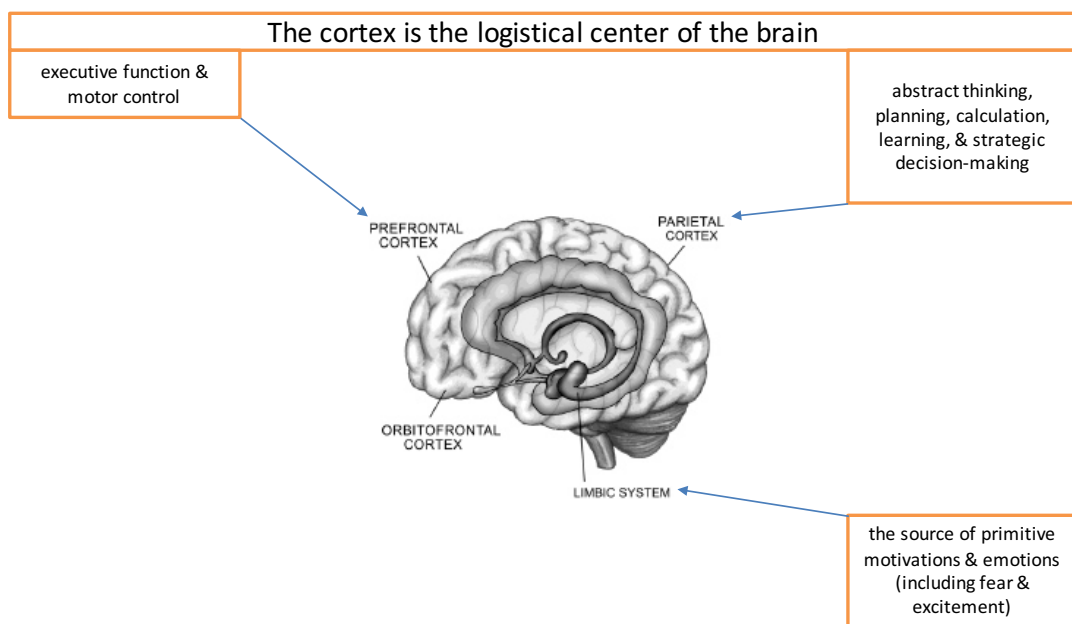


Figure 3. Cortex functions. Picture is extracted from Peterson (2010)

### 6.1.2. The reward system

The reward system is the coordinator of searching, evaluation, and the motivated potential rewards. Dopamine neurotransmitters are the main vector of signals transmission through the reward system.

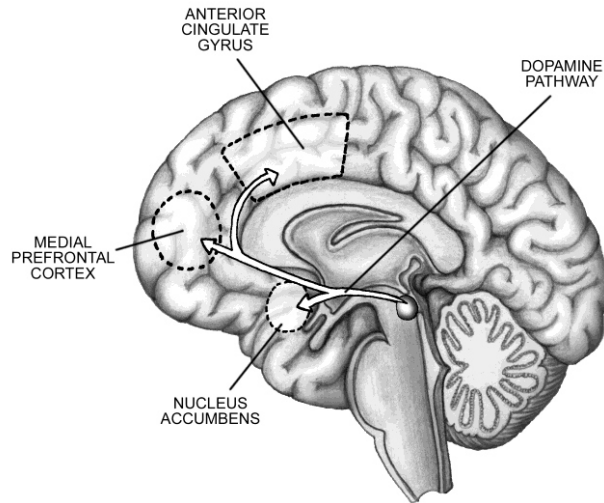
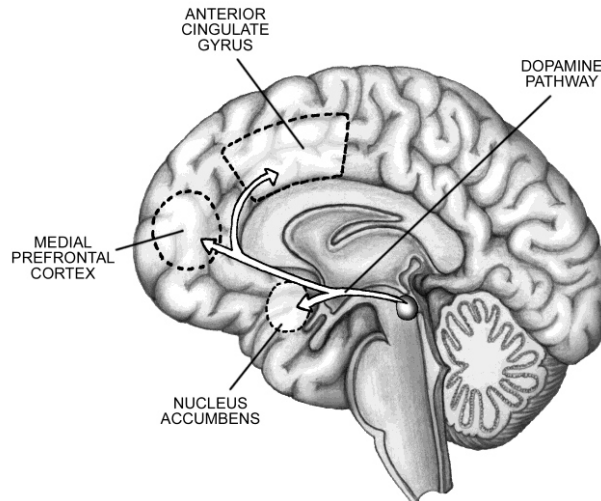


Figure 4. Description of the reward system. Extracted from Peterson (2010)

### 6.1.3. Loss avoidance system

The loss avoidance system finds its origin in the limbic system. It is the centre of fear and danger. Anterior insula and amygdala are particularly involved in loss avoidance. It is activated when threats are at stake. Emotions like anxiety, fear and panic find their origin in this system. Physiological events of the activation of this system are an increased level of stress, pain and panic.



*Figure 5. Regions involved in the loss avoidance system. Extracted from Peterson (2010)*

## **6.2. Decision making under uncertainty**

In the traditional expected utility theory, risk averse agents will only choose a risky action if the utility derived exceeds the utility derived from an alternative riskless choice. This theory lies on the following assumptions; First agents know with certainty the possible outcomes and their related probabilities. Second, agents have the capacities to calculate their expected utility. Hence, under this assumption an agent is able to probability weighting.

Different brain regions are at stake regarding expected utility. Knutson et al. (2001) demonstrate the role of three different subcortical regions with fMRI imaging in the expectation of monetary rewards. In their study participants are asked to perform a task in exchange of a monetary reward at the end of the experiment. Once in the scanner, participant saw several figures representing potential gains and losses, appearing for variable intervals of time. Afterwards they are shown a white target square which appears for a variable length of

time. Subjects trigger the win or the loss by pressing a button. They are then shown a feedback of their earning (or loss) as well as their cumulative earnings. Results show that while subjects anticipate a reward ventral striatum is activated and while they receive the reward, the ventromedial frontal cortex is activated.

In another study on increasing rewards and punishment, using a similar experimental design, Knutson et al. (2001) find that anticipation of increasing rewards leads a rise of the self-reported happiness, NAcc (nucleus accumbens) activation and medial caudate activation, while anticipation of punishment activates neither. However, only the NAcc is correlated with self-reported happiness.

These two results show an increasing activation of NAcc during gains anticipation but not losses. Besides, NAcc is a region rich in dopaminergic transmitters that are known to be linked with positive monetary rewards (Breiter et al. 2001) as well as the use of drugs, especially cocaine (Breiter et al. 1997).

According the Prospect Theory, gains and losses are processed the same way by investors. Hence, as NAcc is only active during anticipation of positive outcomes it can be the brain substrate of expected utility.

We have shown that NAcc is active when anticipation of monetary rewards is at stake only. Knutson et al. (2003) investigate the involvement of another brain region during the reception of a monetary reward. They find that the mesial prefrontal cortex (MPFC) is active during the assessment of a monetary reward. Hence, present utility and expected utility involve different brain regions. The subcortical brain (with NAcc) for the expected monetary rewards and the

prefrontal cortex (labelled as more human specific) for the outcomes realization (see Figure 3 for a description of the reward system).

However, Knutson et al. (2005) fail to find a brain region involved when anticipated losses are at stake.

Causse et al. (2011) investigate the plan continuation error (PCE) that make aircraft pilots. Pilots exhibiting this kind of errors are more willing to pursue flight plans despite bad meteorological conditions. They hypothesize that large and strong of negative emotional consequences, including economic pressure favours PCE. They test their prediction over 19 volunteers who perform simulated landing tasks. They find that volunteers exposed to the economic pressure exhibit lower reaction time suggesting lower level of reasoning before making the decision compared with the control group.

### **6.3. Assessing risk and ambiguity**

In the previous studies from Knutson we reviewed, participants were aware of the probabilities associated with the possible outcomes. Hsu et al. (2005) investigate the neural process of risk with two different treatments with fMRI. In the first condition subjects know the probabilities of the possible outcomes (risk) and in the other condition they do not fully know the probability distribution (ambiguity). They find that the orbitofrontal cortex (OFC) and the amygdala are the most active regions during ambiguity. The OFC is implicated in cognition processes and emotion integration while amygdala is involved when reacting to

emotional cues. Neither of these regions are active during the risk condition. Therefore, they are specific to ambiguity.

Amygdala is known to be involved in fear responses. Hence we can assume that participants under ambiguity experience fear when they are unable to fully understand the outcomes likelihood.

#### **6.4. Loss aversion**

In Prospect Theory, investors are less sensitive to gains than losses. The latter is viewed as a negative deviation from the investor own reference point. In addition, they value shifts from this reference point in a decreasing way. As an example, people perceive a shift from 1% to 2% as a bigger increase than a shift from 40% to 41%. They are risk averse in the gain region whereas they are risk seekers in the loss region. This explains the concavity of their utility function in the gain region and the convexity in the loss region.

Shiv et al. (2005) propose a neural test of myopic loss aversion. To that extend they compare outcomes earned by different groups of participants. The first group (normal) is formed of 19 healthy participants without any brain damages. The second group (target group) consists of 15 patients with brain damages in regions involved in the emotion processing such as amygdala or orbitofrontal cortex. The third group is composed of 7 control patients with brain lesions not involved in emotion processing. Each participant plays a lottery game. At the beginning of the experiment, they are endowed with 20 virtual dollars. They make several rounds of investing decisions where in each round they need to decide whether they want to



invest 1 dollar or not invest. If the subject decide to invest the experimenter toss a coin with 50% of losing 1 dollar and 50% of chance to earn 2.50 dollars. The game end after 20 rounds.

The authors make the assumption that patients with brain lesions involving emotion processing will be less risk averse than the control group since they are not affected by fear anymore. In the present study fear is induced by monetary losses. Results show that patients in the target group are more willing to take risks, investing more than 80% of the rounds on average compared with the two other groups investing around 60% of the time. On average they also earned higher outcomes from the game with average earnings about 25.70 dollars than other groups (respectively 22.80 and 20 for normal subjects and control group).

Furthermore, target patients do not exhibit increasing risk aversion when facing previous losses compared with other groups. They continue to invest whatever they win or lose while other participants show greater risk aversion when facing previous losses.

This result shows that when fear is involved in the neural process it alters judgment and “the negative side of emotions” inhibits the capacity one may have to think clearly.

## **6.5. Genetic component of trading behaviour**

Gambling, novelty seeking and drugs addiction have the same neural circuitry. The dopaminergic reward circuitry is known to be the “pleasure centre” of the human brain. Indeed, Breiter et al. (1997) show that dopaminergic circuits are involved in cocaine addict behaviour. However, the authors show that dopaminergic activity is solely linked with the

craving phase. This result is consistent with the classic economic theory which disconnect utility from money with goods gained with.

Several papers have investigated the link existing between risk taking behaviour and genetic components. Stenstrom et al. (2011) test the impact of testosterone and risk taking. They use the second-to-fourth-digit-ratio (2D:4D) and the length of the second finger relative to the sum of the lengths of all four fingers (rel2) as a proxies of prenatal exposure to testosterone across five topics: financial, recreational, social, ethical and health risk taking behaviours. They find that lower rel2 is predictive of greater risk taking in the financial, social and recreational domains and lower 2D:4D is predictive of greater risk taking in social and recreational domains.

Using data on identical twins completing portfolio financial decisions, Barnea et al. (2010) find a genetic component explaining around 30% of the variation in stock market participation and asset allocation. The authors show that while the family environment has a measurable effect on young individuals' behaviour, this effect does not last as the the individual gains experience. They argue that twins who grow up in similar environment as well as twins growing up in different environment exhibit the same investment behaviour beyond a common genetic component.

Coates and Herbert (2008) test the effects of the endocrine system on financial risk taking on London City traders. They find that trader's morning level of testosterone is a good indicator of his day profitability and that his cortisol level increases with the variance of his portfolio and the market volatility. Hence, testosterone is correlated with good performance and cortisol with uncertainty. Furthermore, cortisol is known to influence brain regions linked

with irrational financial decisions. Thus as cortisol fluctuates with risk and returns it may alter trader's ability to make optimal decisions.

In another paper, Coates et al. (2009) use 2D:4D as a predictor of future financial success among traders. 2D:4D has been proved as a good predictor of future success in highly competitive sports already. The authors demonstrate that 2D:4D predicts long-term profitability and the number of year traders remain in the business.

Frydman et al. (2010) test the effects of several genes on financial risk taking behaviour with a simple gamble game. They find that people with MAOA-L gene are more likely to take financial risks compare to MAOA-H carriers but only when it is advantageous given their preferences. MAOA-L carriers exhibit higher connectivity between prefrontal cortex and amygdala and the gene is known to contribute to aggressive and impulsive behaviour. Hence, they are more willing to take risks.

## **6.6.Emotion regulation**

Lo and Repin (2002) propose to test the emotional decision making process on 10 professional traders, taking biofeedback measures such as heart rate, skin conductance and blood pressure as proxies for these emotions. The authors show that traders exhibit greater emotional arousal around important events such as volatility peaks. They also demonstrate that experienced traders experience less these emotional arousals than less experienced ones. The authors argue that making quick decisions based on their emotional arousal is a necessary condition to in the decision making in traders.

Knutson et al. (2008) investigate the effect of positive anticipatory exciting environmental signals on risk taking behaviour in financial markets. They conduct an fMRI experiment on young student males. Before trials they are shown sexy female pictures. The authors find that risk taking is increased after an activation of the subject's nucleus accumbens via this prior picture. Therefore, subjects are more likely to participate in lower expected value gambles.

Porcelli and Delgado (2009) investigate the effects of acute stress on financial making decisions. In their experiment, stress is induced to subjects by immersion of one hand in cold water for several minutes. Non stressed control subjects follow the same procedure with hot water. Participants are then asked to perform a recognition memory task to check for the stress induction. Subjects participate in a gambling game where they face two alternatives either presented in a gain manner or in a loss manner. In one set participants are offered 80% of chance to win 0.75\$ and 20% of chance to lose 3\$. Alternatively, in another set of alternatives they are offered to win 1.5\$ with 40% of chance and 60% of chance to win 1\$. Another set of gambles has other probabilities. During the task, skin conductance is measured. Results show a significantly increase increase in skin conductance levels in the stress condition and stressed participants made riskier choices. Moreover, participants under stress made riskier choices in the loss domain compared with non-stressed and less risky choices than non-stressed in the win domain.

The authors argue that acute stress alter financial decision taking. They tend to use kind of automatized risk biases. They suppose that if stress disrupt resources usually used by the brain executive functions that may lead to an excess reliance on low level automatized systems.

Andrade et al. (2015) test the relationship between excitement and bubbles. Their experiment follows the experimental design of Smith et al. (1988). Participants trade an asset with a finite life of 15 rounds in a continuous double auction game. The asset pays a random dividend after each round with possible values of 0, 8, 28 and 60 cents. Hence, before the first round the asset fundamental value is 3.60 dollars decreasing by 24 cents after each round. In each market, three traders are endowed with 18 dollars and 1 share, three others receive 14.40 dollars and two stocks and the last three receive 10.80 dollars and three shares. Before the experiment starts, the experimenter shows participants a video tape to introduce emotions to participants. The emotional states that can be introduced are fear, calm and excitement. The authors find that bubbles are much larger in the excitement state than the others. The bubble amplitude in round 1 (difference between the average trading price of the asset and its fundamental value) is about 72 while it is respectively about 10.9 and 4 in the calm and fear treatments. This result suggest that excitement generated by increase prices in real stock markets fuel bubbles.

Emotions play a role in the beliefs formation process of investors. In the third chapter of this thesis we propose an experimental test of the Brunnermeier and Parker model (2005). In their paper they show that agents who form optimistic beliefs about their future outcomes make them happier. This belief has an immediate impact on their subjective well-being via anticipatory emotions, and encourage them to prefer skewed assets. In our experiment, we use two equal lotteries except for their Skewness. One has a positive skewness and the other a skewness equal to zero. Half participants in our study play the skewed lottery, while the other half play the non-skewed lottery. We show that subjects participating in the non-skewed lottery exhibit greater self-regulation than other subjects. Hence, they are less prone to optimism. Furthermore, we show that all participants feel positive anticipatory emotions

during the waiting interval between the revelation of the lottery and the results drawing, starting from the second minute of the waiting period. Finally, we show that the happiness felt by participants when learning their payoffs is as powerful as the anticipatory emotion they felt during the waiting period.

### **6.7. Intertemporal choices**

McClure et al. (2004) demonstrate in an fMRI experiment discount future rewards. They look for smaller and sooner rather than larger ones.

The authors exhibit that time discounting is under the influence on the limbic system which is specifically activated when one faces possibility of an immediately available reward and the prefrontal and parietal regions that are involved whatever the delay. Hence, it appears that during a time discounting decision, both regions compete against each other.

When the limbic system is more activated, it is more likely that a sooner reward will be chosen. But, subjects who choose longer and larger rewards exhibit a greater activation of the latter region. This region is associated with cognitive tasks such as calculation and planning.

### **6.8. Framing effect**

De Martino et al. (2006) test framing effect with fMRI imaging. In their experiment, participant receive at the beginning of each session their initial endowment. Afterwards,

subjects have to choose between a “sure” and a “gambling” options framed differently. The sure option is expressed positively as a gain (you keep...) or as a loss (you lose...). The gambling option is presented the same way with a pie chart expressing the probabilities.

The results show that subjects are very sensitive to framing. They are risk averse when frames are expressed as gains, preferring the sure option over the gamble one. Solely 43% of participants in that condition choose to gamble. On the other hand, when frames are expressed as losses participants are risk seekers. More than 60% of subjects in that condition choose to gamble. These results are in line with Prospect Theory.

The authors also find that amygdala seems to mediate framing. Indeed, it is activated with gain frames for both sure and gamble conditions. Furthermore, they show an activation of the orbital and medial prefrontal cortex, region associated with reasoning, in subjects less sensitive to framing. Put another way, the more rational subjects behave the more OMPC is activated. Overall, framing (gain and loss) is linked with amygdala activation, known as an emotional centre and as being involved in learning, danger and value-related predictions.

## **6.9. Disposition effect**

Frydman et al. (2014) propose a neural test of the disposition effect. They find robust results on three main predictions. First, when a participant will decide to sell a stock, brain activity in areas associated with encoding the value of the potential action at the time of the decision will be proportional to the difference between the sale and the purchase price. Hence, they expect brains areas involved in computation of the values of different options to be positively

correlated with the capital gained (ventromedial prefrontal cortex). Second, participants strongly influenced by realization utility will exhibit greater disposition effect (subjects with vmPFC activity at the selling time highly correlated with potential gain). Finally, when participants realize a capital gain they get a positive burst of utility (inversely a negative burst when they realize a loss) that should lead to an increasing activation of the ventral striatum which encodes changes in net present value of lifetime utility.



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## Chapter 2: Risk Aversion, Asset Allocation and the Role of Banks around Financial Crises

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### **Abstract**

The relation between individual investors' risk aversion and its influence on investors' asset allocation is the aim of this article. Nevertheless, we examine the expectations of the clients relative to their banks in the scope of the 2008-2011 financial crises. In order to test our researches, we use questionnaire survey data submitted to asset managers in 4 representative countries in Europe (Belgium, France, Germany and Luxembourg) and we compare the results obtained with time series data between June 2004 and June 2012 for the same countries. Our results show that when considering the investors' endowment, the wealthiest are the less risk averse and this has not changed with the financial crisis. Another main finding is their investment strategy; it is less conservative for wealthy investors. However, when we look at the expectations of investors on their financial intermediaries, all expect more transparency as well as more reputation and more client services. Therefore, these results need to be weighted by country as investors' investment strategies depend also on countries specificities such as taxes.

## 1. Introduction

Analysing the individual investors' behaviour is a wide topic of the literature in finance. Numerous papers in theoretical, empirical and experimental finance address this issue. It is well known that investors are sensitive to social biases such as age and social status (Cervellati et al. 2010) and cognitive biases such as overconfidence (Kahneman & Tversky 1992), disposition effect (Odean 1998), or experience (Malmendier & Nagel 2010).

Therefore, the understanding of the changes of the investors' behaviour around financial crisis is still an ongoing question. For that purpose, the recent 2008 financial crisis provides a good natural experiment. Several papers yet demonstrate changes in individual investors' behaviour during financial crisis, nevertheless little is known regarding the differences in behaviour between different types of investors in different countries and the impact of the financial crisis on investors' expectations about their financial intermediaries.

In this article we test individual risk aversion for different levels of endowment, using banks customers splitting (retail and wealthy). We then investigate the investors' risk appetite regarding their demand for the most common financial products and their investment policies. We also perform several analyses to see whether or not we would be able to distinguish some changes in behaviour, and if existing, are linked to their confidence in their financial intermediaries.

We show that, when considering the investors' endowment, the wealthiest are the less risk averse and this has not changed with the financial crisis. We also found that, regarding their investment strategy, it is less conservative for wealthy investors. However, when we look at

the expectations of investors on their financial intermediaries, all expect more transparency as well as more reputation and more client services.

The literature highlights the split existing between wealthier investors and the others as well as cases when high payoffs are available. Indeed, Holt and Laury (2002) have shown that when payoffs are low and hypothetical most subjects are risk averse. However, they become more risk averse when available payoffs increase. High incentives have an impact on investors' risk aversion. Bombardini and Trebbi (2005) is extent of Holt and Laury with payoffs above half a million dollars. They also found that with high payoffs individuals tend to become more risk averse. Our results do not support these results as in our case wealthier investors have not changed their risk aversion level. Other papers such as Perraudin and Sorensen (2000) or Vissing-Jorgensen (2002) have shown that the wealth share invested in risky assets increases with wealth. Makarov and Schornick (2010) demonstrate the same behaviour with a CARA framework in which wealthier investors' acquire more costly information and so more knowledge in financial markets thus decreasing their level of uncertainty.

When considering the impact of the financial crisis on investors' behaviour, Hoffman et al. (2012) show that investors' return expectations decrease when they experience a month with bad returns, especially in September and October 2008 (peak of the crisis), using a monthly survey on Dutch brokerage data between 2008 and 2009. They also notice that, although investors' risk tolerance and perceptions are stable on the long-term, it fluctuates in periods of crisis, especially in June 2008 (first month with bad returns) and September 2008: investors' risk appetite decreases when stock markets go badly. They also show the temporary nature of the investors' fall in risk tolerance together with an increase in risk perception. During the

crisis and especially in June and September 2008, investors' risk tolerance (perception) strongly decreases (increases) for getting back at a normal level at the end of the sample in March 2009.

Regarding the changes in investors' investment strategies, the literature is divided. Despite the common assumption that investors rebalance their portfolios in order to decrease risk levels and increase liquidity, some empirical studies show that, on the one hand, investors decrease the level of risk of their portfolio, but on the other hand, increase their trading activity (Bateman et al., 2011). Hoffman et al. (2012) show a more mixed result. The investors' monthly returns track the market volatility with a spike in October 2008. This shows that during the height of the crisis, investors do not seem to de-risk their portfolios. Investors may have been surprised by the sharp decrease in markets returns. Moreover, while the market volatility decreases after October 2008, at the investor level it does the opposite, being even higher than prior to the crisis in April 2008.

Our contribution to the existing literature is twofold. Using qualitative and quantitative data from questionnaires submitted to financial intermediaries, we investigate the changes in individual investors' behaviour, regarding their risk aversion, their investment policies and their expectations about their financial institutions. For that purpose, our sample is composed with data from four countries (Belgium, France, Germany and Luxembourg), accounting for 48.5% of life assurance premiums and 49% of private banking clients, and are representative of the diversity of the 27 EU Member States, for two different types of customers (wealthy and retail ones) in 17 banks.

We then compare our results with time series data about different financial assets from the same countries.

We compare countries apparently similar in terms of quality of life, geographically located in Central Europe and economically dependent and using the same currency. This last point is known to increase market dependence especially for large countries such as France and Germany (Söhnke et al. 2006). We test if countries responses to the crises are equivalent in terms of periods if these countries experience a decrease in investment rate, and if it occurs at the same time and amplitude.

There is an extensive literature about financial crises and a particular focus on the 2008 sub primes crisis. Since 2009, Europe faces an unfolding sovereign debt crisis. We investigate the unicity of both crises should we consider them as a unique from 2008 to 2012, or should we distinguish them.

The literature is still unclear about the effects of experience and knowledge on investors' behaviour. Malmendier and Nagel (2010) demonstrate that investors who have experienced low stock-market returns throughout their lives report lower willingness to take financial risk, are less likely to participate in the stock market, invest a lower fraction of their liquid assets in stocks if they participate in financial markets, and are more pessimistic about future stock returns. Individuals who have experienced low bond returns are less likely to own bonds. In the same way, less experienced investors have less diversification in their portfolio than "knowledgeable" ones (Stambaugh, Yu and Yuan, 2011). Experience also has a great impact on retirement plans. Agnew and Skyzman (2005) show experimentally that people with low financial knowledge are more willing to choose a portfolio allocation which does not

adequately fit their need. This result is in line with van Rooij et al. (2007) where people consider themselves as conservative and financially unsophisticated regarding the pension fund domain. However results provided by Hoffman et al. (2012) and Glaser & Weber (2005) suggest that as the financial crisis has a temporary effect on investors' behaviour it does not allow investors to learn from the crisis.

In addition, despite the fact that a series of works highlights the insufficient diversification of individual portfolios, little is known about the changes the financial crisis has generated. We know that individuals tend to trend in concert. They buy and sell shares that are correlated (Kumar & Mc Lee, 2006) using US retail investors data between 1991 and 1996. They also concentrate their trades in both small and low-priced firms. Employees invest in higher proportion in the securities of companies in which they work (e.g. Holden & VanDerhei, 2001, and Liang & Weisbenner, 2003) and, more generally, the attractiveness of an investment increases with its familiar appearance (Huberman, 2001, Chan et al., 2005). Nonetheless, we do not know if the crisis has generated more diversified portfolio allocations. Regarding our questionnaires data, our results suggest that risk aversion depends on investors' endowment. Indeed, wealthy investors appear to be less risk averse than retail ones despite the fact that when we look at our qualitative results from the same questionnaire both types consider themselves as more risk averse since the crisis.

We also notice that the crisis has affected investors' preferences for low risk assets such as life insurance for retail investors. Our quantitative findings from questionnaires do not show a change for wealthy investors; however our qualitative findings suggest that they changed their investment policies since 2011, going back to more risky assets but with shorter duration.

We detect a change in investors' expectations about their financial intermediaries since the crisis. Both types of investors report that the reputation of their financial institution has become an important criterion as well as the quality of client services and the transparency about fees and products. This last one was largely neglected before the crisis.

When we consider country specificities, Belgian, French and German investors focus in a good balance between risk and return when Luxembourgers focus on long-term returns.

Country specificities are also salient regarding investors asset preferences. Demand for structured products remains stable in France and Luxembourg while strongly decreasing in Belgium and Germany. Demand for equities remains stable in Germany but has significantly decreased in France. Cash deposits have slightly decreased in Belgium and France and are stable in Germany and Luxembourg. A switch to liquid investments was detected in Belgium, France and Germany. French investors have increased their liquidity levels but German investors have not.

On aggregated items, our results from time series data suggest that the investment rate in financial assets by households has not changed with the crisis in Belgium, but has decreased in France (-5% in average) and in Germany (-2% in average). The French households' response to the crisis occurred earlier (from June 2007) than in Germany (from December 2007). Contrary to Belgian and French households who have not changed the flow of their financial transactions, German households have increased them in average by 7 million Euros per quarter from December 2008. Globally, the crisis has had an effect on household behaviour with respect to mutual funds: Belgian response to the crisis was an outflow from mutual fund shares from June 2007 (-1.6 billion Euros in average). A similar pattern occurs in



France but later (from September 2009) and was more pronounced (-4.7 billion Euros in average). The German households have exhibited a strong divesture in mutual fund shares between June 2006 and March 2009, but recover a positive trend as early as June 2009. Regarding deposits of all forms held by households, no major changes occurred over the period. Only German households showed a strong positive peak during the last quarter of 2008. In Belgium, France and Germany, the net sales of funds is negatively linked with the flow of total deposits held by households, which attests of the existing trade-off between deposits and the investment in funds' shares. In Germany only, there is a strong link between the flows of direct holdings of all type of financial securities (bonds, equities, money market's ones) and their mutual funds' counterparts.

On household direct holdings of financial securities (flow of holdings), our results are as follows. The average flow of equity holdings is positive in each of the 3 countries even if it appears strongly volatile in Belgium. The flow of equity holdings does not seem to have been influenced by the crisis in any of the 3 countries under consideration (Belgium, France and Germany). No major change in bonds has occurred in France despite the crisis. On the contrary, we have observed a positive average trend of 733 million Euros (vs - 3.4 billion Euros before) into bonds' holdings by Belgian households after mid-2007. Conversely, a drop (with a strong peak in 2008) is observed in Germany since 2008 with an average flow of -3.2 billion Euros. Household demand for money market securities experienced a temporary drop concentrated in 2009 for Belgian households, whereas this effect seems to be more permanent in France with an average negative flow of -380 million Euros since the beginning of 2009. German demand for such securities experienced a large volatility in 2008.

On household holdings of mutual fund shares (net sales), the net sales of equity funds appear to be very volatile. They have strongly declined only in France with the crisis: the average net sales have been of -3.4 billion Euros since June 2007. Regarding bond funds, the crisis has not had any impact in France. On the opposite, it has had a very temporary effect concentrated around the 2008 year with a large drop of the net sales in Germany and Luxembourg. The net sales of money market funds experienced, in average, a large drop of more than 11 billion Euros in France from mid-2009. This effect seems to be more permanent than that observed in Germany where they recover neutral values (around zero) from 2009. In Germany, a sharp temporary drop occurred during the crisis (from mid-2008 to late 2009).

The remainder of the paper is organized as follows. Section 2 presents the data and the methodology employed throughout the paper. The results combining both a quantitative and qualitative analysis of the questionnaires which is compared to the time-series data related to the asked questions are described in the section 3. The last section serves as a conclusion.

## **2. Research Methodology**

As 2008 and 2011 crisis are recent and complex phenomenon, we chose to construct a questionnaire divided into two parts, in order to distinguish two different approaches. The first part of the questionnaire is driven by semi-opened questions and the second part (qualitative part) is made of boxes to tick.

Furthermore, this approach was judged the most efficient, in order to go as far as possible into details, enabling interviewees to raise any topic they wanted to.

Our approach allowed us to detect all types of investor behaviour changes before and after the crisis. The interviewed persons were questioned and we tried to dissect the specific themes into categories. We seek a constructive demarche to show the consequences of the change of investment that customers of these banks have taken over the two successive crises. We have also taken care to segregate types of investors in the questionnaire between retail clients and HNWI, but we tried to know the reasons for these changes through key issues.

Selected companies were chosen in four different countries (France, Luxembourg, Belgium and Germany) and represent leading companies in their dedicated sector.

18 major financial institutions (Private and Retail Banks as well as Insurance companies) were interviewed at a senior level: 5 in Belgium and Luxembourg<sup>1</sup> and 4 in France and Germany. For most of them, we got answers from distinct senior managers operating in the respectively, retail and private, banking branches. Finally, we obtain 33 responses as follows: 6 from Belgium and Luxembourg, 7 from France and 14 from Germany; 22 of them concern high net worth customers, and 11 retail ones (refer to Figure 4 in Appendix for demographical statistics about the sample used). Globally, these financial institutions represent more than 50% of the banking market share in their respective countries. To avoid any possible misinterpretation of the questions as well as a high rate of responses to all questions, all the questionnaires have been completed by phone interviews in the own language of the respondent.

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<sup>1</sup> Given that Luxembourg represents the major “off-shore” centre for the 3 countries under consideration (Belgium, Germany and France), especially in the case of high net worth households, 5 Private Banks operating from Luxembourg have been added.

In order to contrast some of the results obtained from the analysis of questionnaires' responses, we collect flow-type quarterly data from June 2004 to June 2012 for the same 3 countries under consideration (Belgium, France and Germany). In particular, we get data related to the questionnaires such as: the net sales of mutual funds' shares regarding the major asset classes (Equities, Bonds, Money Market,), the direct ownership of these asset classes and the financial investment rate. Data come from the German Investment Fund Association (BVI), Central Banks (Banque de France, Deutsche Bundesbank), The European Fund and Asset Management Association (EFAMA), Eurostat and the OEE (European Savings Institute).

## **2.1. Questionnaire description**

The questionnaires constructed for the interviews are divided in six different parts.

The section 1 serves as an introduction of the questionnaire presenting to interviewees the purpose of the study, the audience we want to interview and, the approximate duration of each interview and a quick presentation of each part of the questionnaire.

In section 2, we focus on respondents' background such as gender, age, experience, the type of financial institution they work for and their area of activity.

In section 3, we ask respondents to give us the general trends of asset allocation since the financial crisis for different types of assets (real estate, structured products...) based on a five points (from 1 to 5) scale from "strong decrease" to "strong increase". As our questionnaires

mix qualitative and quantitative answers, we ask interviewees to give us their thinking about these changes.

In section 4, we measure the changes in behaviour of their clients split into two categories: high net worth costumers (asset under management above 1 million Euros) and retail investors... The purpose of this section is to detect the changes in behaviour such as their risk aversion and their investment policies (changes in liquid investments, changes in asset duration...) with a five points scale from “strongly decreased” to “strongly increased”. We complement these questions with open questions on the same topics. Several questions serve to monitor the accuracy of the respondent’ answer: for instance, we ask a question relative to the risk aversion of their clients and later, relative to their risk appetite.

The purpose of section 5 is to detect what are the most important expectations and opinions of the customers regarding the services provided by their financial advisor. The items we propose to interviewees were found by compiling items from other surveys on this topic. This section is composed of two questions in order to measure the changes due to the financial crisis: the same question is asked to interviewees in reference of their opinion before and after the crisis. They have to choose a maximum of three items among the following choices: the firm reputation (denoted REP in the tables), the performance monitoring (denoted PM in the tables), the quality of client services (denoted QoS in the tables), the transparency about fees and products (denoted TANNY in the tables), the investment strategy (denoted IS in the tables), the number of investment products available (denoted NOP in the tables), the Asset allocation decisions (denoted AA in the tables), the actual performance of the fund (denoted FP in the tables), or other. We use a two points scale (0,1) to indicate respectively a negative or positive answer.

## **2.2. Qualitative Methodology**

### **2.2.1. Data Collection**

In order to collect answers, interviews were conducted by phone in the native language of each respondent. Qualitative questions were semi-opened questions and were designed to add value to the information collection. Interviews were conducted between October and November 2012. Each interview lasted between 30 to 45 minutes. Once collected, all interviews were transcribed into Word and a few German interviews were translated into English word by word. In order to perform our qualitative analysis, we chose to use the Nvivo system to perform this analysis. Detailed notes were taken during the interviews, also additional material such as presentation slides assisted us in our data collection and furthermore the analysis.

All the transcripts were uploaded in Nvivo and classified as internal sources. Once uploaded in the system, our approach is to classify all the transcripts with classifications and provide attributes for each transcript. The data analysis started with open coding of the collected information from the available resources.

Each attribute was already defined previously in the questionnaire, we decide to apply the same methodology, we define the gender (male or female), types of investors (retail banking, private banking, wealth management, or insurance), the age of the interviewee ( under 25, 25 to 35, 36 to 45, 46 to 55, more than 56) the type of business (domestic, European level only or both), the country (France, Belgium, Luxembourg and Germany), the type of products (own products, products from other firms, both or involved in products development) and the working experience (less than 5 years, 5 to 9 years, 10 to 14 years, more than 20 years).

We decide to define the main themes before initiating the coding. All the semi-opened questions were used as a starting point, the themes were already pre-defined such as asset allocation, asset duration, changes in bank overall strategies, changes in priorities since the crisis, changes observed in governments bonds and the future of financial services. Then we applied a structural methodology (open coding) to deduct all the key categories and sub categories. We proceeded a general coding by subdividing all the categories, then once the first review was finalised we initiated a second coding review in order to improve the sub categories and themes.

Once the answers classified, all themes and sub-themes from participants emerge into interesting quotes drawn by the raw data.

Assisted by Nvivo we were able to make specific dies and a more generalized model that describes the impact of the two crises on the financial products and investors' behavior, and we also deducted various matrixes based on our coding approach.

### **2.2.2. Data Analysis**

Given the different schemes on the general model (figure 5) we deduct that there is an impact on the customers' behaviour before the 2008 crisis and after the sovereign debt crisis. Most obvious change observed after the 2008 crisis, the customers starting acting differently. Customers have definitely changed their behaviors and became more risk averse on specific financial products such as structured products, fixed income and alternatives funds.

The lack of transparency and trust in the banking sector confirm that the customers were more willing to reduce the risk and reduce the duration of investments. During our qualitative research we noticed that the interviews mentioned a couple of times that their clients wanted to minimize the risk and ensure to secure their assets on a short-term period. It could explain why the majority of customers started investing in real estate, commodities and governments bonds, considered as secured assets during this timeframe.

After the second major crisis, the sovereign crisis, we observe that the interviewees noticed some slight changes in customers' behavior. Most of customers are still risk averse and have a lack of confidence in the banking sector. Therefore we notice that the clients started investing in another type of products considered as secured, with low returns – corporate bonds. The corporate bond issued by corporations, are considered as more secured and interesting for clients as these types of products are mainly used by companies who want to expand business and applied on long term. The term is usually applying to short-term period and with a maturity shorter than one year also known as commercial papers.

### **2.2.3. Asset Allocation**

Following our research framework, we decide to summarize all the information collected by creating matrices. The first matrix will show all the different aspects recognised and analysed during our qualitative research on how the customers allocated their financial resources.



Given the variety of products per countries and type of investors, the type of allowance varies in function of different criteria such as the type of products and the size of investors' portfolios.

Overall we observe that all the countries were affected by the lower investment in alternative funds after the crisis, the financial system that have led customers to look for more secured assets, and tend to decrease their positions in alternatives funds, except the HNWI German investors who kept a risk appetite for alternative products as mentioned one HNWI, Head of Private Banking in Germany "*we need for investments which remains independent from the inflation*".

Even though the customers are more turned to secured products and such as commodities, cash deposits and corporate bonds since the 2008 crisis. We can say that all the countries are concerned with these changes in asset allocation.

We find that increased investment in France, Germany, Luxembourg and Belgium for all types of customers' retail and HNWI, they are willing to secure cash despite a low yield. This change can be sponsored by a greater aversion to risks post crisis. Some customers are also expecting more flexibility in investing in these kind of products. Commodities are considered as a "safe investment" due to the fear of inflation, clients invest in secure and proper products. The investments in commodities allow the retail clients to diversify their portfolio with less risk than what expected with volatile products.

Concerning other type of products such as equities and fixed income, we discover that all our interviewees, even these working in private banking, asset management and retail banking

noted a decrease for these products. They confirmed that all the customers are no longer aiming to invest due to the product complexity and lack of transparency. The market volatility after the 2008 crisis impacted these products, customers especially HNWI in Germany mentioned these products are “unattractive” with low returns. The desertification of investments in equities and fixed income are well known after the 2008 crisis and the European sovereign debt crisis.

The investment in life insurance is down significantly across countries, for example, in France the decline was less significant than in other countries, where one finds among customers in the private banking that the decrease is related to the lack of attractiveness of the product, the low investment return and duration. Another significant example in the panel of interviewees, some have noticed that their retail customers are not driven by rating ratings but rather by lower guaranteed interest rates.

One can also see a significant increase in the real estate investment, which impacts all the types of customers in Belgium, France, Luxembourg and Germany back in force investment in real estate, considered as a safe haven. The after 2008 certainly had a significant impact on lowering prices, but generally retail and HNWIs are likely finding in the real estate, a good investment and a higher return on the long term.

We find a different pattern for the structured products and the money markets funds, the HNWI are now willing to invest more in structured products after the 2008 crisis, especially the German and the Luxembourg investors. Therefore, we see that for the retail customers, the risk appetite has decreased due to lack of transparency and market volatility.

Otherwise we notice that the government bonds were treated significantly in our case study, this type of investments is really specific in the questionnaire. We see that the interviewees distinguished two time periods: before the 2008 crisis and after the European sovereign debt crisis.

Before the sovereign debt crisis, the governments bonds were not considered as attractive products. In the retail banking sector, the customers were aiming to invest in government bonds, like in France, even if the low yields and interests were significant, the safety and the trust of French government drove the customers to invest. In Luxembourg and Belgium, the same event occurred, the retail investors and HNWI invested in government bonds, as the risk minimization guaranteed by the state were configured. The simplification of products and the decrease of rates ensure the confidence of customers. In Germany, we see that HNWIs are more inclined to invest with support from the German government. The financial and economic strength of the country has led to an increased appetite for these investments because the Germans after the crisis had much faith in their government.

After the sovereign debt crisis, the interviewees talked about the changes occurred, and it seems that the investors and the governments bonds have significantly decreased in all the countries. The trust and the confidence in all European governments and how they handled the crisis in Europe with the collapse of Greece market, marked a turning point in the European economy. Investors including retail clients and HNWI have significantly reduced the purchase of governments bonds in France, Luxembourg and Belgium. However, Germany has experienced a slight decline, only HNWIs continued to invest but by taking precautions.

#### **2.2.4. Asset Duration**

During our case study, we also constructed a matrice allocated to the changes of asset duration. The asset duration results of changes in customers' behaviour after 2008 crisis and the impacts assessments.

After the 2008 crisis, globally the customers' behaviour has been modified and the way of investments have also evolved for retail customers and HNWI.

One of the most significant changes occurred was on the type of duration, the customers are now more willing to invest in short term rather long term. The infatuation of short term investment results from different factors and we can explain these changes by changes in all the markets conditions, the interviewees mentioned that the retail customers are investing on short term, to avoid risk and product complexity. The HNWI shared the same opinion and are also investing on short term in order to avoid risk. The decrease of higher returns is also one of the major impacts of the change in asset duration.

On the other hand, the long term investment is decreasing significantly due to markets practices and risk aversion to products complexity. The potential change can be explained by the lessened attractiveness of certain financial products, and the feeling that long duration might also impact other types of customers' behaviour.

The attractiveness of the market is down and customers tend to develop feelings of insecurity in face of investments in which they want to invest their financial portfolios.

After the crisis of 2008, HNWI's and retail clients have evolved their risk perception. Customers tend to invest in the products or companies that have solid values, they seek to build a clearer trust with their bankers. This distrust of the bankers and the growing inflation pushed the shareholders change strategies, and investing but certainly assess risks and seeking for more secured investments.

### **2.2.5. Changes in the priorities in financial services since 2008**

The changes in priorities of the banking sector is one of the major consequences of the crisis, the way in which banks and firms have adopted the change are radical or moderate to try to win back the market and the confidence of their customers. During the interviews, we asked our stakeholders to express what their customers ask them and how they can evolve mentalities.

The companies must face changes and need to re-think their strategy toward customers. In the private banking sector, some interviewees affirmed that the financial sector must evolve and challenge their economic model, a need to find new sources of growth and develop a new commercial approach with clients. In the retail sector, the interviewees said that the bankers should adapt themselves to their customer's needs.

The regulatory and the reputation of the banking sector have also impacted; a few interviewees mentioned that after the 2008 crisis, we have seen an emerging of regulatory laws in Europe and in the rest of all the financial places. This increase forces bankers to reduce the risk and ensure a certain safety and solvency of their products. Being compliant

with local laws and regulations ensures bankers and investors to have a new way to do business.

A couple of interviewees in the private banking confirm that the reputation increased more after the sovereign debt crisis, due to the government controls and empowerment. The multibancarism, the decrease of pricing have also a huge impact on banks. Investors tend to diversify their placement assets between various banks. Interviewees in the Asset Management companies mentioned that it assists customers to decrease the pricing fees towards their placements. It enables customers to play with their portfolios and improve the diversification of their assets and returns. Another aspect also noticed when we performed our analysis is that the customers are looking for a better quality of services; all the domains in banking are touched. We noticed that there is a constant demand of customers to increase the quality of service, institutional corporations should be more flexible and adapt their languages and skills set to their clients. Customers are more and more expecting since the different financial crisis a better understanding of their needs but also a better digitization of online services. Customers have evolved and the financial sector needs also to improve and adapt themselves to the current trend of markets and clients.

### **3. Statistical methodology**

Given the weak number of data points obtained whether by questionnaires (33 points) or by time-series (33 points as well), we only apply non-parametric statistical procedures. The objective of the quantitative study of questionnaires is to extract the differences in the behaviours/opinions according to two dimensions (country-type and customer-type): the

country in which the bank is based (Belgium, France, Germany, or Luxembourg) and the type of investors (retail customers or high net worth ones). We use the Kruskal-Wallis test to compare the different samples: 2 in the case of the customer-type analysis and 4 in the case of the country-type one. It allows to test if the different samples come from populations with identical properties.

We compute the  $K$  statistics as follows:

$$K = \frac{12}{N(N+1)} \sum_{i=1}^k \frac{R_i^2}{n_i} - 3(N+1)$$

where  $n_i$  is the size of sample  $i$ ,  $N$  is the sum of the  $n_i$ 's, and  $R_i$  is the sum of the ranks for sample  $i$ .

The  $K$  statistics follows a Chi-square distribution with  $(k-1)$  degrees of freedom. Given the weak number of observations in each sample (sometimes only 6), the computation of the p-value is also obtained thanks to a Monte-Carlo study with 10 000 random resampling. We then obtain a 99% confidence interval for the p-value. In the case where there are more than 2 samples for the considered variable (per country analysis), if the p-value is such that the null hypothesis (all the samples come from identical populations) is to be rejected, then at least one sample is different from another. To identify which samples are responsible for rejecting the null hypothesis, we utilise the multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (see Hollander and Wolfe, 1999).

Regarding the time-series data, we use the Pettitt's homogeneity test to determine if we may consider that a series is homogeneous over time, or if there is a time at which a change occurs due to the financial crisis. The Pettitt's test (see Pettitt, 1979) is a nonparametric test that

requires no assumption about the distribution of data. It is an adaptation of the rank-based Mann-Whitney test that allows identifying the time at which the shift occurs.

In the tables, all figures in bold are statistically significant at the 5% risk level, whereas they are underlined if it is only the case at the 10% risk level. We usually provide the tables corresponding to the non-parametric tests only when they exhibit statistically significant results.

#### **4. Discussion methodology and sample**

We have in our scope wealthy institutional customers and retail customers; we are fully aware that this split is not bullet proof. We use the split commonly used in the banking industry and communicated by interviewees. Therefore, the only issue is when wealthy investors hold different multiples portfolios in various banks (it will be categorised as retail although as they are billionaire). The only way to avoid this bias would be to get access to portfolios data for each investor in our scope. We did not have the possibility to access this data.

We have in our questionnaire 4 West European countries (France, Belgium, Germany and Luxembourg); therefore, Luxembourg is excluded from flow-type quarterly data. We notice during interviews with bankers that native Luxembourgish individual investors are very few, that explains the lack of data collected for this country.



## 5. Results

### 2.3. Risk Aversion

Globally, risk aversion has increased with the crisis but it is not a very strong phenomenon (see table 1a). There are no major differences in the behaviour of clients when the four countries are considered separately. When we restrict the analysis by types of costumers, it appears that risk aversion has largely increased for retail investors while no change can be detected for high net worth individuals (see table 1b). The joint analysis of the responses regarding either risk aversion or risk appetite demonstrates a strong consistency.

If we look at the customers' behaviour changes in qualitative way, all the interviewees have highlighted that all their clients became more risk averse. The retail customers became more risk averse before the 2008 subprime crisis while HNWI remain the same, due to a larger diversification in their portfolios allocations. We can also notice that all these feelings have been detailed in the questions relative to the increase or decrease of the demand for some types of investments and in the questions relative to clients' assets allocation and assets duration. From a qualitative point of view, a margin effect of the crisis on retail customer appears to be feared They become more risk averse and look for more secure and liquid investments in order to protect themselves from an uncertain future.

The difference between quantitative and qualitative answers could come from the difference between the perception investors have on their risk aversion and their real behaviour.

To confirm these findings on risk aversion, we analyse the aggregate time-series of the financial investment rate in each of the 3 countries under consideration. It is calculated by

dividing the net acquisition of financial assets (cash and deposits, any type of securities, life insurance) of households by their disposable income. Since the risk taking behaviour is governed by expectations and risk attitudes, the evolution through time of the financial investment rate may capture the household's aversion towards financial investments.

Belgian, French and German households do not display similar behaviour (zero correlation) regarding their investment rate in financial assets (see table 1c). Whereas it seems not to have been influenced by the crisis in Belgium, it has strongly declined with the crisis in France (-4.3% in average) and only slightly in Germany (-2.3% in average). The French households' response to the crisis occurs earlier (from June 2007) than in Germany (from December 2007). The investment rate in Belgium is much higher (more than 12% in average with respect to 9.4% and 8.4% in average in France and Germany respectively) and volatile than in France and Germany. It reached a peak of roughly 25% at the beginning of the sample (June 2004). France and Germany are comparable, to each other, with a slightly higher participation in France. The evolution of this rate through time exhibits no similarities among the 3 countries under consideration (see figure 1).

## **6. Asset Allocation**

It was asked to interviewees to what extent the demand for real estate, structured products, equities, cash deposits, commodities, traditional life insurances, balanced assets, money market instruments, fixed income products and alternative investments has changed due to the crisis. Tables 2a and 2b show that the demand for real estate has strongly increased. It is also the case at a weaker extent for fixed income products. At the same time, the demand

regarding equities, commodities and structured products has declined. For other type of assets, the results are either, rather mixed or testify of no major change due to the crisis.

This broad picture deserves to be qualified using the by country and by type of customers' analysis. It appears that the response to the crisis regarding the change in asset allocation is different when the countries are considered (table 2a) as well as the type of costumers (table 2b). While no change has been declared in Germany regarding equities (average close to 3), a statistically significant drop at the 10% level is observed in France. The slight decreases observed in Belgium and Luxembourg is not statistically significant. This result seems principally driven by the behaviour of retail investors (see table 2b) who have strongly diminished their position in this asset class with respect to those of high net worth individuals. At the same time, the behaviour of costumers in the 4 countries with respect to cash deposits has been strongly different. While it has strongly decreased in Belgium and France, it has strongly increased in Germany and Luxembourg. Moreover, the life insurance demand has slightly increased for retail investors but has not changed for high net worth individuals.

Considering the changes in customers' demand in a qualitative way, we can point out that globally customers ask for more secure assets. This is the reason for the decrease in structured products investments as well as equities. If they are still investing in equity markets they are tended to choose very carefully assets and markets (DAX, for instance). Another main point that we notice in this survey is that the majority of the customers would like to protect their capital from market volatility and the lack of transparency of prices (due to the crisis). In fact, they are also willing to accept lower interest rates (we will discuss this in details later) and take short term positions. They also prefer investing in products "easily understandable" and presenting a lower risk profile, (according to interviewees, clients often link lower risk profile

with short assets duration close to 18 months in average), typically real estate and commodities. A minor part of investors even wants physical commodities in their portfolios, this phenomenon being in line with the idea that investors want tangible (palpable) assets. Even if in our interviews gold is the most cited product, it does not mean that is the only type of commodities customers wish to invest in, but only the easiest example interviewees could give.

The period between 2008 and 2012 can be split into 3 periods. Starting from 2008-2011 customers wanted to protect themselves from uncertainty, volatility and risk by increasing their positions in liquid assets (Cash Deposits, Money Markets) and Government Bonds.

The switch occurs in 2011 with the sovereign debt crisis, as the insecurity about Southern European countries decreased, French and German decreased. HNWI started to look at best returns in Corporate Bonds and Foreign Europe Government Bonds. Germany need to be considered as a special case German interviewees reported that the trust and the demand for German Bonds remained stable.

We compare these results with those stemming from the analysis of time-series data. We test the time-homogeneity of the net flow for three types of securities held by households (cash deposits, money market securities, bonds and stocks) in Belgium, France and Germany. We also examine the net sales of mutual funds shares for the same asset classes domiciled in France and marketed in Germany<sup>2</sup>. It allows us to contrast the results obtained from questionnaires.

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<sup>2</sup> Most German promoters domicile their funds in Luxembourg for tax purposes, to then are marketed back in Germany.

Regarding the flow of short and long term cash deposits held by households, the results are consistent with those from the questionnaires for Belgium and France, and somehow contradict those got for Germany. Belgian, French and German households' display a similar behaviour regarding the flow of their deposits (see table 2c). No major changes occur over the period from 2004-Q2 and 2012-Q2. German households even had a strong positive peak during the last quarter of 2008. The flow of cash deposits exhibits a positive average over the period for the 3 countries considered with comparable volatility<sup>3</sup>. French and German data are strongly correlated and the correlation is weaker with Belgium. No structural change was detected in any of these three countries.

Concerning the flow of money market securities held by households, while questionnaires' results display a positive change in the demand for such securities only in Belgium and Germany with figures mainly driven by retail investors (see tables 2a and 2b), we observe a pattern which somehow confirms this: in average over the 2004Q2-2008Q2, the figures are slightly negative in Belgium and France and only marginally positive in Germany. The appetite for money market securities by Belgian households experienced a large temporary drop concentrated in 2009<sup>4</sup>, whereas this effect seems to be more permanent in France and occurs earlier: the Pettitt's test detects a structural break by the end of 2008 (see table 2d). The German demand for such securities experienced a large volatility in 2008. Overall the correlation is low and even negative when Belgium and Germany are considered.

This is also confirmed when we look at the aggregate data on the net sales of money market mutual funds share. We observe negative figures in average for France and Germany. French data display a strong decline from mid-2009 (see table 2e). This effect seems to be more

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<sup>3</sup> The high figure for Germany is only driven by the peak observed in the last quarter of 2008.

<sup>4</sup> If we drop the data for the first two quarters of 2009, the Pettitt's test rejects the change of structure observed in the whole sample from 2009.

permanent than that observed in Germany where they recover neutral values (around zero) from 2009. The net sales of money market funds experienced a sharp temporary drop in Germany during the crisis (from mid-2008 to late 2009). They are also extremely volatile in France compared to Germany. A structural break in the net sales of money market funds is observed in France from July 2009 where its mean becomes strongly negative (from 5.852 billion Euros to -11.208 billion Euros). In Germany, a structural change is also observed but earlier (mid-2008). But it appears very temporary since the break seems to be mainly driven by the figure of the last quarter of 2008 (a drop of more 20 billion Euros during this quarter).

Regarding bond securities directly held by households, the figures shed light on another pictures from that of the questionnaires. While questionnaires exhibit an increasing demand due to the crisis for all countries, no similarities are found in the flows of bond holdings by households (see table 2f). No major change has occurred in France despite the crisis. The flow of households' bond holdings is also very volatile for each of the three countries considered. Its average value is negative only in Belgium. The negative correlation (not statistically significant from zero) found shows no similarities among the 3 countries under consideration. Whereas we can observe a structural change in the flow of Bond holdings by Belgian households from an average of -3,436 million Euros before June 2007 to a positive value of more than 733 million Euros thereafter, a structural drop is detected in Germany from the last quarter of 2007: the average flow of bond holdings sharply decreased, passing from 8,000 million Euros to -3,228 thereafter. This result is mainly driven by the last quarter of 2008 which exhibits a drop of more than 22 billion Euros in Bond holdings. Nevertheless, the figures remain slightly negative in average since then. The results obtained when looking at the aggregate data on the net sales of bond funds domiciled in France and marketed in Germany do not display any similarities in their temporal structure. The crisis has had a very

temporary effect concentrated around the year 2008 with a large drop of the net sales in Germany, which drives the structural break detected in the statistical analysis<sup>5</sup>. While they are still positive in average for funds marketed in Germany, they appear to be negative in France with a slight structural drop detected at the 10% risk level from mid-2007.

Contrary to the questionnaires data wherein we observe a negative pattern for equity in Belgium and France<sup>6</sup>, the flow of equity holdings by households does not seem to have been influenced by the crisis in any of the 3 countries under consideration. Its average is even positive in each of the 3 countries even if it appears strongly volatile in Belgium (see table 2h). No temporal similarity between the 3 countries is detected in the data. From the last quarter of 2008, a positive structural change is observed in France where the average flow goes from 1,425 million Euros to 3,928 million since then. At the 10% risk level, we observe a similar pattern in Germany but much earlier, since the break is detected from the second quarter of 2007: the average flow jumps from 1,018 million Euros to 3,486 million Euros. Therefore, the crisis does not seem to have influenced the direct equity holdings of households. Actually, this result should be interpreted with cautiousness, since the net sales of equity funds have strongly declined with the crisis as soon as the third quarter of 2007 (see table 2i and figure 2) from 8,183 million Euros to -3,476 million Euros in average. When the net sales of equity funds marketed in Germany are considered, no structural change seems to have occurred despite the crisis even if a little drop is observed around the year 2008.

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<sup>5</sup> This break disappears if we skip the data of the year 2008.

<sup>6</sup> No major change is observed in Germany (see table 2a).

## **7. Changes in customers' expectations towards their financial intermediaries**

The firm reputation has become an important criterion of choice after the crisis whatever the country or the type of investors considered (see table 3a). The performance monitoring is not considered as an important criterion by investors, either before or after the crisis. This criterion is even weaker after the crisis whatever the country or the type of customer considered (see table 3b).

The quality of client services (see table 3c) correspond to an important criterion for customers excepted for Germans before the crisis as the non-parametric tests show it. It has not changed with the crisis, excepted for Germans who from now on consider this as a relatively important criterion. We can also note that this criterion was more important for high net worth clients than for retail ones before the crisis; the opposite occurs after the crisis.

Whatever the country or the type of investors, the transparency about fees and products has become an important criterion after the crisis while it was neglected before (see table 3d).

While globally, the investment strategy is not considered as a very important criterion of choice either before or after the crisis, it appears significant for Germans after the crisis (see table 3e). Moreover, high net worth clients paid more attention to this criterion than retail costumers before the crisis.

The number of products available was a relatively weak criterion before the crisis. It has become even weaker after it (see table 3f).



The asset allocation decisions are considered as a very feeble criterion of choice. It has not changed with the crisis (see table 3g)

The actual performance of the fund was a key indicator for retail investors (vs. HNWI) before the crisis. It has become much less important compared to the others after the crisis and, from now on, both types of investors share the same relative disinterest towards this criterion (see table 3h).

Regarding the qualitative answers provided by interviewees, the financial crisis conducted to a global lack of trust of customers regarding financial institutions. In order to restore the reputation, they may have lost and simply for responding to this lack of trust, bankers have to undertake profound changes. They do it quantitatively, by adapting their prices and products and qualitatively by adapting their services panel. The most cited way to increase clients' confidence in a financial institution is to increase transparency. If customers trusted bankers before the crisis by favouring returns, they are now looking for more information about fees and rebates for instance. Customers also widely use internet and newspapers to get the information they require. So, bankers face a double issue. They need to provide strong information to respond to the lack of trust, to mandatory obligations and to avoid the "Russian dolls" effect. But they have clients for whom financial rules and pricing models may be difficult to understand. Increasing transparency is also a way to differ from other competitors when the cost reduction is not possible anymore. Giving information about "how these costs are made of" and also why it "cannot be made for free" can legitimize these costs. One solution to solve the gap between information accuracy, customers' expectations and simplicity, could be to limit the access to "simple and understandable products" depending on

the customers' profiles, "spending more time with customers" to explain those fees, return and funds access conditions.

Interviewees also provided answers about the need of more advising. Since the crisis, clients switch banks easily. As most financial institutions propose the same investment types to customers, they differ in advising to keep clients. It also increases clients' fidelity and trust. Customers' expectations, products complexity and tax regimes take different shapes (this last one only concern France in interviewees' answers). Customers think more in term of trust than in terms of products, but at the same time, the products complexity and tax regimes increase. Advisors need to propose specific products to their customers' profiles with powerful economic analysis giving them trends and warnings about possible issues on assets (the Greek bonds crack was mentioned). Customers ask for more convenience. They want to deal with only one advisor, highly available, who keeps things simple, and guide them with a language they understand.

As we have shown above, price transparency is quite new in financial industry. This transparency, as well as the low performance of some asset classes (money markets, UCITS, cash deposits, life insurance) with low returns, encourages clients to ask for fees reductions. The fact that an increasing part of clients have multiple accounts in multiple institutions increases this phenomenon. The increasing competition between traditional companies and online companies with lower fees pushes prices down.

Incorporating online services into financial offers is a cross sectional aspect. It impacts transparency as customers can get direct and precise information about markets and pricing rules. It affects advising with the increasing use of smartphones with embedded video chat

compatibility and with the capability to give personalized information about markets and products in relation to their actual portfolio and investment profile with a suitable cost for the financial institution. The generational gap observed few years earlier between the connected generation and the others is going to disappear with the use of smartphones. So, we would like to add that creating new online services is now one of the financial institutions priorities. It could be a response to the lack of time of customers who face a relative traditional industry in which branches still play the contact role.

## **8. Conclusion**

Using qualitative and quantitative data from questionnaires submitted to financial intermediaries, we investigate the changes in individual investors' behavior, regarding their risk aversion, their investment policies and their expectations about their financial institutions. We have found that the change in investors' risk aversion depends on the type of investors, affecting more retail than HNWI. This is illustrated by the asset allocation of different types of investors, retail investors increasing their positions in less risky assets such as life insurance. Our qualitative findings are not fully in line with this result. This may be due to the limit of our questionnaire study, based on asset managers' answers rather than investors' ones. However this technique enables us to analyse a wider panel of investors. However, both types of investors have changed their investment policies, accepting lower returns and seeking for greater liquidity in order to take shorter positions. We also noticed a hard change in the expectations investors have regarding their financial intermediaries, looking for more transparency, more services and a greater reputation.

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**Tables and Figures**

**For all tables, any statistical significance at the 95% level or more appear in bold whereas underlining is used at the 90% level.**

**Table 1a: Absolute Risk Aversion Change (ARA\_CH) due to the crisis per country**  
 - Scale from strong decrease (1) to strong increase (5) -  
 (BE for Belgium, DE for Germany, FR for France and LU for Luxembourg)

Variable	Obs.	Min	Max	Mean	Std. Dev.
ARA_CH   BE	6	1	5	3.83	1.83
ARA_CH   DE	14	1	5	3.14	1.75
ARA_CH   FR	7	1	5	4.14	1.46
ARA_CH   LU	6	2	5	3.60	1.34

**Table 1b: Absolute Risk Aversion Change (ARA\_CH) per type of Costumers**  
 - Scale from strong decrease (1) to strong increase (5) -  
 (HNWI for High Net Worth Individuals, RET for Retail ones)

Variable	Obs.	Min	Max	Mean	Std. Dev.
ARA_CH   HNWI	22	1.00	5.00	3.18	1.65
ARA_CH   RET	11	2.00	5.00	4.36	1.21

**Kruskal-Wallis test (ARA\_CH):**

K	4.75
p-value	<b>0.03</b>

99% confidence interval on the p-value:

**] 0.02; 0.03 [**

**Table 1c: Financial Investment Rate per country**

Variable	Obs.	Min	Max	Mean	Std. Dev.
Belgium	32	-3%	25%	12%	7%
France	32	1%	19%	9%	3%
Germany	32	2%	14%	8%	2%

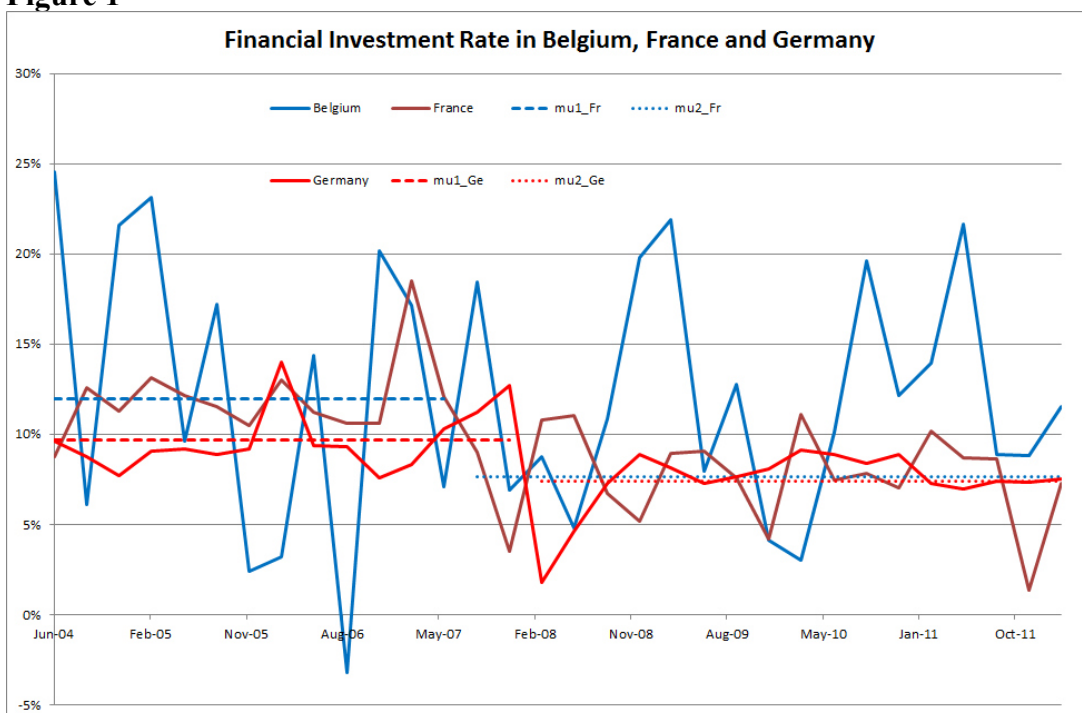
Pettitt's test (Belgium):

Pettitt's test (France):

Pettitt's test (Germany):

<i>K</i>	72.00	<i>K</i>	215.00	<i>K</i>	197.00
<i>t</i>	Sep-05	<i>t</i>	Jun-07	<i>t</i>	Dec-07
p-value	0.60	p-value	0.00	p-value	0.00
99% confidence interval on the p-value:		99% confidence interval on the p-value:		99% confidence interval on the p-value:	
	] 0.59; 0.61 [		] -0.00; 0.00 [		] -0.00; 0.00 [

**Figure 1**



**Table 2a: Change in the demand for different type of assets due to the crisis by country**  
- Scale from strong decrease (1) to strong increase (5) -

Variable	Obs.	Min	Max	Mean	Std. Dev.
Real Estate   BE	6	3	5	4.50	0.84
Real Estate   DE	14	3	5	4.57	0.65
Real Estate   FR	7	3	5	4.14	0.69
Real Estate   LU	6	4	5	4.50	0.55
Structured Products   BE	6	1	4	2.00	1.10
Structured Products   DE	12	1	3	1.58	0.67
Structured Products   FR	7	2	5	3.71	0.95
Structured Products   LU	6	1	4	2.67	1.21
Equities   BE	6	1	4	2.00	1.10
Equities   DE	11	1	5	3.00	1.26
Equities   FR	7	1	3	1.57	0.79
Equities   LU	6	1	4	2.17	1.33
Cash Deposits   BE	6	3	5	4.67	0.82
Cash Deposits   DE	10	1	3	2.40	0.97
Cash Deposits   FR	7	2	5	4.29	1.11
Cash Deposits   LU	6	1	3	2.17	0.75
Commodities   BE	6	1	3	2.67	0.82
Commodities   DE	12	2	5	3.83	1.27
Commodities   FR	4	3	5	3.50	1.00
Commodities   LU	6	2	5	3.83	1.33
Life Insurance   BE	4	2	4	3.00	0.82
Life Insurance   DE	14	1	4	2.50	0.94
Life Insurance   FR	7	2	5	3.71	1.11
Life Insurance   LU	6	2	5	3.83	1.33
Balanced assets   BE	5	2	4	2.60	0.89
Balanced assets   DE	9	3	5	3.67	0.87
Balanced assets   FR	4	3	5	4.00	1.15
Balanced assets   LU	5	2	4	3.20	0.84
Money Market   BE	6	2	5	3.33	1.21
Money Market   DE	12	1	5	3.75	1.71
Money Market   FR	6	2	3	2.33	0.52
Money Market   LU	6	2	5	4.00	1.55
Fixed Income   BE	6	3	5	4.50	0.84
Fixed Income   DE	12	3	5	3.50	0.80
Fixed Income   FR	5	3	5	4.20	0.84
Fixed Income   LU	4	3	4	3.25	0.50
Alternative Investment   BE	5	1	3	2.20	0.84
Alternative Investment   DE	12	1	5	3.00	1.54
Alternative Investment   FR	6	1	3	2.00	0.89
Alternative Investment   LU	6	1	5	2.67	1.51

**Kruskal-Wallis test (Structured Products):**

K	13.26
p-value	0.00
99% confidence interval on the p-value:	
	] 0.00; 0.00 [

**Kruskal-Wallis test (Equities):**

K	6.34
p-value	0.08
99% confidence interval on the p-value:	
	] 0.08; 0.09 [

**Kruskal-Wallis test (Cash Deposits):**

K	16.96
p-value (Two-tailed)	< 0,0001
99% confidence interval on the p-value:	
	] -0.00; 0.00 [

**Multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (p-values only):**

	Structured Products   BE	Structured Products   DE	Structured Products   FR	Structured Products   LU
Structured Products   BE	1	0.87	0.09	0.74
Structured Products   DE	0.87	1	0.00	0.21
Structured Products   FR	0.09	0.00	1	0.38
Structured Products   LU	0.74	0.21	0.38	1

**Multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (p-values only):**

	Equities   BE	Equities   DE	Equities   FR	Equities   LU
Equities   BE	1	0.34	0.87	1.00
Equities   DE	0.34	1	0.08	0.66
Equities   FR	0.87	0.08	1	0.86
Equities   LU	1.00	0.66	0.86	1

**Multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (p-values only):**

	Cash Deposits   BE	Cash Deposits   DE	Cash Deposits   FR	Cash Deposits   LU
Cash Deposits   BE	1	0.01	0.82	0.02
Cash Deposits   DE	0.01	1	0.02	0.86
Cash Deposits   FR	0.82	0.02	1	0.05
Cash Deposits   LU	0.02	0.86	0.05	1

**Table 2b: Change in the demand for different type of assets due to the crisis by type of costumers - Scale from strong decrease (1) to strong increase (5) -**

Variable	Obs.	Min	Max	Mean	Std. Dev.
Real Estate   HNWI	22	3	5	4.45	0.67
Real Estate   RET	11	3	5	4.45	0.69
Structured Products   HNWI	22	1	5	2.18	1.18
Structured Products   RET	9	1	4	2.78	1.30
Equity   HNWI	21	1	5	2.62	1.28
Equity   RET	9	1	3	1.56	0.73
Cash Deposits   HNWI	20	1	5	3.10	1.48
Cash Deposits   RET	9	2	5	3.67	1.22
Commodities   HNWI	21	1	5	3.48	1.21
Commodities   RET	7	2	5	3.71	1.25
Life Insurance   HNWI	21	1	5	2.81	1.08
Life Insurance   RET	10	2	5	3.70	1.16
Balanced assets   HNWI	15	2	5	3.20	0.77
Balanced assets   RET	8	2	5	3.75	1.28
Money Market   HNWI	22	1	5	3.68	1.52
Money Market   RET	8	2	5	2.75	1.16
Fixed Income   HNWI	19	3	5	3.95	0.91
Fixed Income   RET	8	3	5	3.50	0.76
Alternative Investment   HNWI	22	1	5	2.68	1.39
Alternative Investment   RET	7	1	4	2.29	1.11

**Kruskal-Wallis test (Equities):**

K	4.76
p-value	0.03
99% confidence interval on the p-value:	
	] 0.03; 0.04 [

**Kruskal-Wallis test (Life Insurance):**

K	3.72
p-value	0.06
99% confidence interval on the p-value:	
	] 0.05; 0.06 [

**Table 2c: Total (short-term and long-term) flow of cash deposits held by households in million Euros**

Variable	Obs.	Min	Max	Mean	Std. Dev.
Belgium	32	-5,627	9,139	3,573.25	3,905.42
France	33	-8,801	22,142	9,005.79	7,396.72
Germany	33	1,200	87,100	17,142.42	15,159.05

**Correlation matrix (Pearson)**

Variables	Belgium	France	Germany
Belgium	<b>1</b>		
France	0.31	<b>1</b>	
Germany	0.33	<b>0.57</b>	<b>1</b>

**Table 2d: Money market securities directly held by households  
- Net flows in million Euros -**

Variable	Obs.	Min	Max	Mean	Std. Dev.
Belgium	32	-666	520	-15.28	273.97
France	33	-1,701	2,133	-59.36	745.74
Germany	33	-3,100	3,700	54.55	1,179.01

**Pettitt's test (Belgium):**

K	150.00
t	Dec-08
p-value	<b>0.02</b>
99% confidence interval on the p-value:	<b>] 0.01; 0.02 [</b>

**Pettitt's test (France):**

K	152.00
t	Sep-08
p-value	<b>0.02</b>
99% confidence interval on the p-value:	<b>] 0.02; 0.02 [</b>

**Pettitt's test (Germany):**

K	98.00
t	Dec-06
p-value	0.27
99% confidence interval on the p-value:	<b>] 0.26; 0.28 [</b>

**Table 2e: Net Sales of Money Market Funds domiciled in France and marketed in Germany (in million Euros )**

Variable	Obs.	Min	Max	Mean	Std. Dev.
France	33	-34,900	41,300	-868.48	19,400.38
Germany	33	-20,776	14,632	-919.31	6,673.02

**Pettitt's test (France):**

K	150.00
t	Mar-09
p-value	<b>0.02</b>
99% confidence interval on the p-value:	<b>] 0.02; 0.03 [</b>

**Pettitt's test (Germany):**

K	180.00
t	Mar-08
p-value	<b>0.00</b>
99% confidence interval on the p-value:	<b>] 0.00; 0.00 [</b>



**Table 2f: Bond securities directly held by households**  
**- Net flows in million Euros -**

Variable	Obs.	Min	Max	Mean	Std. Dev.
Belgium	32	-7,850	6,746	-960.47	3,669.69
France	33	-2,034	4,298	478.91	1,596.05
Germany	33	-22,900	18,800	1,548.48	8,115.23
Pettitt's test (Belgium):		Pettitt's test (France):		Pettitt's test (Germany):	
K	175.00	K	44.00	K	223.00
t	Jun-07	t	Mar-05	t	Sep-07
p-value	<b>0.00</b>	p-value (Two-tailed	0.98	p-value (Two-tailed	<b>&lt; 0,0001</b>
99% confidence interval on the p-value:		99% confidence interval on the p-value:		99% confidence interval on the p-value:	
] 0.00; 0.00 [		] 0.97; 0.98 [		] 0.00; 0.00 [	

**Table 2g: Net Sales of Bond Funds domiciled in France and marketed in Germany (in million Euros )**

Variable	Obs.	Min	Max	Mean	Std. Dev.
France	33	-37,200	12,400	-949.70	8,889.93
Germany	33	-18,820	8,665	371.43	5,344.46
Pettitt's test (France):			Pettitt's test (Germany):		
K	126.00	K	152.00		
t	Jun-07	t	Mar-06		
p-value	<u>0.09</u>	p-value	<b>0.02</b>		
99% confidence interval on the p-value:			99% confidence interval on the p-value:		
] 0.08; 0.10 [			] 0.02; 0.03 [		

**Table 2h: Equity shares directly held by households**  
**- Net flows in million Euros -**

Variable	Obs.	Min	Max	Mean	Std. Dev.
Belgium	32	-11151.00	5969.00	350.13	3259.08
France	33	-2400.00	8159.00	2562.76	2651.92
Germany	33	-9500.00	15000.00	2539.39	4950.44
Pettitt's test (Belgium):		Pettitt's test (France):		Pettitt's test (Germany):	
K	73.00	K	138.00	K	137.00
t	Dec-06	t	Sep-08	t	Mar-07
p-value	0.58	p-value	<b>0.049</b>	p-value	<u>0.054</u>
99% confidence interval on the p-value:		99% confidence interval on the p-value:		99% confidence interval on the p-value:	
] 0.57; 0.59 [		] 0.04; 0.05 [		] 0.05; 0.06 [	

**Table 2i: Net Sales of Equity Funds domiciled in France and marketed in Germany (in million Euros )**

Variable	Obs.	Min	Max	Mean	Std. Dev.
France	33	-12,300	12,300	763.64	6,980.54
Germany	33	-5,159	7,166	156.95	3,256.31

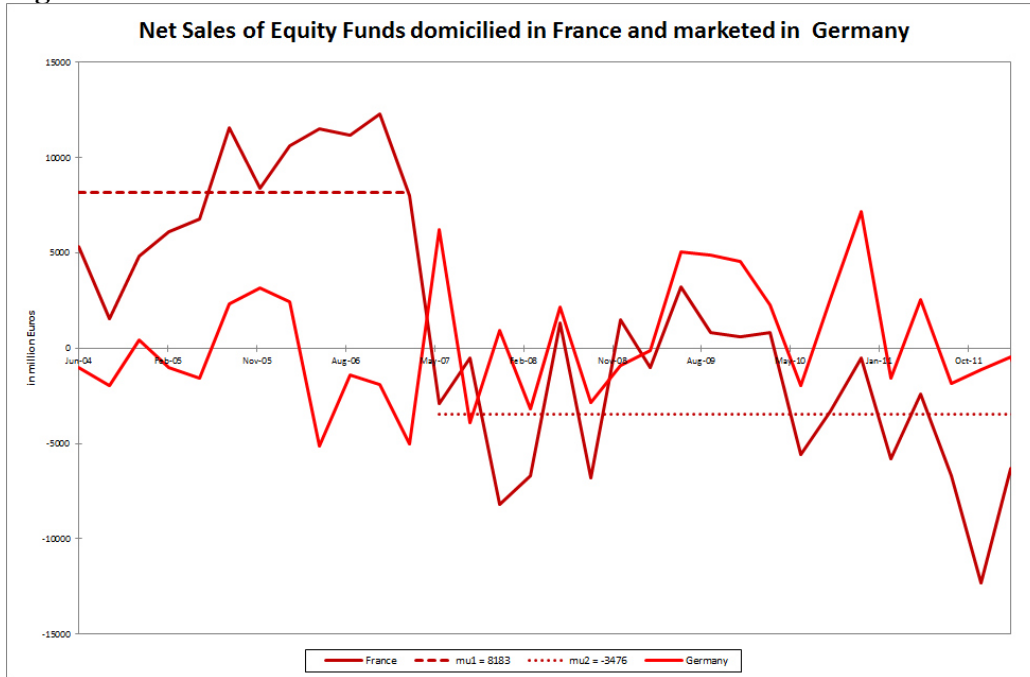
**Pettitt's test (France):**

<i>K</i>	250.00
<i>t</i>	Mar-07
p-value	< 0,0001
99% confidence interval on the p-value:	]
	0.00; 0.00 [

**Pettitt's test (Germany):**

<i>K</i>	90.00
<i>t</i>	Sep-08
p-value	0.38
99% confidence interval on the p-value:	]
	0.36; 0.39 [

**Figure 2**



**Table 3a: The Firm Reputation (REP) as an important criterion of choice before (BC) or after (AC) the crisis**  
 - No (0) or Yes (1) -

(HNWI for high net worth individuals and RET for retail ones)  
 (BE for Belgium, FR for France, DE for Germany and LU for Luxembourg)

**Kruskal-Wallis test:**

Variable	Obs.	Min	Max	Mean	Std. Dev.
REP_BC	33	0.00	1.00	0.33	0.48
REP_AC	33	0.00	1.00	0.76	0.44

Variable	Obs.	Min	Max	Mean	Std. Dev.
REP_BC   BE	6	0.00	1.00	0.50	0.55
REP_BC   DE	14	0.00	1.00	0.36	0.50
REP_BC   FR	7	0.00	1.00	0.14	0.38
REP_BC   LU	6	0.00	1.00	0.33	0.52
REP_AC   BE	6	0.00	1.00	0.83	0.41
REP_AC   DE	14	0.00	1.00	0.71	0.47
REP_AC   FR	7	0.00	1.00	0.86	0.38
REP_AC   LU	6	0.00	1.00	0.67	0.52

Variable	Obs.	Min	Max	Mean	Std. Dev.
REP_BC   HNWI	22	0.00	1.00	0.32	0.48
REP_BC   RET	11	0.00	1.00	0.36	0.50
REP_AC   HNWI	22	0.00	1.00	0.77	0.43
REP_AC   RET	11	0.00	1.00	0.73	0.47

<i>K</i>	11.80
p-value (Two-tailed)	0.00
99% confidence interval on the p-value:	] 0.00; 0.00 [

**Table 3b: The Performance Monitoring (PM) as an important criterion of choice before (BC) or after (AC) the crisis**

- No (0) or Yes (1) -

(HNWI for high net worth individuals and RET for retail ones)

(BE for Belgium, FR for France, DE for Germany and LU for Luxembourg)

Variable	Obs.	Min	Max	Mean	Std. Dev.
PM_BC	33	0.00	1.00	0.27	0.45
PM_AC	33	0.00	1.00	0.12	0.33

Variable	Obs.	Min	Max	Mean	Std. Dev.
PM_BC   BE	6	0.00	1.00	0.33	0.52
PM_BC   DE	14	0.00	1.00	0.14	0.36
PM_BC   FR	7	0.00	1.00	0.29	0.49
PM_BC   LU	6	0.00	1.00	0.50	0.55
PM_AC   BE	6	0.00	0.00	0.00	0.00
PM_AC   DE	14	0.00	1.00	0.14	0.36
PM_AC   FR	7	0.00	1.00	0.14	0.38
PM_AC   LU	6	0.00	1.00	0.17	0.41

Variable	Obs.	Min	Max	Mean	Std. Dev.
PM_BC   HNWI	22	0.00	1.00	0.32	0.48
PM_BC   RET	11	0.00	1.00	0.18	0.40
PM_AC   HNWI	22	0.00	1.00	0.18	0.39
PM_AC   RET	11	0.00	0.00	0.00	0.00

**Table 3c: The Quality of Client Services (QoS) as an important criterion of choice before (BC) or after (AC) the crisis**  
**- No (0) or Yes (1) -**  
**(HNWI for high net worth individuals and RET for retail ones)**  
**(BE for Belgium, FR for France, DE for Germany and LU for Luxembourg)**

Variable	Obs.	Min	Max	Mean	Std. Dev.
QoS_BC	33	0.00	1.00	0.45	0.51
QoS_AC	33	0.00	1.00	0.45	0.51

Variable	Obs.	Min	Max	Mean	Std. Dev.
QoS_BC   BE	6	0.00	1.00	0.67	0.52
QoS_BC   DE	14	0.00	1.00	0.14	0.36
QoS_BC   FR	7	0.00	1.00	0.86	0.38
QoS_BC   LU	6	0.00	1.00	0.50	0.55
QoS_AC   BE	6	0.00	1.00	0.50	0.55
QoS_AC   DE	14	0.00	1.00	0.36	0.50
QoS_AC   FR	7	0.00	1.00	0.57	0.53
QoS_AC   LU	6	0.00	1.00	0.50	0.55

**Kruskal-Wallis test (QoS\_BC):**

K 10.86

p-value 0.01

99% confidence interval on the p-value:

] 0.00; 0.01 [

**Multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (p-values):**

	QoS_BC   BE	QoS_BC   DE	QoS_BC   FR	QoS_BC   LU
QoS_BC   BE	1			
QoS_BC   DE	0.10	1		
QoS_BC   FR	0.86	0.01	1	
QoS_BC   LU	0.94	0.35	0.54	1

Variable	Obs.	Min	Max	Mean	Std. Dev.
QoS_BC   HNWI	22	0.00	1.00	0.50	0.51
QoS_BC   RET	11	0.00	1.00	0.36	0.50
QoS_AC   HNWI	22	0.00	1.00	0.36	0.49
QoS_AC   RET	11	0.00	1.00	0.64	0.50

**Table 3d: The Transparency as an important criterion of choice**  
**- before (BC) or after (AC) the crisis**  
**- No (0) or Yes (1)**  
**(HNWI for high net worth individuals and RET for retail ones)**  
**(BE for Belgium, FR for France, DE for Germany, LU for Luxembourg)**

<b>Variable</b>	<b>Obs.</b>	<b>Min</b>	<b>Max</b>	<b>Mean</b>	<b>Std. Dev.</b>
TANNY_BC   HNWI	22	0,00	1,00	0,18	0,39
TANNY_BC   RET	11	0,00	1,00	0,09	0,30
TANNY_AC   HNWI	22	0,00	1,00	0,73	0,46
TANNY_AC   RET	11	0,00	1,00	0,91	0,30

<b>Variable</b>	<b>Obs.</b>	<b>Min</b>	<b>Max</b>	<b>Mean</b>	<b>Std. Dev.</b>
TANNY_BC   BE	6	0,00	0,00	0,00	0,00
TANNY_BC   DE	14	0,00	1,00	0,29	0,47
TANNY_BC   FR	7	0,00	1,00	0,14	0,38
TANNY_BC   LU	6	0,00	0,00	0,00	0,00
TANNY_AC   BE	6	0,00	1,00	0,67	0,52
TANNY_AC   DE	14	0,00	1,00	0,86	0,36
TANNY_AC   FR	7	0,00	1,00	0,86	0,38
TANNY_AC   LU	6	0,00	1,00	0,67	0,52

**Table 3e: The Investment Strategy (IS) as an important criterion of choice before (BC) or after (AC) the crisis**  
**- No (0) or Yes (1) -**  
**(HNWI for high net worth individuals and RET for retail ones)**  
**(BE for Belgium, FR for France, DE for Germany and LU for Luxembourg)**

Variable	Obs.	Min	Max	Mean	Std. Dev.
IS_BC	33	0.00	1.00	0.21	0.42
IS_AC	33	0.00	1.00	0.30	0.47

Variable	Obs.	Min	Max	Mean	Std. Dev.
IS_BC   BE	6	0.00	0.00	0.00	0.00
IS_BC   DE	14	0.00	1.00	0.29	0.47
IS_BC   FR	7	0.00	1.00	0.14	0.38
IS_BC   LU	6	0.00	1.00	0.33	0.52
IS_AC   BE	6	0.00	0.00	0.00	0.00
IS_AC   DE	14	0.00	1.00	0.57	0.51
IS_AC   FR	7	0.00	0.00	0.00	0.00
IS_AC   LU	6	0.00	1.00	0.33	0.52

**Kruskal-Wallis test (IS\_AC):**

K	10.14
p-value	0.02
99% confidence interval on the p-value:	
	] 0.01; 0.02 [

**Multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (p-values):**

	IS_AC   BE	IS_AC   DE	IS_AC   FR	IS_AC   LU
IS_AC   BE	1			
IS_AC   DE	0.09	1		
IS_AC   FR	< 0,0001	0.06	1	
IS_AC   LU	0.45	0.78	0.38	1

Variable	Obs.	Min	Max	Mean	Std. Dev.
IS_BC   HNWI	22	0.00	1.00	0.32	0.48
IS_BC   RET	11	0.00	0.00	0.00	0.00
IS_AC   HNWI	22	0.00	1.00	0.36	0.49
IS_AC   RET	11	0.00	1.00	0.18	0.40

**Kruskal-Wallis test (IS\_BC):**

K	4.31
p-value (Two-tailed)	0.06
99% confidence interval on the p-value:	
	] 0.06; 0.07 [

**Table 3f: The Number Of Products (NOP) as an important criterion of choice before (BC) or after (AC) the crisis**

- No (0) or Yes (1) -

(HNWI for high net worth individuals and RET for retail ones)

(BE for Belgium, FR for France, DE for Germany and LU for Luxembourg)

Variable	Obs.	Min	Max	Mean	Std. Dev.
NOP_BC	33	0.00	1.00	0.24	0.44
NOP_AC	33	0.00	1.00	0.09	0.29

Variable	Obs.	Min	Max	Mean	Std. Dev.
NOP_BC   BE	6	0.00	1.00	0.33	0.52
NOP_BC   DE	14	0.00	1.00	0.29	0.47
NOP_BC   FR	7	0.00	1.00	0.14	0.38
NOP_BC   LU	6	0.00	1.00	0.17	0.41
NOP_AC   BE	6	0.00	1.00	0.33	0.52
NOP_AC   DE	14	0.00	1.00	0.07	0.27
NOP_AC   FR	7	0.00	0.00	0.00	0.00
NOP_AC   LU	6	0.00	0.00	0.00	0.00

Variable	Obs.	Min	Max	Mean	Std. Dev.
NOP_BC   HNWI	22	0.00	1.00	0.32	0.48
NOP_BC   RET	11	0.00	1.00	0.09	0.30
NOP_AC   HNWI	22	0.00	1.00	0.09	0.29
NOP_AC   RET	11	0.00	1.00	0.09	0.30



**Table 3g: The Asset Allocation (AA) as an important criterion of choice  
before (BC) or after (AC) the crisis  
- No (0) or Yes (1) -  
(HNWI for high net worth individuals and RET for retail ones)  
(BE for Belgium, FR for France, DE for Germany and LU for Luxembourg)**

Variable	Obs.	Min	Max	Mean	Std. Dev.
AA_BC	33	0.00	1.00	0.06	0.24
AA_AC	33	0.00	1.00	0.03	0.17

Variable	Obs.	Min	Max	Mean	Std. Dev.
AA_BC   BE	6	0.00	1.00	0.17	0.41
AA_BC   DE	14	0.00	1.00	0.07	0.27
AA_BC   FR	7	0.00	0.00	0.00	0.00
AA_BC   LU	6	0.00	0.00	0.00	0.00
AA_AC   BE	6	0.00	1.00	0.17	0.41
AA_AC   DE	14	0.00	0.00	0.00	0.00
AA_AC   FR	7	0.00	0.00	0.00	0.00
AA_AC   LU	6	0.00	0.00	0.00	0.00

Variable	Obs.	Min	Max	Mean	Std. Dev.
AA_BC   HNWI	22	0.00	1.00	0.05	0.21
AA_BC   RET	11	0.00	1.00	0.09	0.30
AA_AC   HNWI	22	0.00	0.00	0.00	0.00
AA_AC   RET	11	0.00	1.00	0.09	0.30

**Table 3h: The Actual Funds Performance (FP) as an important criterion of choice before (BC) or after (AC) the crisis - No (0) or Yes (1) -**

(HNWI for high net worth individuals and RET for retail ones)  
(BE for Belgium, FR for France, DE for Germany and LU for Luxembourg)

**Kruskal-Wallis test:**

Variable	Obs.	Min	Max	Mean	Std. Dev.
FP_BC	33	0.00	1.00	0.55	0.51
FP_AC	33	0.00	1.00	0.09	0.29

K	15.48
p-value (Two-tailed)	<b>0.00</b>
99% confidence interval on the p-value: ] -0.00 ; 0.00 [	

Variable	Obs.	Min	Max	Mean	Std. Dev.
FP_BC   BE	6	0.00	1.00	0.50	0.55
FP_BC   DE	14	0.00	1.00	0.50	0.52
FP_BC   FR	7	0.00	1.00	0.57	0.53
FP_BC   LU	6	0.00	1.00	0.67	0.52
FP_AC   BE	6	0.00	1.00	0.17	0.41
FP_AC   DE	14	0.00	1.00	0.07	0.27
FP_AC   FR	7	0.00	1.00	0.14	0.38
FP_AC   LU	6	0.00	0.00	0.00	0.00

Variable	Obs.	Min	Max	Mean	Std. Dev.
FP_BC   HNWI	22	0.00	1.00	0.36	0.49
FP_BC   RET	11	0.00	1.00	0.91	0.30
FP_AC   HNWI	22	0.00	1.00	0.09	0.29
FP_AC   RET	11	0.00	1.00	0.09	0.30

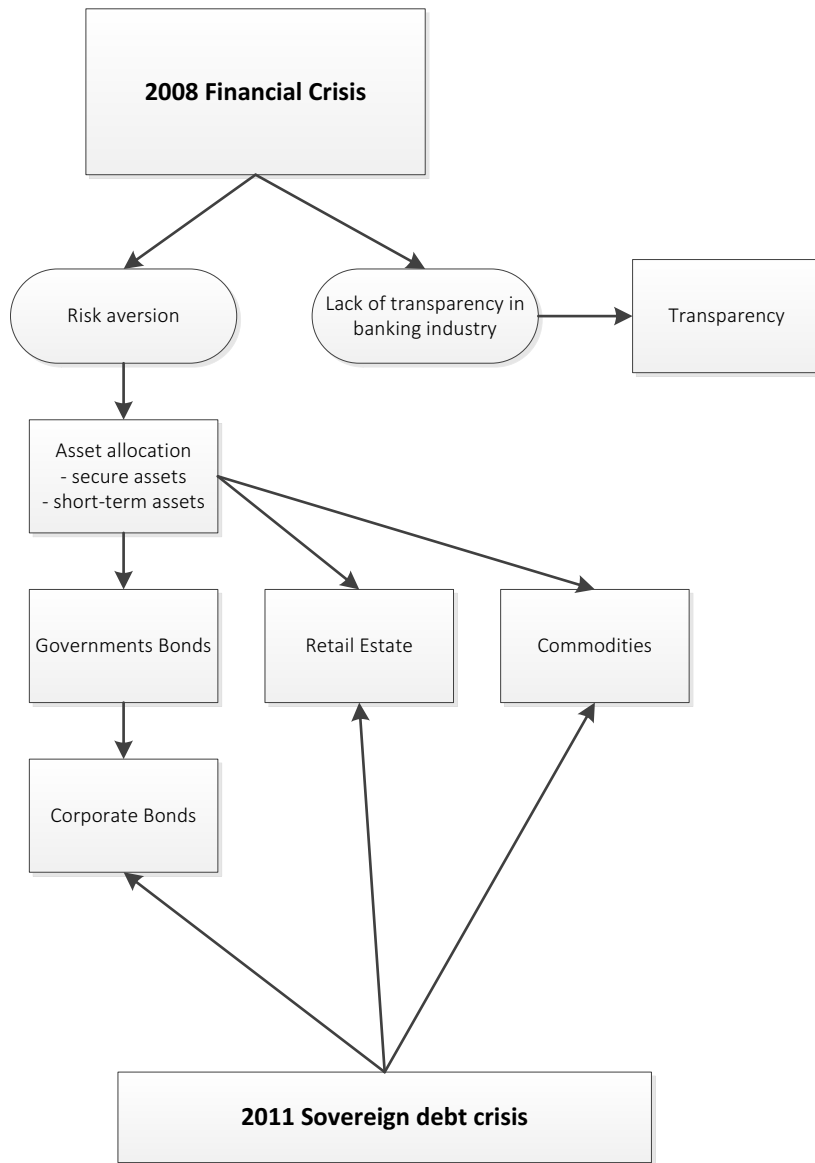
**Kruskal-Wallis test (FP\_BC):**

K	8.53
p-value (Two-tailed)	<b>0.01</b>
99% confidence interval on the p-value: ] 0.01; 0.01 [	

**Figure 4**  
**Demographic Statistics about questionnaire sample**

		<b>Number</b>	<b>%</b>
<b>Country</b>	<b>Belgium</b>	6	18,18%
	<b>France</b>	7	21,21%
	<b>Luxembourg</b>	6	42,42%
	<b>Germany</b>	14	18,18%
<b>Gender</b>	<b>Male</b>	27	81,82%
	<b>Female</b>	6	18,18%
<b>Age</b>	<b>Under 25</b>	0	0,00%
	<b>25-35</b>	3	9,09%
	<b>36-45</b>	15	45,45%
	<b>46-55</b>	14	42,42%
	<b>56 and more</b>	1	3,03%
<b>Experience</b>	<b>Less than 5 years</b>	5	15,15%
	<b>5 to 9 years</b>	4	12,12%
	<b>10 to 14 years</b>	7	21,21%
	<b>More than 15 years</b>	17	51,52%
<b>Business Divisions</b>	<b>Retail Banking</b>	12	36,36%
	<b>Private Banking</b>	20	60,61%
	<b>Asset Management</b>	2	6,06%
	<b>Insurrance</b>	2	6,06%
<b>Types of clients</b>	<b>Retail</b>	11	33,33%
	<b>HNWI</b>	22	66,67%

**Figure 5**  
**Qualitative general model**



**Figure 6**  
*Qualitative model based on questionnaires answers*



	Retail Banking	Private Banking	Insurance	Asset Management
	Retail	Retail	HNWI	Retail
			HNWI	HNWI
<b>Changes in asset duration since the crisis in 2008</b>				
Asset illiquidity			Investment behaviour of customers has generally changed, more flexibility required The durations got shorter due to the fact that a lot of liquidity is being held	Increase of asset illiquidity in overall products especially in hedge funds
Flexibility	More flexibility required from bankers to enable customers to be flexible with their investments			
Less performance	Less performance on long-term investments; customers are demanding more flexibility			
Lower returns	Customers behaviour has evolved; on short term investments; customers are reaching quickly and re-invest in other products	Low returns; the demand is now focused on holding more liquid assets on a short term period and increase the flexibility		Low returns; the demand is now focused on holding more liquid assets on a short term period and increase the flexibility
Reactivity	Inflation has increased; so customers are more risk averse to changes; and it's a run to risk-free interest rate	Customers are pro-active and re-invest their portfolio quickly on other complex products on a short-term period		HNWI are more sensitive to markets practice and adapt their reactivity to the markets and products
Inflation risk				
Insecurity	Less attractively for long-term investments due to markets instability Decrease significantly on the long-term investments; due to market practice and clients risk aversion to products complexity	Customers are feeling insecure in general and ask for more guarantees before investing Less attractivity to long-term investments; customers are more risk aware in long duration period and potentially losses Lower returns on long-term investments; inflation Decrease of life assurance products; due to long-term of long-term investments proposed products from the period and failure in banking system since 2008 and increase since 2010 with the sovereign debt crisis		Decrease of long-term period due to insecurity and lower returns
Inflexibility	Uncertainty due to markets fluctuation since the crisis	Customers are inflexible when they invest on long term period		
Uncertainty	Customers behaviour has evolved and the risk perception has now increase to due market volatility	Uncertainty due to limits of protection for customers		Increase of demand for safe products and less complexity
Risk Perception	Clients are looking for more secured companies and investments	Risk aversion for unsecured assets; customers are more specific		
Safety				
Short Term	Increase of short-term investments; inflation of low rates returns	Due to market conditions customers go for shorter durations because interest rates are very low Increase of short-term investments due to low long rates returns		Increase of short-term investments in Germany Decrease of higher returns; clients want flexibility and security and ask the banking sector to simplify the product strategy

	Retail Banking	Private Banking	Insurance	Asset Management
	Retail	Retail	HNWI	HNWI
<b>Changes in priorities in the financial sector since 2008</b>	Retail	Retail	HNWI	HNWI
<b>Decrease risk levels</b>	Bankers are now focused on decrease the risk level for customers	Bankers are now focused on decrease the risk levels for customers The risk minimization is now a priority for bankers in order to maintain their clients portfolio	Banking companies are willing to reduce the risk levels for their HNWI. New banking priority for risk management	Banking companies are willing to reduce the risk levels for their HNWI. New banking priority for risk management
<b>Higher returns</b>	Clients are looking for better performance in products and they will develop a greater trust in institutional companies	Higher returns are a need for customers who invest in specific products; clients are looking for performance and less fees	Higher returns have been always a need for customers who are more interested in products performance Institutional tend to develop products with higher returns and less complexity	Higher returns have been always a need for customers who are more interested in products performance Institutional companies proposed less complex products and greater transparency on costs, fees and products development Regulatory pressure that is exerted from outside the financial services; forces bankers to take this issue seriously More conflicts of interest in advisory services as the bankers are not independent to customers would like to see more advice targeted to their needs
<b>Increase Transparency</b>	New strategy develop by the banking sector; to be more transparent on costs/ fees related to portfolios development	Bankers tend to develop more strategic solutions for their customers and engage the client in costs and fees discussion at earlier stage Restore confidence. This strengthens trust as an important part of the customer-bank relationship and limit the risk of conflicts of interest if now recurrent and bankers need to ensure that the client is truly benefiting and rules	Transparency is a key point for customers especially for the insurance products, customers and bankers need to develop strengths towards their investments	Increase the transparency is a priority for bankers; clients are engaged in strategic solution and decisions Institutional companies proposed less complex products and greater transparency on costs, fees and products development Regulatory pressure that is exerted from outside the financial services; forces bankers to take this issue seriously More conflicts of interest in advisory services as the bankers are not independent to customers would like to see more advice targeted to their needs
<b>Limit risk of conflicts of interest in advisory services</b>	Limit the conflicts of interest if now a priority for institutional companies; more advice of services and build a strong relationship with their clients	Customers are expecting lower fees and a significant reduction of costs associated to products investments Fees became a stronger issue due to legal regulations	Customers are expecting lower fees and a significant reduction of costs associated to products investments	Customers are expecting lower fees and a significant reduction of costs associated to products investments
<b>Lower fees</b>	Customers are expecting less fees from banks	Customers are expecting lower fees and a significant reduction of costs associated to products investments Fees became a stronger issue due to legal regulations	Customers are expecting lower fees and a significant reduction of costs associated to products investments	Customers are expecting lower fees and a significant reduction of costs associated to products investments
<b>More convenience</b>	Bankers are developing more tailored made advisory services for customers	Improve quality of services and advisory for customers Less closed debates and increase strong relationship with clients	Improve quality of services and advisory for customers Less closed debates and increase strong relationship with clients	Improve service quality and focus on customer satisfaction
<b>More efficient advices</b>	Increase services and advisory and assist clients in their decisions	It's giving the time is the feeling that the advice we give it are more in its own interests, develop confidence and good relationship More corporate advised independent advisory service are required by clients	More corporate advised independent advisory service are required by clients	More personalized advices and less complexity in products will increase customers a safe environment to trust their banks
<b>Multibancuarism</b>	Redistribution of assets between various banks, customers make play competition between the banks Increase of competition between all the banks who offered similar services	It's the strengthening relation between banks so they are diversifying their interconnectors; they have less confidence in one banker in several bankers - They address several bankers to have different points of view of a banker to another and to be able compare ideas .	High demand from customers for online services combined with interactive advisory services, customers cannot wait and want reactivity in the financial sector Less standard services, customers tend to ask bankers for more innovation required and adaptability from the financial services Pricing is not longer attractive as it used to be because the financial structure is sound and the market has stabilized, but for lower risk the yield is still more important.	Diversification of portfolios means automatically with multibancuarism, customers are now tend to diversify portfolios with various banks; to play on costs and advices
<b>New Online services</b>	Due to time constraints customers want to see more flexible services and ask the banking sector to innovate permanently Institutional banks are developing more online application to dedicate customers the 24/7	More innovation required and adaptability from the financial services Pricing is not longer attractive as it used to be because the financial structure is sound and the market has stabilized, but for lower risk the yield is still more important.	High demand from customers for online services combined with interactive advisory services, customers cannot wait and want reactivity in the financial sector Less standard services, customers tend to ask bankers for more innovation required and adaptability from the financial services Pricing is not longer attractive as it used to be because the financial structure is sound and the market has stabilized, but for lower risk the yield is still more important.	Clients are expecting a higher digitization of the banking sector; less standard canal of communication
<b>Pricing</b>				Pricing conditions and terms are generally the first point discussed with clients
<b>Quality of service</b>	Increase services and advisory and assist clients in their decisions	Quality advice and quality in compliance with the risk parameters that the customer wishes.	Quality advice and quality in compliance with the risk parameters that the customer wishes.	
<b>Reputation</b>		Negative impacts increased significantly since the sovereign debt crisis Customers behaviour changes address risks induces a change in the business it means that bankers must go through a challenging economic model, a need to find new sources of growth and a changing environment. Redefinition of the commercial approach.	Negative impacts increased significantly since the sovereign debt crisis Customers behaviour changes address risks induces a change in the business it means that bankers must go through a challenging economic model, a need to find new sources of growth and a changing environment. Redefinition of the commercial approach.	
<b>Strategy</b>	Bankers need to develop new products, strategy but also evolve their research with clients in order to adapt themselves to customer needs			
<b>Regulatory</b>		Increase of regulatory laws and international rules (Solvency II, Basel 3), force bankers to reduce the risks and ensure that the safety of their products	Increase of regulatory laws and international rules (Solvency II, Basel 3), force bankers to reduce the risks and ensure that the safety of their products	Increase significantly of international and local regulations which affect the banking sector Bankers need to be compliant and ensure the strengths and the solvency of their products

# Chapter 3: Physiological Test on Beliefs Formation

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## Abstract

In this paper we test the beliefs formation in line with the Brunnermeier and Parker model (2005). Our experimental setup allows us to test their anticipatory emotions about future outcomes as well as their preference for Skewness. We use a two similar lotteries setup, except for Skewness. We show that participants who play with the non-skewed lottery elicit greater self-regulation than the other participants one minute before learning the lottery results, they best regulate their emotions one minute before learning their outcomes. Considering all participants, we find that participants form anticipatory pleasure about their future earnings only two minutes after knowing in which lottery they will play and that anticipatory emotion is stable. Like in the Brunnermeier and Parker framework participants form an anticipatory emotion about the future payoffs of the lotteries that makes them better off. Our results suggest that the anticipations formed by our subjects are as strong as the emotions they feel when they learn the lottery results.



## 1. Introduction

Anticipations and feelings have been widely studied in Neuroscience. The topic is younger in Finance but is now widely investigated, particularly the link between anticipation and the possibility of bad outcomes. Some papers support anticipations theoretically, others experimentally but from our knowledge none in Finance investigate the neurological basis of anticipations. But, nowadays neurosciences represent an increasing field in Management Science and allow researchers to find the point of origin of a lot of biases or behaviours they investigated traditionally so far.

In this study we show that all participants form anticipatory feelings about their future lotteries outcomes. Subjects who take part in the non-skewed lottery form as much anticipatory emotions as those playing with the skewed lottery, however, they exhibit greater self-regulation one minute before learning the lottery results.

Several theoretical papers have investigated anticipations in financial markets. Brunnermeier and Parker (2005) study a model where agents are forward looking, believing that their investment will pay well makes them happier. This behaviour generates a first order gain with an increase in anticipatory utility and a second order loss because of the biased behaviour. Put another way, agents' beliefs have an instantaneous impact on their well-being via anticipatory emotions about their future utility flows. It influences their investment decision, by encouraging them to prefer skewed assets, which can lower their incomes. The authors also show (2007) that as the cost of biased beliefs are second order, investors hold biased judgments about probabilities. Hence, they do not diversify their portfolios properly and preferred skewed assets. The increase in demand for skewed assets can lower their returns. Brunnermeier et al. (2008) also test optimistic belief with planning fallacy framework.

Similarly, optimistic beliefs have been investigated experimentally as well. Mayraz (2011) conducts an experiment to test biased optimism. In this experiment, subjects are farmers (sellers) or bakers (buyers). Participants are shown a chart representing the evolution of wheat prices over a period of time and then asked to predict the future price at a certain future date. Hence, they are like speculators who ignore fundamental value of wheat and only predict future values based on historical data standardized from date 0 to 99. The task is to predict the value at time 100. Subjects receive a participation fee as well as the value of their sales and an accuracy bonus. According to the optimism bias, farmers should predict higher prices than bakers. This prediction is confirmed with his data, more than 60% of farmers are above median and 62% of bakers below. Another prediction is that the optimism bias decreases as the cost of holding this biased belief increases. Hence, the greater the optimism, the lower should be the accuracy bonus. This prediction is not confirmed by the experiment results; the author finds that the bias is an increasing function of the accuracy bonus. He also shows a positive correlation between bias and confidence.

This optimism bias, or optimism belief, finds robustness with diseases testing. Oster et al. (2011) investigate the relation between optimistic beliefs and Huntington disease (HD) testing. They use a dataset of people at risk with the disease. These patients reported the subjective probability of having the disease. Among people with minor signs of having HD the probability reported was 40%. Over those with more signs of HD, the probability increases to 50%. In another study, Sieff and Loewenstein (1999) test peoples' reactions when learning results from HIV test. In this experiment, subjects are asked to predict their reaction to HIV test results 5 weeks after learning the results. They also asked subjects to estimate the likelihood that the test would be positive. Overall people who learnt that they were positive to

HIV experienced more distress than those with a negative one. However, when comparing the anticipative response and the post result response from the newspaper subjects, they find that the anticipatory distress was higher than the actual distress. This pattern was the same with negative results.

These two papers refer to bad anticipation. But, people also tend to delay future possible good outcomes in contradiction with discounted utility theory which predicts that people prefer to consume their desired outcomes as soon as they can. Indeed, Loewenstein (1987) conducted a survey based experiment where he asks participants the amount of money they are willing to pay for different possible outcomes in different periods of time. The different items proposed were to obtain four dollars, to avoid losing four dollars, to avoid losing 1,000 dollars, to get a kiss from their favourite movie star and to avoid receiving a non-lethal electric shock. The time delay proposed were immediately, 3 hours later, 24 hours later, 3 days, 1 year and 10 years. Both the movie star kiss and the shock follow strange patterns. People are more willing to pay to receive the kiss in 3 days rather than immediately, this delay allow them to form anticipation regarding the kiss they would receive. Likewise, they are willing to pay more to delay the electric shock in 10 years than now.

To elicit the investors affective approach, Rottenstreich and Hsee (2001) use the same movie star and shocks items to investigate people preferences. In a survey based experiment they asked their subject to respond their preferences about receiving 50 dollars for sure and being kissed by their favourite movie star for sure. In another condition they were asked in which of the following lotteries they would prefer to participate: 1% of chance of receiving a kiss from their favourite movie star and another lottery offering 1% of chance to receive 50 dollars in cash. In the certainty condition, more than 60% of participants prefer the cash reward. But, in

the uncertain condition about 70% of participants prefer to participate in the lottery allowing to receive the movie star kiss. In another experiment, they told half their subjects that they would receive an electric shock and to the other half that they would lose 20 dollars. For each of the two conditions, participants need to imagine how much they would pay to avoid these bad outcomes relative to the following probabilities: 1% of chance that the bad outcome occurs, 99% of chance, occurs for sure. In the certainty condition the median price to avoid the shock was 20 dollars. In the 1% condition, the median price was 7 dollars, greater than the median price to avoid losing 20 dollars (only 1 dollar). This result shows that for subjects, the certainty of receiving a shock for sure is less stressful or aversive than 1% of chance to receive a shock. The authors find that subjects value more low probabilities for affect-rich outcomes (electric shock) and less for affect-poor outcomes (losing 20 dollars). Alternatively, the median price to avoid 99% of chance to receive an electric shock was lower than the median price to avoid losing 20 dollars with the same probability, meaning that subjects underweight large probabilities for affect rich outcomes. They find the same results with positive affect-rich and affect-poor outcomes (affect-poor: 500 dollars in coupons for courses / affect-rich: 500 dollars to travel to Paris). Overweighting small probabilities of affect-rich outcomes seems to be linked with hope or scare.

On the other hand, Neuroscience experiments have shown that regarding bad possible and affect-rich outcomes, probabilities do not matter. Monat et al. (1972) conducted two experiments measuring heart rate and skin conductivity on subjects. Their experiments consist in receiving electric shocks under a temporal uncertainty where the subject knows that he would receive an electric shock but ignore when, and an event uncertainty where the participant knows when but not if the shock would occur. Under the temporal condition, subjects formed anticipatory stress in the beginning of the measuring and less as time passed.

In the event uncertainty, results are inverse. Indeed, when subjects know the precise timing of the shock their attention increases toward the upcoming event, increasing their arousal.

This last result suggest that fear seems to increase as the upcoming bad event approaches. Breznitz (1971) makes an experiment where he tells participants they would receive an electric shock in either 3, 6 or 12 minutes. His results show that the mean heart rate was higher for participants in the 3 or 6-minutes treatments without statistical differences and much lower in the 12-minutes condition.

Other research has found positive correlation between anxiety and outcome predictions. Shepperd et al. (2005) show that anxiety contribute to lower predictions about future events.

In this paper we use two lotteries with the same characteristics except in terms of Skewness and take heart rate measures to investigate the beliefs formation and anticipation made by subjects between the lottery announcement and the moment when they watch the result.

We want to demonstrate that subjects who participate in the positively skewed lottery elicit more anticipatory pleasure than subjects participating in the 0 skewed lottery. We investigate the evolution over time of this anticipation, and its robustness compared with feelings experienced after the earnings announcements.

We show that participants who play the non-skewed lottery exhibit greater self-regulation than subjects taking part in the positively skewed one from the last minute of the waiting interval. In terms of mean heart rate and mean beat to beat intervals, this anticipation is stable until they watch the drawing without differences among lotteries. However, this anticipation

only starts the second minute after watching the lottery announcement. In addition, the emotion felt by subjects after learning the results is less persistent than the anticipation formed earlier. When considering standard deviations of heart rate and beat to beat intervals the anticipation is formed the first minute after watching the lottery in which subjects will play and vanishes one minute after.

We also highlight that, considering mean heart rate, mean beat to beat intervals, and standard deviations, this anticipation of pleasure is as strong as the happiness participants feel when watching their earnings whatever the physiological measure taken.

This paper is organized as follows. In section 2 we discuss our experimental design including our sample, the physiological measures and the statistic test we will use. In section 3 we present our results about our significant variables. In section 4 we discuss and interpret our results. Section 5 elicits the limitations of our study and open a way to further research. We conclude in section 6.

## 2. Experimental design and procedure

### 2.1. Subjects

A total of 43 students from Toulouse Business School (Toulouse, France) in their last years in Master participated in the experiment. We exclude 5 subjects in our analysis because of bad measurements. Details on our sample are presented in Table 1.

	<b>Treatment 1</b>	<b>Treatment 2</b>	<b>Whole sample</b>
<b>Age</b>	24.39	24.4	24.39
<b>Male</b>	13	14	27
<b>Female</b>	5	6	11

*Table 1 Subjects used for the experiment*

### 2.2. Experimental procedure

We propose to our subjects to participate in a lottery to earn bonus points for their module in Finance. Two lotteries are available, one with a Skewness equal to 0 (lottery 1) and another with a positive Skewness of 2,65 (lottery 2). Both have equal means and standard deviations. Details of the two lotteries are presented in Table 2. Each subject only participates in one lottery, once. Lottery 1 refers to treatment 1 and lottery 2 to treatment 2.

<b>Lottery 1</b>		<b>Lottery 2</b>	
Probability	Bonus points	Probability	Bonus points
0,01	1.5	0.01	4.25
0,49	1.5	0.49	1.35
0,50	0.5	0.50	0.59

	<b>Lottery 1</b>	<b>Lottery 2</b>
Expected Bonus	0.1	0.1
Variance	0.25%	0.25%
Standard deviation	0.05	0.05
Skewness	0	2.645

*Table 2 Details of the lotteries presented to subjects*

Before the experiment starts, each subject receives the rules of the game written in English and French, depending on the subject's preferences (see appendix 1). Once the rules read, the subject can ask the experimenter any further explanations about the procedure of the experiment. Then the experimenter shows the way to paste electrodes for ECG properly and records age and gender of the subject.

The experiment takes place as follows. Once the subject has paced the electrodes and has asked all remaining questions, the experimenter starts taking ECG measures until the end of the experiment. The experiment has three periods during which the subject has to stay as motionless as he can. During all periods the experimenter tells the subject the remaining time (3 minutes, 2 minutes, 1 minutes 30 seconds, 30 seconds). At the end of the first period the experimenter draws the lottery in which the subject will play in front of him (lottery 1 or lottery 2). Then the second waiting period of 4 minutes starts. At the end of this period the experimenter draws the results of the lottery in front of the subject and shows him the results. Then the third waiting period of 4 minutes starts. At the end of this period the subject can put the electrodes off and asks the experimenter any questions he wants.



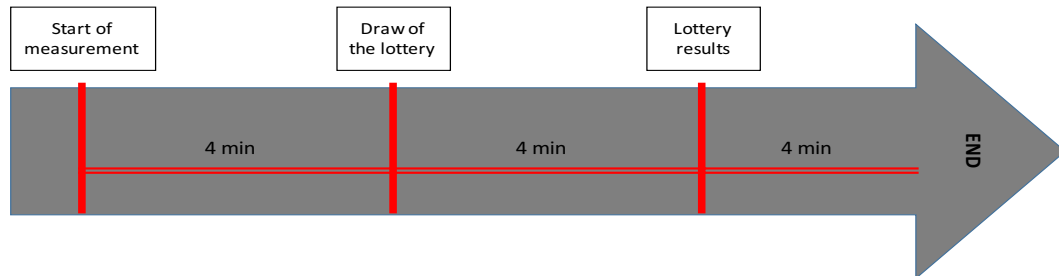


Figure 7. Experiment timeline

### 2.3. Physiological measures and statistical methods

Heart rate was recorded with Biograph EKG Pro/Flex and Procomp 2 with three electrodes paced on the chest of each subject. Heart rate was recorded continuously for each subject with a heart rate sampling of 2048Hz and time separations between time intervals were computed manually during each replication. Mean heart rate and heart rate variability (HRV) were computed via Kubios HRV 2.1 with automatic artefact correction set to very low.

## **2.4. Selection of time intervals**

Each original time interval has been divided in 1 minute intervals to enable proper measures comparisons. Indeed, for HRV measurements (heart-rate variability), the variance increases with the length of the interval, the longer the interval, the higher the HRV (Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996).

Hence, we select the last minute of the first waiting period as a baseline that we compare with all periods after. This period will be named “variablename\_0” in all tables. We take period 4 as baseline to avoid any contradictory measures linked with the experiment itself. Indeed, no participant took part in a Neurofinance experiment before and they were not comfortable (that may induce higher heart rate) with electrodes on their chests during the first minutes.

Hence, the fourth minute of the first waiting is referred as the baseline period, periods 1, 2, 3, 4 are in the interval between the drawing of the lottery and the drawing of the results and periods 5, 6, 7, 8 are in the interval after the drawing of the results. Variables are named “variablename\_periodnumber” in all tables.

## **2.5. Physiological variables**

We present in Figure 1 the list of all variables obtained with Kubios HRV.

Parameter	Units	Description
<b>Time-Domain</b>		
RR	[ms]	The mean of RR intervals
STD RR (SDNN)	[ms]	Standard deviation of RR intervals
HR	[1/min]	The mean heart rate
STD HR	[1/min]	Standard deviation of instantaneous heart rate values
RMSSD	[ms]	Square root of the mean squared differences between successive RR intervals
NN50	[count]	Number of successive RR interval pairs that differ more than 50 ms
pNN50	[%]	NN50 divided by the total number of RR intervals
HRV triangular index	–	The integral of the RR interval histogram divided by the height of the histogram
TINN	[ms]	Baseline width of the RR interval histogram
<b>Frequency-Domain</b>		
VLF, LF and HF peaks	[Hz]	Peak frequencies for VLF, LF and HF bands
VLF, LF and HF powers	[ms <sup>2</sup> ]	Absolute powers of VLF, LF and HF bands
VLF, LF and HF powers	[%]	Relative powers of VLF, LF and HF bands
		VLF [%] = VLF [ms <sup>2</sup> ]/total power [ms <sup>2</sup> ] × 100 %
		LF [%] = LF [ms <sup>2</sup> ]/total power [ms <sup>2</sup> ] × 100 %
		HF [%] = HF [ms <sup>2</sup> ]/total power [ms <sup>2</sup> ] × 100 %
LF and HF powers	[n.u.]	Powers of LF and HF bands in normalized units
		LF [n . u .] = LF [ms <sup>2</sup> ]/(total power [ms <sup>2</sup> ] – VLF [ms <sup>2</sup> ])
		HF [n . u .] = HF [ms <sup>2</sup> ]/(total power [ms <sup>2</sup> ] – VLF [ms <sup>2</sup> ])
LF/HF	–	Ratio between LF and HF band powers
Total power	[ms <sup>2</sup> ]	Total spectral power
EDR	[Hz]	ECG derived respiratory frequency
<b>Nonlinear</b>		
SD1, SD2	[ms]	Standard deviations of the Poincaré plot
ApEn	–	Approximate entropy
SampEn	–	Sample entropy
D <sub>2</sub>	–	Correlation dimension
α <sub>1</sub> , α <sub>2</sub>	–	Short-term and long-term fluctuations of detrended fluctuation analysis (DFA)
Lmean	[beats]	Mean line length of diagonal lines in recurrence plot (RP)
Lmax	[beats]	Maximum line length of diagonal lines in RP
REC	[%]	Recurrence rate (percentage of recurrence points in RP)
DET	[%]	Determinism (percentage of recurrence points which form diagonal lines in RP)
ShanEn	–	Shannon entropy of diagonal line lengths' probability distribution

Figure 8. List of all parameters obtained with Kubios HRV software with their definitions and units. Source Tarvainen et al. (2013)

However, in the present study we only use mean heart rate (mean HR), standard deviation of heart rate (SDHR), mean inter beat intervals (mean RR), and the standard deviation of beat intervals (SDNN) for the time-domain analysis. In addition, we use low frequency power in Fast Fourier Transform spectrum (FFT) in absolute and in average power (lowpowfft, lowpowprfft), the total power of all frequencies in FFT spectrum (totpowfft), the ratio of low frequencies over high frequencies for the frequency-domain analysis as well as a surrogate of the LF/HF ratio we will discuss. Our 1-minute time intervals do not allow us to use very low frequencies in our study (The European Society of Cardiology and The North American Society of Pacing and Electrophysiology 1996).

SDNN represents the total power of heart rate variability in the time domain, total power in all frequencies represent the same in the frequency domain. LF bands are in the range from .004Hz to .15Hz and are associated both with parasympathetic and sympathetic activation. HF

bands are in the .15 to .4Hz range. An increase in LF is correlated with an activation of the parasympathetic system responsible of positive arousal (see Kreibig 2010 for a survey about emotions and heart rate measures).

The Task Force of the European Society of Cardiology and The North American Society of Pacing and Electrophysiology (1996) recommends 24h intervals and 5-minutes intervals for long-term and short-term HRV analysis. However, several papers investigating the feasibility of taking shorter intervals demonstrate good correlations for heart rate measures (mean RR and SDHR) and some HRV parameters as SDNN, RMSSD and LF/HF (Nussinovitch et al. 2011) in healthy people in resting condition. In our study we do not obtain significant results with LF/HF. Hence we compute SDNN/RMSSD ratio as a surrogate.

## **2.6. Statistical analysis**

Statistical analysis was performed with SPSS 23. Data were tested for normal distribution with Kolmogorov-Smirnov Test. As all variables are not normally distributed non-parametric tests are used for the analysis. Comparisons within groups are made with Friedman Test for two or more groups and with Dunn Test with Bonferroni correction for two groups. Comparisons between groups are made with Mann-Whitney *U*-Test. A  $p$ -value  $\leq 0,05$  is considered significant. Some exceptions are made with  $p$ -values under .10.

### 3. Results

#### 3.1. Differences between samples

To test whether a difference exists between our two samples (treatment 1 and treatment 2) we run a Mann-Whitney *U*-Test for all our variables (see Table 4 for the list of our variables). No statistical differences exist between the two samples ( $p$ -value  $> 0,05$ ) except for *sdhr\_4* ( $U = 104$ ,  $p = .026$ ), *lfpowfft\_2* ( $U = 108$ ,  $p = .035$ ), *lfpowprfft\_3* ( $U = 106$ ,  $p = .030$ ) and *totpowfft\_4* ( $U = 107$ ,  $p = .033$ ).

We present in Table 3 statistics for each variable. SDHR in period 4 (+1,488), power of low frequencies in period 4 (+1 672,749ms<sup>2</sup>), power of low frequencies in period 3 (+13.094%) and total power of all frequencies in period 4 (+2 451,019ms<sup>2</sup>) are significantly higher in treatment 1 (0 skewed lottery) compared with treatment 2 (Skewed lottery).

treatment		sdhr_4	lfpowfft_4	lfpowprfft_3	totpowfft_4
1	Mean	6,68269406	3146,59110	52,3097330	5469,31987
	Std. Error of Mean	,476056944	706,839577	4,12749359	1066,39971
	Std. Deviation	2,01973856	2998,86635	17,5114722	4524,35081
	N	18	18	18	18
2	Mean	5,19493190	1473,84207	39,2155568	3018,30124
	Std. Error of Mean	,411805083	266,226010	3,39708177	561,213829
	Std. Deviation	1,84164832	1190,59891	15,1922115	2509,82454
	N	20	20	20	20
Total	Mean	5,89966134	2266,19687	45,4180613	4179,31007
	Std. Error of Mean	,331769624	383,075071	2,82524115	610,822269
	Std. Deviation	2,04516532	2361,43333	17,4159561	3765,36135
	N	38	38	38	38

Table 3. Descriptive statistics for SDHR, and frequencies power between the two samples

Regarding the power in the LF band in  $\text{ms}^2$  (lfpowfft\_periodnumber) we run a Friedman Test to detect differences between the waiting periods compared with baseline. The Chi-square is 12.267 ( $p = .015$ ). Only period 4 is statistically higher than baseline ( $Z = -1.667, p = .016$ ) with an increase of  $921.713\text{ms}^2$ , whereas we do not see any differences with baseline in treatment 2 (Chi square = .880,  $p = .927$ ).

We have the same results for the total power of all frequencies (Chi-square = 12.489,  $p = .014$ ) where period 4 is significantly higher than baseline in treatment 1 ( $Z = -1.667, p = .016$ ) with a rise of  $568.220\text{ms}^2$ . As for the power of low frequencies, no meaningful difference exists between baseline and period 4 (Chi square = 2.680,  $p = .613$ ).

However, we do not find statistical difference compared with baseline for the average power of low frequencies (lfpowprfft) neither in treatment 1 (Chi-square = 2.067,  $p = .559$ ) nor in treatment 2 (Chi square = 5.920,  $p = .205$ ).

### **3.2. Results considering the whole sample**

We are interested in differences in means between our 1-minute baseline period and the four periods after the lottery drawing. Then we compare the baseline period with the four periods after drawing the results. Finally, we compare differences between the periods after revealing the lottery and after drawing the results to subjects.

### 3.2.1. Heart rate (time-domain)

The Friedman Test for the baseline and periods 1, 2, 3 and 4 reports a Chi-square of 26.653 ( $p = .000$ ). We detect differences among our periods. Periods 2 ( $Z = 1.711, p = .000$ ), 3 ( $Z = 1.079, p = .029$ ) and 4 ( $Z = 1.026, p = .047$ ) are statistically different with baseline with respective lowering of -2.948, -1.934 and -2.012. Period 1 is significantly higher than period 2 ( $Z = 1.316, p = .003$ ) with a diminution of 1.918 bpm between the two periods.

The Friedman Test between baseline and periods 5 to 8 reports a Chi-square of 21.937 ( $p = .000$ ). Only periods 6 ( $Z = 1.500, p = .000$ ) and 7 ( $Z = 1.368, p = .002$ ) are statistically lower from baseline respectively about -3.363 and -2.967 bpm, without differences between these periods.

There are no differences among periods after the lottery revelation and after the draw of the results except for periods 2 ( $Z = 1.763, p = .048$ ), 6 ( $Z = -2.316, p = .001$ ) and 7 ( $Z = -1.921, p = .018$ ) with period 1 with respective decrease of -1.918, -2.333 and -1.937 bpm. We present in Table 4 the descriptive statistics about heart rate and in Figure 3 the evolution of heart rate across periods compared with the baseline period.

	meanhr_0	meanhr_1	meanhr_2	meanhr_3	meanhr_4	meanhr_5	meanhr_6	meanhr_7	meanhr_8
Mean	81,5264883	80,4968470	78,5786887	79,5922724	79,5139917	79,3120525	78,1634328	78,5597034	79,5494766
Std. Error of Mean	2,36592171	2,19121707	1,99202332	2,01936031	2,14204698	2,05504833	2,02995550	2,00911866	2,10218218
Std. Deviation	14,5845209	13,5075692	12,2796565	12,4481730	13,2044644	12,6681687	12,5134861	12,3850392	12,9587212
N	38	38	38	38	38	38	38	38	38

Table 4. Descriptive statistics for mean heart rate

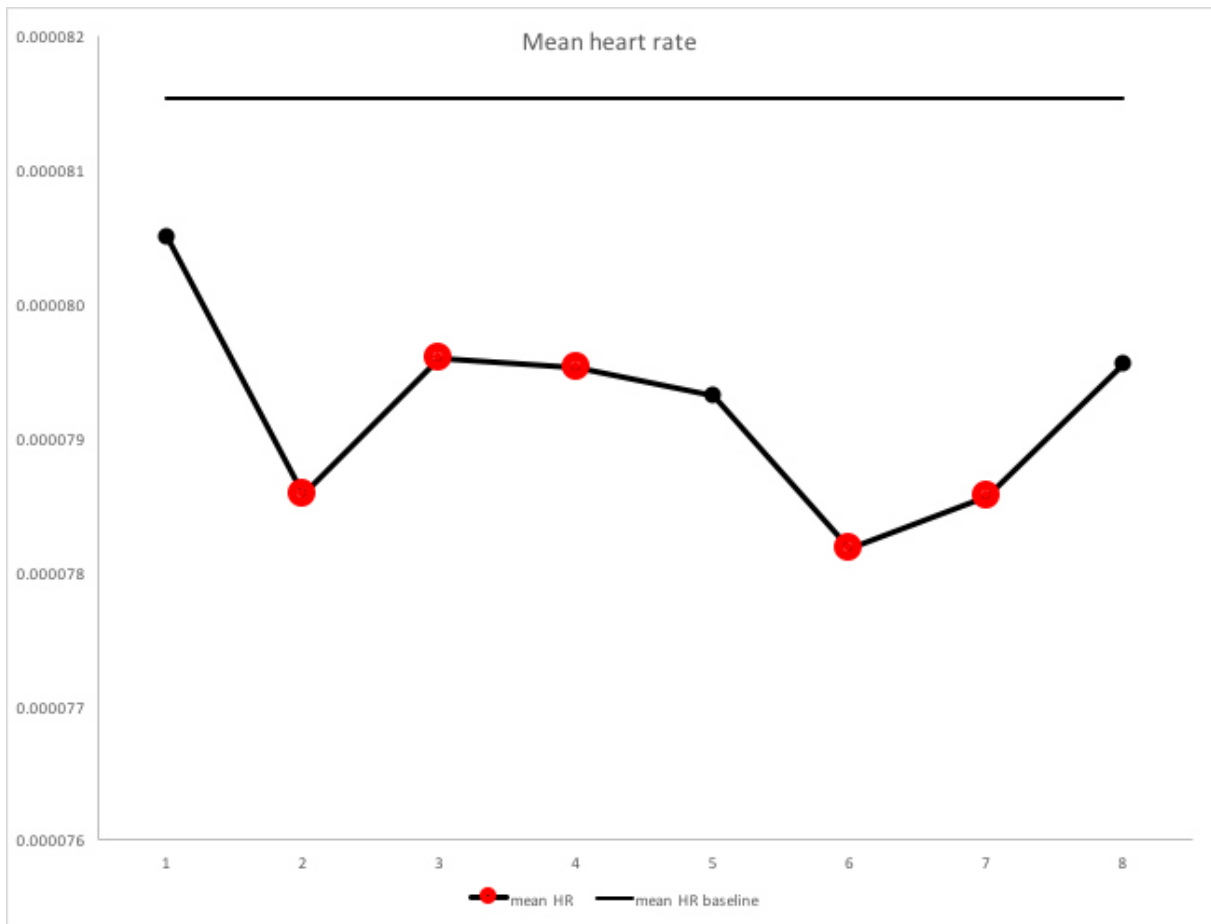


Figure 9. Mean heart rate compared with baseline. Periods in red are different from baseline ( $p < .05$ )

The Friedman Test for the standard deviation of heart rate reports a Chi-square of 16.253 ( $p = .003$ ). Only period 1 is significantly different from baseline ( $Z = -1.158$ ,  $p = .008$ ) with an increase of 1.485 bpm. Other differences are among periods 2 ( $Z = 1.158$ ,  $p = .014$ ), 3 ( $Z = 1.211$ ,  $p = .008$ ) and 4 ( $Z = 1.079$ ,  $p = .029$ ) with period 1. SDHR decreases for -1.252 from period 1 to 2 as well as from period 1 to period 4. However, it increases for 6.977 bpm between period 1 and period 3.

Results are similar regarding the differences between baseline and the periods relative to the results drawing (Chi-square of 21.263,  $p = .000$ ). Only period 5 is statistically different from



baseline ( $Z = -1.395$ ,  $p = .001$ ) with a rise about 1.433 bpm. Other differences are among periods 6 ( $Z = 1.342$ ,  $p = .002$ ), 7 ( $Z = 1.289$ ,  $p = .004$ ) and 8 ( $Z = 1.237$ ,  $p = .007$ ) with period 5 with respective attenuations of -1.170, -1.072 and -1.191.

No statistical difference exists between periods 1 and 5 ( $p = .712$ ), but periods 3 and 5 are different ( $Z = 2.105$ ,  $p = .005$ ) with an increase of 1.263 bpm between the two periods. At a 10% level, we notice a difference between periods 1 and 8 ( $Z = -1.737$ ,  $p = .056$ ) and between periods 4 and 5 ( $Z = 1.711$ ,  $p = .065$ ). We present descriptive statistics about SDHR in Table 5 and the evolution of SDHR across periods compared with baseline in Figure 4.

Standard deviation of heart rate									
	sdhr_0	sdhr_1	sdhr_2	sdhr_3	sdhr_4	sdhr_5	sdhr_6	sdhr_7	sdhr_8
Mean	5,49173724	6,97711147	5,72470026	5,66273079	5,89966134	6,92512426	5,75520105	5,85266055	5,73350168
Std. Error of Mean	,258320167	,396349509	,333049382	,321540886	,331769624	,309667145	,391229077	,341882993	,336839039
Std. Deviation	1,59239246	2,44326246	2,05305428	1,98211114	2,04516532	1,90891648	2,41169800	2,10750831	2,07641529
N	38	38	38	38	38	38	38	38	38

Table 5. Descriptive statistics about standard deviation of heart rate

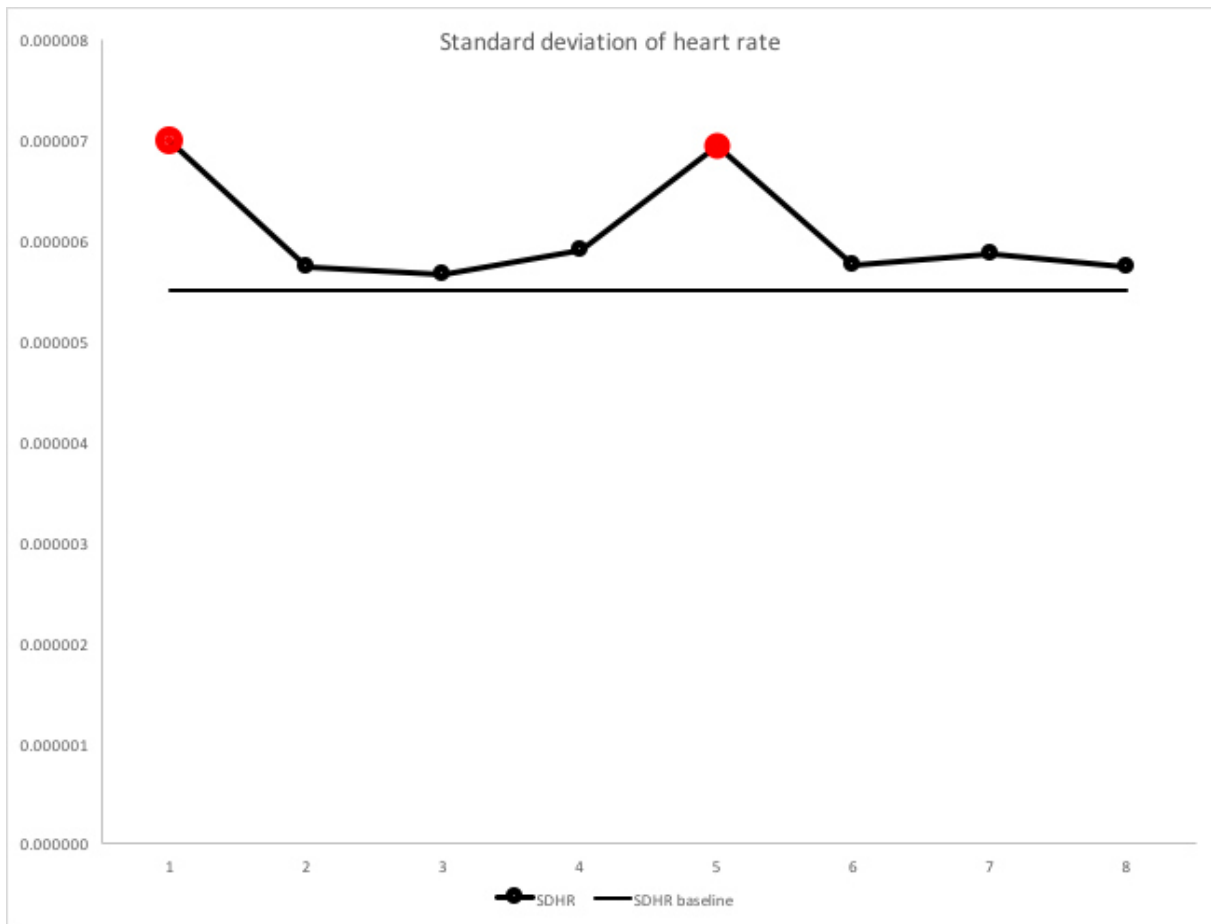


Figure 10. Standard deviation of heart rate compared with baseline. Periods in red are different from baseline ( $p < .05$ )

### 3.2.2. Heart rate variability (time domain)

We use mean beat to beat interval (mean RR) and the standard deviation of beat to beat interval (SDNN) for the time domain analysis of heart rate variability (HRV).

The Friedman Test for mean RR between baseline and periods 1, 2, 3 and 4 gives a Chi-square of 21.874 ( $p = .000$ ). The only difference in mean detected at a 5% level is amongst baseline and period 2 ( $Z = -1.605$ ,  $p = .000$ ) with an increase of the beat to beat interval of 23.694ms. Baseline and period 4 are also statistically different, but only at a 10 % level ( $Z = -$

1.132,  $p = .058$ ) with an increase between the two periods of 17.528ms. The mean RR rises about 14.469ms between periods 1 and 2 ( $Z = -1.132, p = .018$ ).

Results are quite similar regarding the differences between baseline and periods 5, 6 and 7 with a Chi-square of 23.621 ( $p = .000$ ). At a 5% level, periods 6 ( $Z = -1.553, p = .000$ ) and 7 ( $Z = -1.421, p = .001$ ) are different from baseline with respective rises of 28.921 and 24.414ms.

Regarding differences in mean RR between the lottery revelation interval and the results drawing (Chi-square = 22.930,  $p = .002$ ), we notice differences between periods 6 ( $Z = -2.132, p = .004$ ) and 7 ( $Z = -1.842, p = .029$ ) with period 1 at a 5% level, with growths of 19.696 and 15.189ms. At a 10% level, period 6 is significantly higher than period 3 with an increase of 15.361ms ( $Z = -1.658, p = .089$ ). We present descriptive statistics about mean RR in Table 6 and its evolution across periods compared with baseline in Figure 5.

Mean beat to beat interval									
	meanrr_0	meanrr_1	meanrr_2	meanrr_3	meanrr_4	meanrr_5	meanrr_6	meanrr_7	meanrr_8
Mean	762,655815	771,880604	786,349768	776,215247	780,184040	781,626078	791,576831	787,069745	777,852180
Std. Error of Mean	21,6776366	20,8268538	19,6728433	19,3580989	21,4511771	19,8202324	20,4734738	19,8658490	19,8774046
Std. Deviation	133,629927	128,385349	121,271551	119,331336	132,233936	122,180118	126,206968	122,461318	122,532551
N	38	38	38	38	38	38	38	38	38

Table 6. Descriptive statistics about mean beat to beat interval

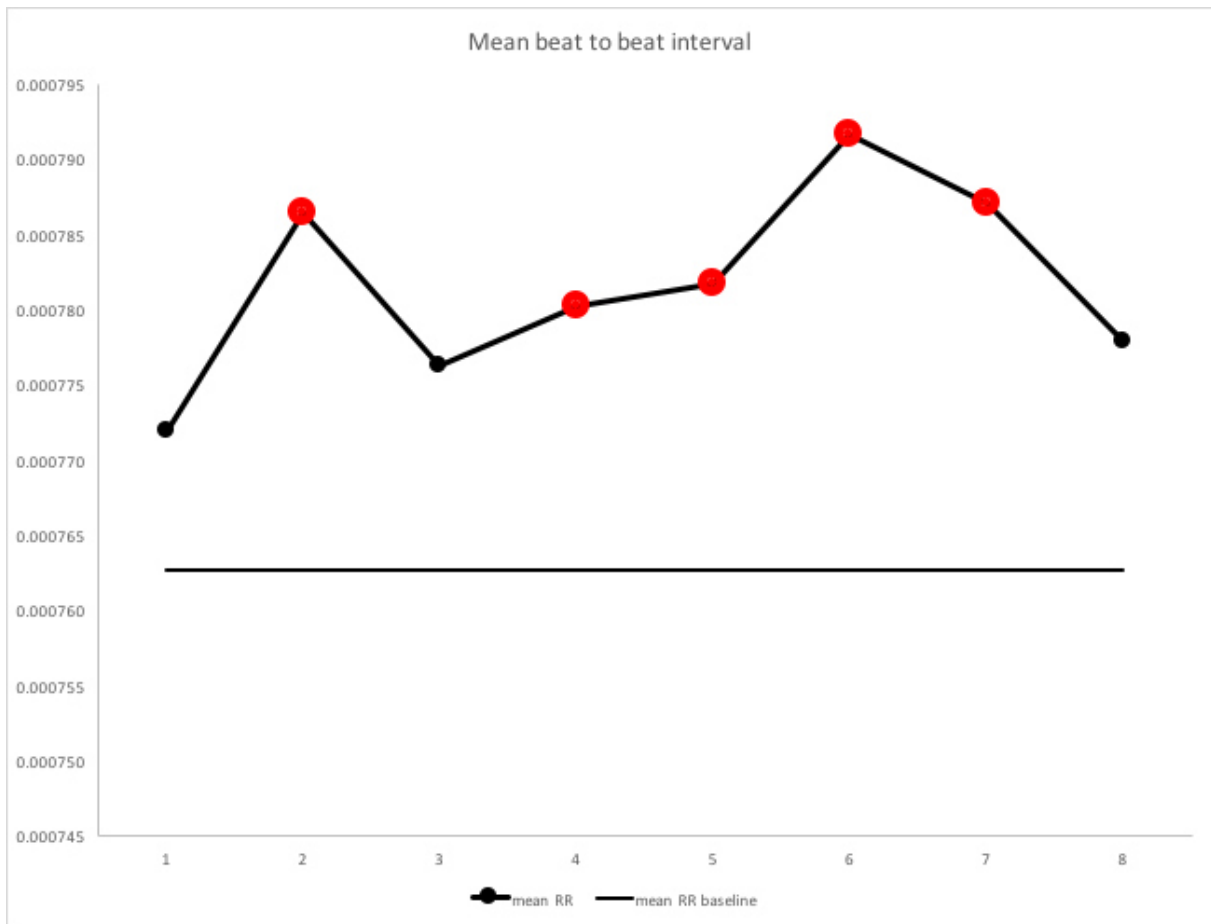


Figure 11. Mean beat to beat interval compared with baseline. Periods in red are different from baseline ( $p \leq .10$ )

Our results about standard deviation of beat to beat interval (SDNN) are in line with those from SDHR. The Friedman Test Chi-square gives a value of 12.547 ( $p = .014$ ) from baseline to period 4. Only period 1 is different from baseline ( $Z = -1.158$ ,  $p = .014$ ) with an increase of 10.440ms. Period 3 is significantly lower than period 1 ( $Z = 1.026$ ,  $p = .047$ ) with a diminution of -7.895ms.

We obtain similar results regarding baseline and periods 5 to 8 with a Chi-square of 22.968 ( $p = .000$ ). Only period 5 is superior to baseline ( $Z = 1.684$ ,  $p = .000$ ) with a growth of 69.956ms. Other differences are between periods 6 ( $Z = 1.158$ ,  $p = .014$ ), 7 ( $Z = 1.026$ ,  $p = .047$ ) and 8 ( $Z = 1.132$ ,  $p = .018$ ) with respective decline of -12.900, -10.612 and -12.898ms.

Across waiting intervals, the Chi-square for the Friedman Test is 25.860 ( $p = .001$ ). At a 5% level, period 5 is significantly higher than period 3 ( $Z = -2.158, p = .003$ ) by 12.875ms as well as periods 6 and 8. At a 10% level, period 5 is significantly higher than period 2 about 4.980ms ( $Z = -1.711, p = .065$ ). We present in Table 7 descriptive statistics about SDNN as well as its evolution across periods compared with baseline in Figure 6.

Standard deviation of beat to beat interval									
	sdnn_0	sdnn_1	sdnn_2	sdnn_3	sdnn_4	sdnn_5	sdnn_6	sdnn_7	sdnn_8
Mean	54,5356972	64,9757039	58,3121201	57,0808957	59,3120324	69,9556037	57,0551843	59,3434525	57,0576125
Std. Error of Mean	4,18062207	3,30765624	3,99057197	4,14292365	3,74402280	4,24041098	3,28496946	3,96822747	3,66073931
Std. Deviation	25,7710853	20,3897624	24,5995377	25,5386966	23,0797066	26,1396488	20,2499117	24,4617970	22,5663126
N	38	38	38	38	38	38	38	38	38

Table 7. Descriptive statistics about standard deviation of beat to beat interval

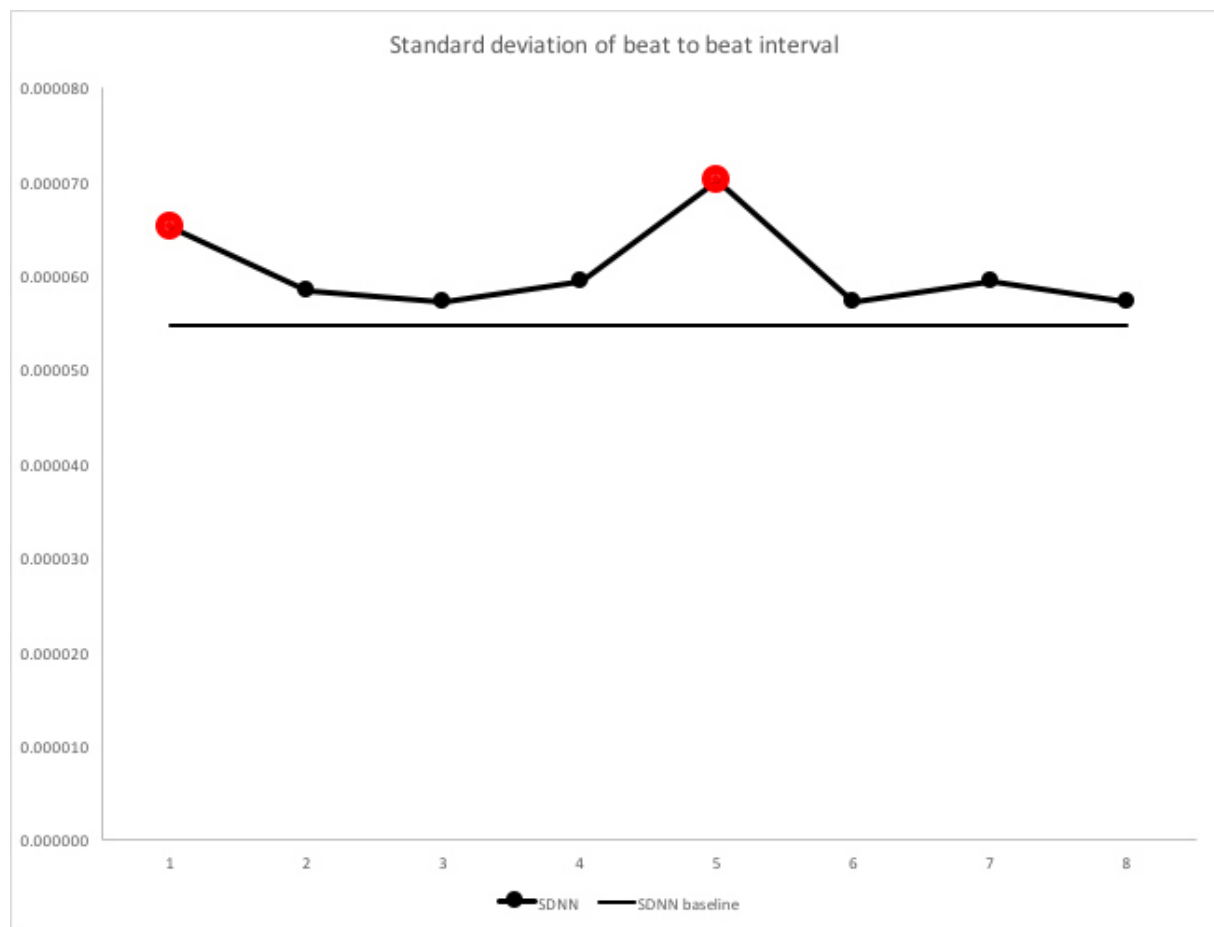


Figure 12. Standard deviation of beat to beat interval compared with baseline. Periods in red are different from baseline ( $p < .05$ )

### 3.2.3. Heart rate variability (frequency domain)

Considering the total power in  $ms^2$  of all frequencies we do not detect any differences between baseline and periods 1, 2, 3 and 4 with a Chi-square of 7.095 ( $p = .131$ ) for the Friedman Test. However, baseline and periods 5, 6, 7 and 8 differ significantly (Chi-square = 15.432,  $p = .004$ ). Only period 5 differs significantly from baseline ( $Z = -1.237$ ,  $p = .007$ ) with an increase about  $1130.607ms^2$ .

Baseline apart, we notice differences between period 2 ( $Z = 2.132$ ,  $p = .004$ ) and 3 ( $Z = 2.132$ ,  $p = .004$ ) and period 5 with respective increases of  $1302.184$  and  $1727,154ms^2$ . We also notice a decrease between period 5 and 7 of  $1345.869ms^2$  at a 10% level ( $Z = 1.711$ ,  $p = .065$ ). We present descriptive statistics about the total power of all frequencies in Table 8 as well as its evolution across periods in Figure 7.

Total power of all frequencies in FFT spectrum									
	totpowfft_0	totpowfft_1	totpowfft_2	totpowfft_3	totpowfft_4	totpowfft_5	totpowfft_6	totpowfft_7	totpowfft_8
Mean	3913,14968	3648,39763	3745,12629	3319,55607	4179,31007	5047,75629	3324,60655	3701,44102	3719,11728
Std. Error of Mean	1044,56836	418,431801	750,811123	600,473163	610,822269	673,392976	451,674888	555,172883	477,254306
Std. Deviation	6439,15180	2579,38685	4628,31060	3701,56517	3765,36135	4151,07309	2784,31101	3422,31550	2941,99313
N	38	38	38	38	38	38	38	38	38

Table 8. Descriptive statistics about the total power of all frequencies in  $ms^2$

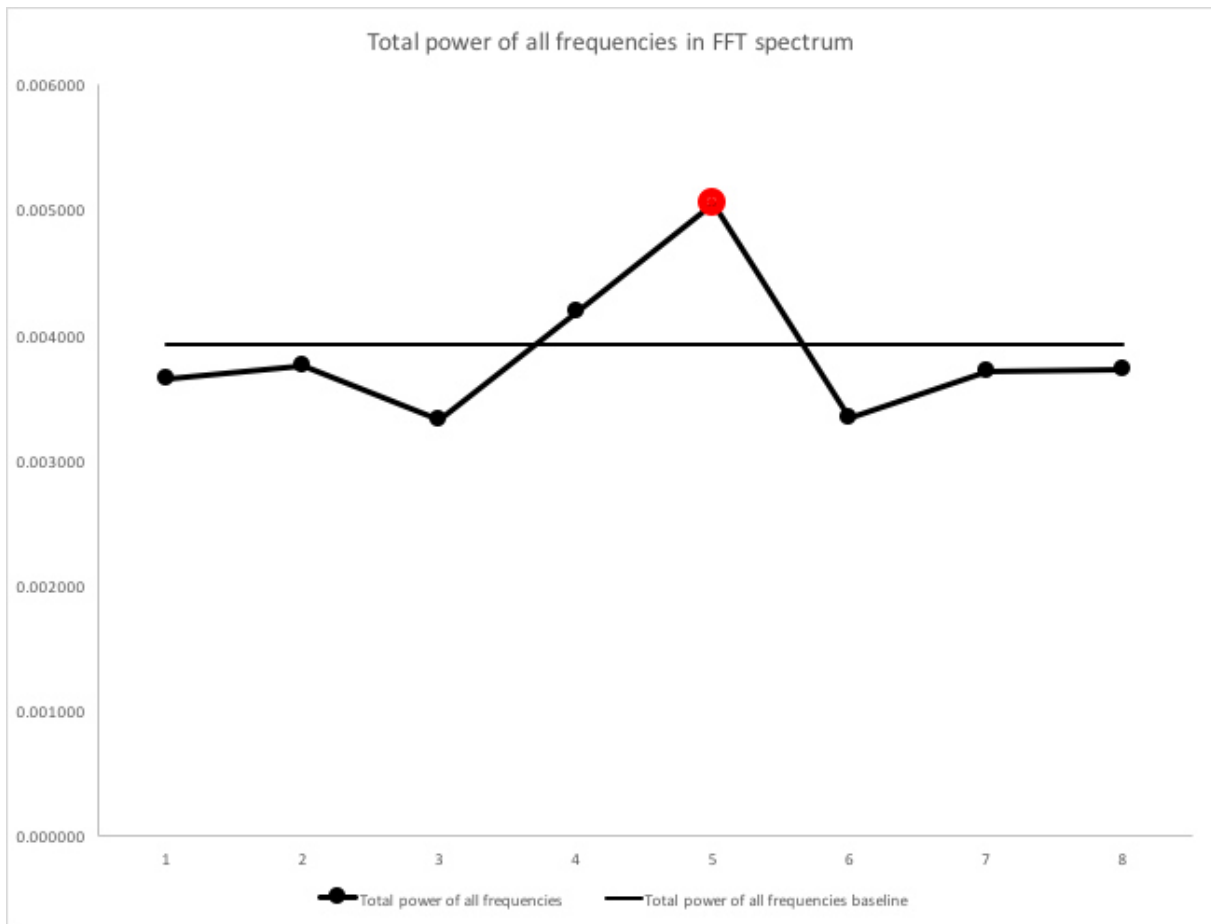


Figure 13. Total power of all frequencies in FFT spectrum compared with baseline. Period in red is different from baseline ( $p < .05$ )

We do not find any statistical difference across periods regarding LF/HF ratio with a Chi-square of 12.302 ( $p = .138$ ) for the Friedman Test. Hence, we decide to test a surrogate for this ratio (Wang & Huang, 2012): SDNN/RMSSD. Regarding the difference between baseline and the lottery revelation interval (Chi-square = 18.211,  $p = .001$ ), only period 1 is significantly higher ( $Z = -1.289$ ,  $p = .004$ ) with a rise of .315. Other differences are among periods 2 ( $Z = 1.342$ ,  $p = .002$ ) and 4 ( $Z = 1.105$ ,  $p = .023$ ) with period 1 with respective drops of -.291 and -.280.

Considering changes in SDNN over RMSSD between baseline and the results interval (Chi-square of 20.821,  $p = .000$ ), only period 5 is positively different from baseline ( $Z = -1.184$ ,  $p = .011$ ) with an increase of .244. Other differences are amongst periods 6 ( $Z = 1.053$ ,  $p =$

.037), 7 ( $Z = 1.237, p = .007$ ) and 8 ( $Z = 1.526, p = .000$ ) with period 5 with respective drops of  $-.203, -.257$  and  $-.106$ .

We find no significant difference between period 1 and 5 ( $Z = -.237, p = .706$ ). We present in Table 9 descriptive statistics about SNDD over RMSSD and its evolution across periods in Figure 8.

	SDNN/RMSSD								
	SDNNRMSSD _0	SDNNRMSSD _1	SDNNRMSSD _2	SDNNRMSSD _3	SDNNRMSSD _4	SDNNRMSSD _5	SDNNRMSSD _6	SDNNRMSSD _7	SDNNRMSSD _8
Mean	1,66100252	1,97588656	1,68464081	1,71866477	1,69624168	1,90488826	1,70172212	1,64728900	1,79840203
Std. Error of Mean	,079342019	,112145553	,093332510	,079378803	,084228327	,090981112	,090498640	,090744846	,141462729
Std. Deviation	,489097056	,691311616	,575340233	,489323804	,519218281	,560845240	,557871082	,559388799	,872034827
N	38	38	38	38	38	38	38	38	38

Table 9. Descriptive statistics about SDNN/RMSSD

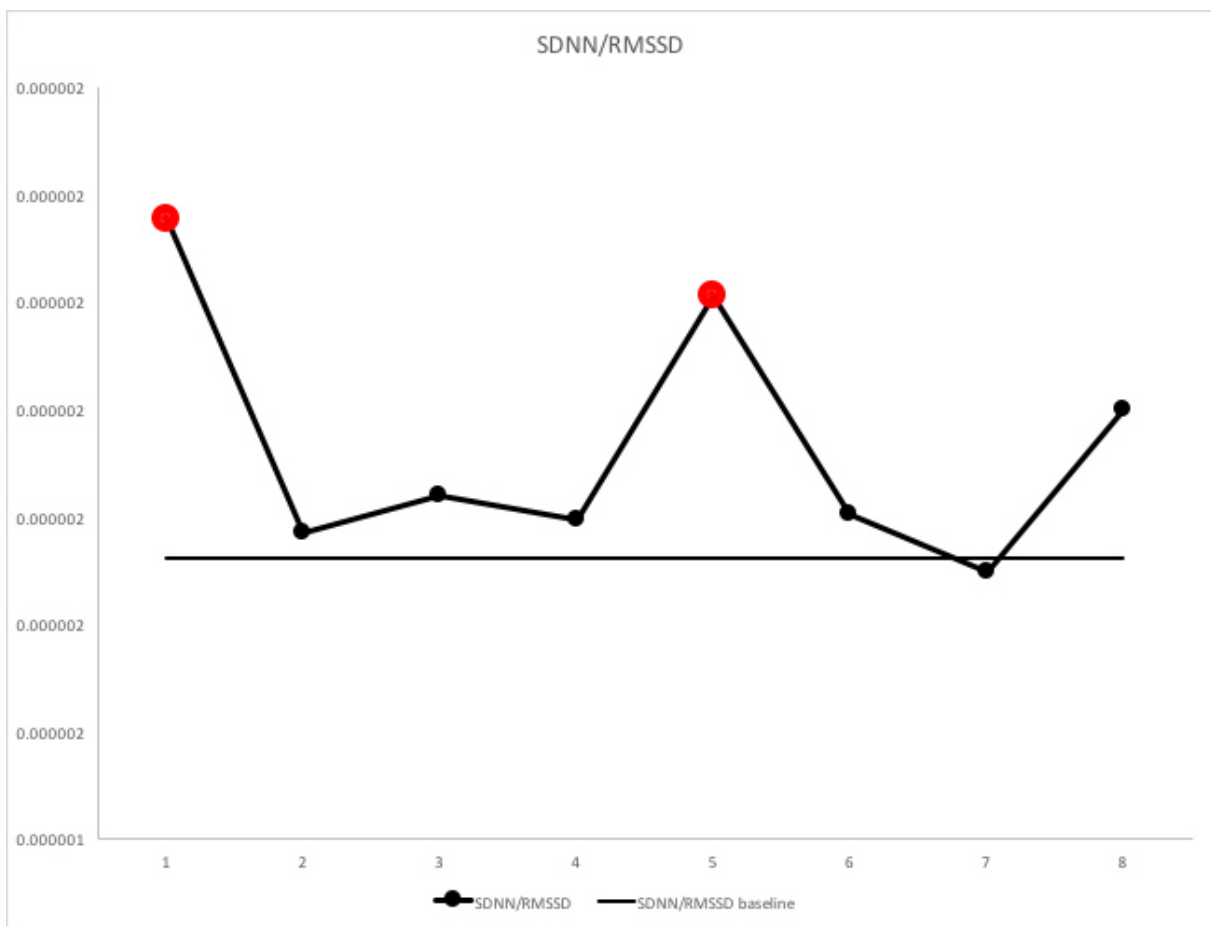


Figure 14. SDNN/RMSS compared with baseline. Periods in red are different from baseline ( $p < .05$ )



## **4. Discussion**

We investigate the formation of anticipations in subjects when facing lotteries. For that purpose, we compare physiological measures across different periods of time.

For all variables, the first period “variablename\_0” is considered as a baseline. During this interval, participants are in a waiting condition, where they do not form neither beliefs nor anticipation. Then subjects are shown a lottery (lottery 1 or lottery 2) and they are free to form or not anticipations about their future earnings during the four subsequent minutes. If participants form anticipations about their future outcomes, we expect to detect changes, positive or negative, during these periods (1, 2, 3 and 4) compared with the baseline period. Finally, they are shown the results of the lottery and are free to feel any sentiment about the result. If they experience sentiment we expect to measure changes in our physiological measures during periods 5, 6, 7 and 8, depending on the subject’s sentiment.

### **4.1. Formation of anticipations**

In the previous section we elicit differences between our two samples regarding standard deviation of heart rate in period 4, power of low frequencies in period 4, power of low frequencies in percentage in period 3 and total power of all frequencies in period 4. In particular, we highlight the fact that participants in treatment 1 have significantly higher values for all these variables (Table 3), especially regarding values for frequencies in the low band. Moreover, only the power of low frequencies (lfpowfft) as well as the total power of all frequencies (toppowfft) are significantly different from baseline. Higher LF values indicate

better emotion regulation in subjects in treatment 1 compared with those in treatment 2. Bradley et al. (2010) have tested the effects of a self-regulation program on students. They show that students who have received this program have learned better to regulate their emotions. They elicit greater both HF and LF frequency compared to students who have not received the program. Emotion regulation is related with emotion suppression and reappraisal (which can be interpreted as seeing the bigger picture) as well as better cognitive functioning (Gross 2002). Hence, participants in treatment 1 regulate more their anticipations about the future outcomes than participants in treatment 2 only from the last minute of the waiting period.

From now we will consider the whole sample. Heart rate measures are known to be good proxies of happiness and anticipatory pleasure. In our sample we detect significant changes in mean heart rate between period 2 and period 6 (Table 4, Figure 3) compared with baseline. Our results suggest that participants in the lotteries start making anticipations only from period 2, they stay in a pure waiting condition the first minute after learning the lottery they participate in. After period 2 mean heart rate is significantly lower than during baseline. The research in Neuroscience is mixed about the interpretation of heart rate. Indeed, heart rate values need to be interpreted differently regarding the experiment setup, particularly the emotion material used. When imagined material is involved, studies report increased heart rate and increased respiratory activity (Van Diest et al. 2001). However, when visual material is involved such as movies (Codispoti et al. 2008) or pictures (Bernat et al. 2006), a decreasing heart rate amongst other factors as skin conductance response is observed. Our experiment follows this kind of path as we show participants pictures with the lottery number and probabilities. Hence, we interpret the differences in heart rate as a formation of an anticipatory pleasure made by subjects about the future payoffs of the lotteries.

The heart rate follows the same pattern when participants learn the results. We only observe differences between periods 6 and 7 with baseline, indicating that participants feel happiness from the second minute after learning the lottery payoffs until the third minute. Several papers experiments with visual materials induction report decreased heart rate (Dimberg and Thunberg 2007).

Inversely mean beat to beat interval is negatively correlated with heart rate, the higher the heart rate, the lower the inter-beat interval. We notice a significant increase in mean RR between baseline and periods 2 and 4 (Table 6 and Figure 5). Surprisingly period 3 is not significantly different from baseline. Several studies have investigated the link between mean beat to beat interval and emotions. In an experiment when emotions are induced with visual material, Christie and Friedman (2004) test the implications of different emotions like amusement, contentment, anger and fear on different heart rate measures. They find a positive correlation between amusement and mean beat to beat interval. Geisler et al. 2010 test the hypothesis that a higher HRV is related to a better subjective well-being, as reported by a better mood and a higher satisfaction with-life. They demonstrate that HRV is positively correlated with positive hedonic tone such as joy and positive tense arousal like calmness.

Regarding the differences in mean between after the draw, only periods 5, 6, and 7 are statistically higher than baseline. This result suggests that participants do not feel any kind of emotion three minutes after knowing the lottery result.

We obtain another insight when taking into consideration standard deviation of heart rate (SDHR) and standard deviation of beat to beat intervals (SDNN). In these two cases we only

observe significant rises in periods 1 and 5 only compared with baseline. The changes in SDHR (Table 5 and Figure 6) in the first minute after the lottery announcement and after the notification of the results suggest a modification in the heart rate one period before what we measured with the mean heart rate.

Increased standard deviation of beat intervals is involved positive emotional states (McCraty et al. 1998) such joy (Kornreich et al. 1998) and happiness when evocating material is shown to subjects (Ritz et al. 2005 and Dimberg & Thunberg, 2007). In the present study SDNN significantly rises (Table 7 and Figure 6) in period 1 just after the lottery announcement and is significantly lower in periods before and after suggesting a peak of positive feeling after the lottery announcement, decreasing in the following periods. The same pattern can be observed in period 5. However, this result should be taken with caution as the literature about SDNN measures during very-short term intervals is still unclear.

Results on SDNN/RMSSD are mixed. We use this variable as a surrogate of LF/HF which represents the balance between the sympathetic system, which prepare the body for emergency actions, and parasympathetic system that functions when the body is relaxed. High LF and LF/HF ratio is involved in cases of anxiety in correlation with high heart rate and low heart rate variability. Murakami & Ohira (2007) research on anxiety have shown one exception to this relationship between heart rate and LF/HF ratio. Ritz et al. (2005) illustrate a simultaneous parasympathetic system deactivation and sympathetic activation when showing pictures of snakes to their subjects. In our sample we notice an increase in SDNN/RMSSD ratio in periods 1 and 5 (Table 9, Figure 8) suggesting a peak of anxiety in subjects.

Regarding our results about the total power of all frequencies we cannot conclude as the high frequencies and the low frequencies are both involved in this variable.

#### **4.2. Power of anticipation**

Regarding mean heart rate and mean RR, we show that statistical differences exist between the baseline periods and the periods after drawing the results of the lottery. However, no such difference exists between the periods when the lottery is announced and the periods when the result is known. This result suggests that the power of the anticipation made by the subjects is as strong as the happiness felt by participants when learning the drawing.

SDHR and SDNN peaks occurring in periods 1 and 5, during the first minute after the lottery announcement and after the drawing, follow the same pattern. We do not detect any differences between periods 1 and 5 regarding SDNN or SDHR. The SDNN/RMSSD ratio exhibit the same pattern, without significant difference existing between periods 1 and 5.

#### **5. Limitations and extension to further research**

When using students in experiments, using bonus points is quite common (Biais et al. 2005 as an illustration). However, most of lottery experiment use cash payments to ensure participants commitment (Shiv et al. 2005) to balance the hazardous and boring sides of a lottery. Moreover, in experiments with market replications, participants do tasks, not in lottery experiments, especially in our case where students have to stay motionless during three

periods of four minutes to ensure good heart-beat measurement. Hence, using bonus-points may not be as affective rich as money and the measure taken not as accurate.

The lottery itself could be demotivating a bit. In order to have equal parameters between the two lotteries except for Skewness our probability distribution is unusual. Subjects participating in lottery 2 with positive Skewness have only 1% of chance to win 4.25 bonus points and even if the experimenter assure them that the lottery is real and that points are added on their grade; they were nor very convinced.

In addition, we were unable to use parametric tests because of the non-normality of our sample. Non-parametric tests are less powerful than parametric ones. To illustrate this, we consider the two treatment as independent for the mean heart rate variable (meanhr\_period). Considering the two treatments separately, we find that for treatment 1 (lottery with 0 Skewness), the Chi-square of the Friedman Test is 9.289 ( $p = .054$ ) when we compare means of baseline and periods 1 to 4. This result suggests that the differences in means we observed considering the whole sample all come from treatment 2, meaning that in terms of heart rate, participants in treatment 1 do not form any beliefs, they just wait. Again if we compare baseline with periods 5 to 8 the Chi-square is 9.022 ( $p = .061$ ), suggesting that participants in this treatment do not feel any sentiment regarding their payoffs. For treatment 2 we obtain a Chi-square of 22.280 ( $p = .000$ ) confirming the prediction that all anticipations and all sentiments are made by participants in the second treatment.

Finally, physiological measures like HRV are usually taken over longer periods of time (usually 24h or 5-minute intervals). Even if several studies have demonstrated the possibility

to take measures in shorter intervals (up to 10 seconds) research is not undivided and some measures like very low frequencies cannot be interpreted over short periods.

## **6. Conclusion**

We introduce physiological measures in the investigation of beliefs formation in the presence of lotteries. We use lotteries with the same characteristics except for Skewness and take heart rate and HRV during several periods of time to highlight the beliefs persistence over time.

We show that participants in the lottery with 0 skewness exhibit greater emotion regulation one minute before learning the lottery result compared with subjects participating in the skewed lottery. Hence their biased anticipation is less persistent about the possible future payoffs. In regards with the self-regulation theory they seem to be more aware about the lottery they take part in.

Considering the whole sample, we find evidence that subjects form positive anticipations the second minute after visualizing the lottery probabilities and that anticipation is stable until the results drawing in terms of mean heart rate and beat to beat interval.

The happiness induced by “winning” follow a similar pattern starting from the second minute after visualizing the results but vanishes two minutes later, eliciting that this emotion is less persistent over time than the anticipations made. However, in terms of mean RR, the happiness starts earlier. Our results regarding standard deviation of heart rate, as well as standard deviation of beat to beat intervals and SDNN/RMSSD demonstrate a peak in the

anticipation felt by participant the minute after watching the lottery and a peak in the emotions felt the minute after learning the results.

Finally, we study the power of the anticipations formed compared with the lottery drawing announcement. We do not find any differences between anticipations and happiness induced by the earnings in terms of mean heart rate, mean of beat to beat intervals, standard deviation of heart rate, standard deviation of beat to beat intervals nor SDNN/RMSSD ratio the anticipation seems to be less powerful.

Overall, our experiment supports the existing literature in Finance on beliefs formation and anticipations.



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## Appendix

Last name:

First name:

Gender:

Age:

For the experimenter only

Subject number:

Treatment number:

Earnings:

### Lottery game: rules of the game

You are going to participate in a lottery game in which you will have the opportunity to win bonus points for Professor Laurent Germain courses. This game is real and the bonus points you will earn will be recorded by your professor.

Please follow these instructions carefully so that the experience occurs in the best conditions.

**You will participate in one of the following lotteries.** The experimenter will draw in which lottery you will participate.

#### Lottery 1:

- 1% of chance to win 1,5 bonus points (1)
- 49% of chance to win 1,5 bonus points (2)
- 50% of chance to win 0,5 bonus points (3)

#### Lottery 2:

- 1% to win 4,25 bonus points (1)
- 49% to win 1,35 bonus points (2)
- 50% to win 0,59 bonus points (3)

The experiment will occur as follows:

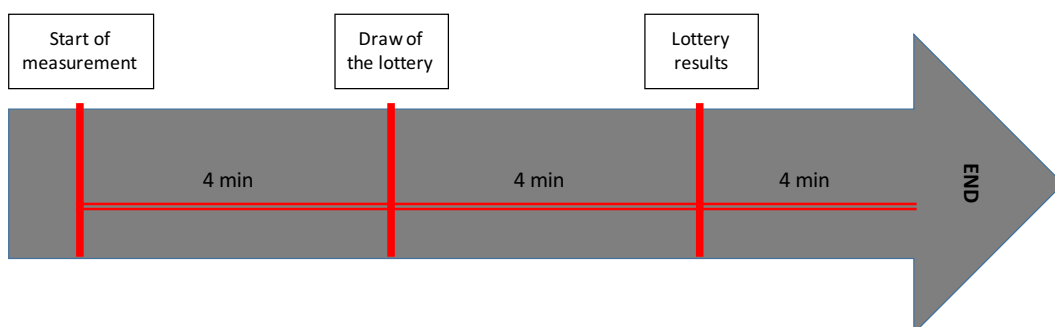
1. With you consent, the experimenter will explain you how to place properly the electrodes to measure your heartbeat in order to guarantee a reliable measure. Then, you will be asked to fill in questionnaires 1, 2 and 3 without thinking too long about the answers you will wish to circle (we are interested in your instinctive impressions).
2. Once these questionnaires filled in, the experimenter will inform you that he will start taking your heartbeat measure continuously until the end of the experiment. **You will have to wait for 4 minutes** without making sudden movements (like shaking etc.). During this period of time the experimenter will tell you the time remaining, 3 minutes, 2 minutes, 1 minute 30, 30 seconds.
3. At the end of this period **the experimenter will draw the lottery in which you will participate in** (lottery 1 or lottery 2). To do so, he will show a sheet of paper with the

lottery number and the possible payoffs of that lottery. Next, **you will have to wait for 4 minutes** without making sudden movements (like shaking etc.). During this period of time the experimenter will tell you the time remaining, 3 minutes, 2 minutes, 1 minute 30, 30 seconds.

4. Just after this period, the experimenter will draw from a transparent box containing 100 papers (1 paper representing the 1% probability, 49 papers for the 49% probability and 50 papers for the 50% probability) the result of the lottery and will inform you of your earnings (verbally and by showing you the paper). The experimenter cannot see what is written on the pieces of papers and shake the bowl before the draw.
  - If the number on the paper is 1, thus your earnings are 1,5 points or 4,25 points depending on the lottery you play.
  - If the number on the paper is 2, thus your earnings are 1,5 points or 1,35 points depending on the lottery you play.
  - If the number on the paper is 3 thus your earnings are 0,5 points or 0,59 points depending on the lottery you play.
5. Next, **you will have to wait for 4 minutes** without making sudden movements (like shaking etc.). During this period of time the experimenter will tell you the time remaining, 3 minutes, 2 minutes, 1 minute 30, 30 seconds.

At the end of this period the experimenter will ask you to remove electrodes and he will conduct a debriefing with you.

**If you have any questions about the procedure, please ask them right now.**



## **General conclusion**

As have been underlined throughout this thesis, mainly in the first chapter, many of the investors investment mistakes and failures in diversification can be explained with behavioural biases and investors preferences. Several empirical findings support the idea that overall they perform worse than the market. We have shown that Neurosciences may be particularly useful to investigate the brain connections underlying such behaviours.

In chapter 2, we investigate the impacts of the 2008-2011 financial crises on individual investors returns and their expectations towards their financial intermediaries in four different countries (Belgium, France, Germany, Luxembourg) and two different types of banks customers (high net worth individuals and retail customers). We show that wealthier investors remain less risk averse than the others and adopt less conservative strategies. We also highlight the news expectations both types have towards their financial intermediaries that is more transparency and better client services.

In chapter 3, we propose a physiological test of the Brunnermeier and Parker model (2005). To extent we use a two identical lotteries experiment except for their skewness. We find that all participants form anticipatory emotions once they know the lottery they will play. These emotions start from the second minute of the waiting interval and remain stable until they learn their payoffs. We also show that the emotions felt by subjects once learned their payoffs are as strong as the anticipatory emotions they formed earlier. Finally, we demonstrate that participants to the skewed lottery are less self-regulated than others, highlighting their preference for skewness. Their emotions are stronger and more persistent.