Incentive Pay as a Factor in the Financial Crisis from Behavioral and Neuroscientific Perspectives

Master Thesis

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Executive summary

The purpose of the current study is to explore the role of managerial behavior in the recent sub-prime mortgage crisis by looking at the link between incentive pay at American financial institutions and risk-taking. In the few years prior to the crisis, executive compensation in the US financial industry was at one of its highest levels in the past two decades, with nondepository lender institutions, among which sub-prime mortgage originators, and broker and dealer institutions, among which investment banks, paying their executives the most. Stock options and bonuses, both of which encourage maximizing short-term profitability at the expense of long-term stability, represented the bigger part of the compensation packages.

We explore the link between incentive pay and increased risk-taking by looking at the amount and structure of incentive pay, as well as at the short-term evaluation horizon on which it is based. We approach the problem using two paradigms – first a behavioral economics one, and then a neuroeconomics one. Since the sub-prime mortgage crisis is in fact an example of the fallibility of human behavior, behavioral economics is an especially advantageous framework to use, as it is concerned with analyzing phenomena that disprove the rationality assumption behind neo-classical economics. While behavioral economics takes a descriptive approach, neuroeconomics adds value by uncovering the neural mechanisms that directed risk-taking behavior in response to incentive pay.

From a behavioral perspective, the peer comparison evaluation inherent in incentive pay encourages herding behavior in the direction of risk-taking. The convex-shaped performance-based evaluation structure further contributes to risk-taking by making investment an asymmetric bet. From a neuroscientific perspective, the amount of incentive pay matters, as high rewards induce excessive activation in the reward-approach structure of the brain, which may lead to a risk-taking error. Monetary rewards, both anticipated and experienced, lead to an increase of the levels of dopamine, a hormone associated with happiness, and activate the same regions of the brain as primary reinforcers, such as food. The short-term evaluation horizon is also related to increased risk-taking. On a neurological level, annual bonuses are time-discounted via a different mechanism than compensation with delay of more than a year.
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1. Introduction

The recent financial crisis, which originated in the United States, has had a resounding effect all over the world, reaching well beyond the financial sector to decrease consumer spending, demolish retirement plans, tighten credit availability, ruin small businesses, increase unemployment rates, stifle entrepreneurship, and reverse the economic cycle from growth to recession or stagnation in most developed countries. The financial crisis has also effectively put an end to investment banking as we know it, with all five big Wall Street investment banks gone – Lehman Brothers went bankrupt, Bear Sterns and Merrill Lynch were acquired by JPMorgan Chase and Bank of America respectively at prices well below their market valuation, and Goldman Sachs and Morgan Stanley were forced by the government to become bank holding companies, i.e. to have commercial banking divisions (The Economist, 2009). Other giants of the US economy escaped the faith of the investment banks only nearly – AIG, the biggest insurance company in the United States, as well as Freddie Mac and Fannie May, the two biggest mortgage lenders who in 2008 either owned or guaranteed about half of America’s $12 trillion mortgage market, needed significant financial support from the government to avoid collapsing (Duhigg, 2008). Hundreds of other financial institutions, including Goldman Sachs, were put on a government relief program to avoid bankruptcy.

Banks outside the United States were also directly affected by the crisis, most notably Deutsche Bank, which was holding a large amount of the American mortgage-backed securities that turned out to be the root of the problem.

In the aftermath of the crisis, the general public and politicians alike started the search for culprits. The blame was put on the lax government regulation of the American banking sector, on the low interest rates characteristic of the US economic policy in the past decade, on the easy access to credit for both consumers and businesses, on the low financial literacy of the average American that made her a victim of predatory lending, etc. However, by far the most favorite culprit that public opinion has pointed to is Wall Street and its investment banks. Allegations range from Michael Moore’s conspiracy theory of a deliberate $700 billion raid on tax-payer money by the banks to the theory that mortgage originators, mortgage bond traders, and mortgage bond insurers acted out of incompetence rather than greed.
If there is one thing that the public opinion is united around, however, it is the idea that whether simply incompetent or smart, greedy, and unethical, banking sector executives, managers, and employees proved that they did not deserve the obscenely high compensation they received. Public outrage over bonuses – at Goldman Sachs, as much as 50% of profits is set aside for bonuses, a figure that amounted to $3.2 billion at the height of the financial crisis in the third quarter of 2009 – has lead politicians in the United States, as well as worldwide, to call for government regulation of executive pay and for a government crack-down on risk-taking activities in the financial sector (The Economist, 2009). There are still voices in support of bonuses with the argument that people who create wealth should be rewarded for it, but even these voices admit that “bonus schemes need to be redesigned to reflect the fact that the old schemes encouraged too much short-term risk-taking – something that is clearly in the interests of shareholders” (The Economist, 2009). In an increasingly knowledge-based economy, a company’s employees are its most valuable asset, and potentially a source of sustainable competitive advantage. This is why it is important that managers be well rewarded. However, the issue of the amount, structure, timing, and performance basis of compensation is not a simple one to solve and should be looked at from many different angles. As tempting and common-sense as it is for politicians and the general public to blame the crisis on the greed of the financial industry, the link between compensation practices and increased risk-taking in the financial industry has not yet been sufficiently explored.

Compensation is traditionally dealt with by agency theory, where principles are the shareholders, and the agents are the managers and employees. Agency theory, while based on the idea that incentives affect motivation and behavior, is still very much aligned with mainstream economic thought, its assumptions, and its mathematical models. However, the failure of mainstream economics to predict the recent financial crisis has called the attention to the limitations of modern economic thought and has called for a rethink, including a rethink of compensation practices (The Economist, 2010). Incentive pay, stock ownership, profit sharing, and performance evaluation were all meant to align the interest of agents and principles – and yet, the financial crisis occurred.

1.1. Problem statement

According to agency theory, the reason for designing compensation schemes is to align the actions of the managers with the interests of the shareholders, thus effectively avoiding what is known as the principal-agent problem. Because it is often not the owners of a company (the
principals) who manage it, there is an imperfect match between their interests and the ones of the company managers (the agents). Company managers can seek to advance their own agenda, including higher pay, more influence, indispensability, etc. at the expense of the long-term interest of the shareholders – increasing shareholder equity. Good compensation schemes reward the agents when they act in the best interests of the principals by finding a balance between rewards for short-term profitability, such as base salary and bonuses based on recent performance, and long-term growth and stability, such as stock options, benefits packages, pension plans, etc. Since boosting short-term profits and performance at the expense of long term investment and stability negatively affects the value of stock options, which is higher than the value of base salary plus bonus, it is in the agents’ interest to take a long-term approach. However, an approach with payouts too far in the future is also undesirable to the agents – thus a balance between short-term profitability and long-term investment is achieved, at least in theory (Jian et al., 2010).

1.1.1. Compensation schemes and risk

However, even the most well-designed compensation schemes cannot prevent every counter-productive behavior that agents (managers) might be tempted to engage in. One of the negative by-products of compensation schemes that are optimal from the shareholders’ view is that they do not control for, and may even induce, excessive risk-taking. Because most firms are financed by a combination of equity and debt, stakeholders of most firms include both shareholders and debtholders, but compensation schemes only aim to align the interests of shareholders and managers, leaving debtholders out. By virtue of being residual claimants, i.e., receiving whatever money is left after debtholders and suppliers have been paid, shareholders stand to lose nothing more than their initial investment should excessive risk-taking lead to the collapse of the firm. However, should the high payoff inherent in excessive risk-taking materialize, shareholders stand to gain unlimited amounts. Therefore, managers have an incentive to take on excessive risk financed by debtholders in an attempt to generate high pay-offs in the short term, and thus serve the interest of shareholders, as well as their own, through boosting the stock price. In addition, short-term incentive pay, a very prominent example of which are annual bonuses, further increases managerial incentive to increase short-term profitability at the expense of long-term financial health – after all, managers do not need to stay with one firm forever. Therefore, incentive pay does what it should do –
namely, align the interests of shareholders and managers – but still induces counter-productive managerial behavior (Jian et al., 2010).

Financial institutions are even more susceptible to incentive pay problems because of their relatively high debt-to-equity ratio necessary for the efficient execution of their primary function – financial intermediation between savers and borrowers (Jian et al., 2010). The more debt a financial institution takes on, the more it can intermediate, the more fees it can collect for its services, the higher short-term profitability it demonstrates. With annual bonuses based on performance, managers in the financial industry have a higher-than-average incentive to take on debt, and consequently, risk.

1.1.2. Executive compensation in the American financial industry

Accessing information about executive pay schemes in the American financial industry is relatively easy, since this information must be disclosed in annual reports which are readily available to the public. Non-executive compensation data is much harder to collect, but it must be kept in mind that the actions of all employees – bankers, traders, and the risk management committees that oversee them – are an important factor to consider when examining compensation schemes. Executives may have a blind spot for the oversight of non-executive employees who make investment decisions on a daily basis. However, “it is still reasonable to say that top executives are the most important agents in setting firm and investment policies and that their compensation really matters” (Jian et al., 2010).

1.1.3. Executive compensation in the financial industry compared to other industries

Fig.1 shows that executives in the financial industry earned the highest pay, but, in the mid-range, the base salary was not much different from the one in other industries. It is also evident that the financial industry awarded higher bonuses and higher restricted share options. Bonuses amount to more than twice the base salary and to 1.5 – 2.5 times the bonuses paid to executives in other industries. In addition, bonuses are often tied to short-term performance, usually over the past one to three years. Thus, “this compensation structure tends to reward short-term profits and may have encouraged ‘short-termism’ at financial institutions” (Jian et al., 2010). Fig.1 also shows that the value of stock options (a long-term incentive) granted to executives in the financial industry was the second lowest among all industries.
1.1.4. Executive compensation across different groups of American financial institutions

Fig. 2 shows differences in executive pay across different groups of financial institutions, with the two highest executive pay groups being securities and commodities brokers and dealers, among which investment banks, and non-depository lenders, among which mortgage and other credit originators (Jian et al., 2010). These two types of institutions were at the heart of the financial crisis, representing the two sides of the same coin – easy consumer credit inflating housing prices, and the creation of mortgage bonds. Executives at commercial banks and real estate earned compensation no higher than executives in other industries.

Source: Jian et al., 2010
Fig. 1. Compensation across different industries in 2005

Fig. 2. Executive compensation in banking and finance, 2005.
The higher pay for executives working for brokers, dealers, and non-depository lenders could have come from three sources – bonuses, restricted stocks, and stock options, and the amounts were very high, exceeding $1 million to $2 million per executive in each channel. Thus, incentive pay and high compensation as an incentive for excessive risk-taking do not seem to point to the entire financial industry, but rather to commodities brokers and dealers, as well as to non-depository lenders (Jian et al., 2010).

1.1.5. Executive pay and firm profitability

Fig. 3 represents the relationship between executive pay and firm profitability. Strong correlations between several compensation items and profit measures suggest that executive compensation is associated more with the size of the institution than with its operating efficiency (Jian et al., 2010). Four components of compensation – base salary, bonuses, restricted stocks, and stock options – all exhibit relatively strong correlations with net income and market value, both of which are driven by firm size. In contrast, correlations between compensation and return on equity and return on assets, both of which are often used as indicators of operating efficiency, are quite low. These observations suggest that the kind of pay structure with an emphasis on bonuses, restricted stocks, and stock options may encourage managers to grow the firm at the expense of returns on the invested capital (Jian et al., 2010).

| Correlation between Executive Compensation and Firm Profitability in Banking and Finance, 2005 |
|---------------------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Total compensation                                           | Net income      | Market value    | Return on assets | Return on equity |
| Salary                                                        | 0.44            | 0.51            | 0.06            | 0.06            |
| Bonuses                                                       | 0.31            | 0.46            | 0.07            | 0.08            |
| Restricted stocks                                            | 0.36            | 0.39            | 0.06            | 0.09            |
| Stock options                                                | 0.39            | 0.35            | 0.08            | 0.08            |
| Stock options                                                | 0.17            | 0.27            | 0.07            | 0.06            |

Source: Jian et al., 2010

Fig.3. Correlation between executive compensation and firm profitability in banking and finance in 2005.

1.1.6. Trends in executive compensation

Executive compensation across all industries in 2005 was at one of its highest levels since 1992, following an overall upward trend, albeit with a significant decrease after the dot-com bubble burst in 2000 (see Fig.4). However, banking and finance executives were the highest paid ones, with nondepository lenders (among which mortgage and other credit originators), and brokers and dealers (among which investment banks) paying their executives the most and accounting for most of the compensation volatility in the financial industry (see Fig.5).
When total executive compensation is broken down into its components (Fig.6), it is important to note that in the years prior to the financial crisis, stock options and bonuses represented the bigger part of the compensation packages. While salaries rose slowly but steadily at an annual rate of 2.6%, bonuses, which are tied to short-term financial performance, increased from 100% of the base salary in 1992 to 216% of the base salary in 2005. (Jian et al., 2010). This boost in bonuses may have encouraged financial industry executives and employees to maximize short-term profitability at the expense of long-term stability (Jian et al., 2010). Stocks and stock options, whose proportion of total compensation also rose over time, (Fig.6) are considered an incentive for managers to develop long-term growth and profitability. However, they can still induce excessive risk-taking in the short run if managers hold too many of them (Jian et al., 2010). When owning stock and/or stock options, managers tend to act like shareholders - by taking excessive risk, they stand to lose their investment at most, but to gain potentially unlimited profits should the high payoff associated with high risk materialize. Fig.7 and Fig.8 show that the amount of bonuses and stock/stock options in the nondepository lenders and brokers and dealers is much higher prior to 2005 compared to the other three types of institutions in the financial industry.
Studying the empirical data about pay structures in the financial industry prior to the financial crisis reveals some practices that may have contributed to the financial crisis by encouraging excessive risk-taking. There are two issues that are particularly problematic – the sheer amount of compensation, most of which in the form of stock(stock options and bonuses, and the short pay-off time – one to three years for bonuses, but usually one, and potentially less for stock. In addition, it appears that the incentive pay structure of nondepository lenders and brokers and dealers is more likely to induce excessive risk-taking than the incentive pay of other institutions in the financial industry. However, the empirical data reflects an observation without providing any insights into it, thus pointing to the fact that there is a reason to look further into the issue.
1.1.7. The need for multidisciplinary approach

As already mentioned, compensation is a topic traditionally dealt with by agency theory and discussed from the standpoint of neo-classical economic theory. However, exploring the link between compensation practices and increased risk-taking in the financial industry using neo-classical economic theory carries the same limitations that lead to the failure to predict the crisis – the same assumptions and the same models are used, leading to the same limited view. There is a need for an alternative, multidisciplinary approach that offers various points of view.

One of the assumptions on which neo-classical economic theory is based is that investors are completely rational. However, real life provides an ample amount of instances where people do not always make rational choices, suggesting that decision-making is not an entirely conscious, emotion-deprived, fact-based process. Two fields that look into the irrational aspect of human behavior, and therefore challenge the neo-classical economic theory, are behavioral science and neuroscience, which are imported into the field of business to form the interdisciplinary fields of behavioral economics and neuroeconomics.

The current study looks at the link between incentive pay and risk-taking from a behavioral and a neuroscientific perspective, seeking to answer the following research question:

Is incentive pay in nondepository lender institutions and broker and dealer institutions in the American financial industry related to increased risk-taking?

1. Is the incentive pay amount and structure in nondepository lender institutions and broker and dealer institutions in the American financial industry related to increased risk-taking?
2. Is the short-term time horizon of performance evaluation on which incentive pay in nondepository lender institutions and broker and dealer institutions in the American financial industry is based related to increased risk-taking?

1.2. Topic delimitation

We are aware that there are numerous factors influencing risk-taking. In light of the complexity of the topic, a broader approach, while certainly providing various perspectives, would not allow for in-depth analysis of any particular issue. In order to provide a detailed
view of the effect of incentive pay on risk-taking, we have decided to narrow our focus at the expense of leaving the variables described below out of consideration.

1.2.1. Incentive pay at different financial institutions

As discussed in Section 1.1.4., institutions in the American financial industry are not homogenous. There are five distinct types of institutions: 1) commercial banks, 2) nondepository lenders, 3) brokers and dealers, 4) insurance, and 5) real estate. Executive compensation, both in terms of amount and structure, varied significantly between the five types of institutions prior to the crisis, reaching its highest levels in nondepository lenders and brokers and dealers. Executive compensation level in commercial banking, insurance, and real estate was similar to the levels in other American industries. We focus on nondepository lenders and brokers and dealers, because they stand apart from both the rest of the financial industry, and the rest of the major industries in the United States.

Incentive pay in nondepository lenders and brokers and dealers consists of three types: bonuses, restricted stock, and stock options. While as already discussed, all three can encourage short-term profit-seeking at the expense of long-term financial stability, we concentrate on bonuses. The conditions for receiving a bonus are relatively homogenous from institution to institution – they may be based on different performance metrics, but the underlying condition is the same – as long as the performance metric is reached within the accounting period, the bonus is paid out at the end of the accounting period. In contrast, restricted stock and stock options come with more variability – vesting periods, call options, put options, and trading restrictions all vary from institution to institution, making it difficult to come up with a general structure for these two types of incentive pay.

1.2.2. Other factors contributing to the financial crisis

Many factors, both internal and external to the financial industry, contributed to the recent financial crisis. On a broader scale, social and cultural factors such as consumerism, overspending, over-reliance on credit, and other aspects of consumer behavior, as well as economic policy factors, such as the American government’s policy of low interest rates and minimal capital requirements, all have played a role in the financial crisis (Rizzi, 2008).
1.2.3. The limitations of mathematical models

Within the American financial industry, the use of mathematical models without understanding their limitations is considered a factor in the systematic under-valuation of risk (Rizzi, 2008). In order to work, statistical models require homogenous populations with a long history of observations, when in fact the securitization model created securities that were small, heterogeneous, and had limited history by virtue of being a new invention. Statistical models also have the disadvantage of being “blinded” by the mean, underestimating unexpected events, and hiding potential losses due to unexpected events in their tails. Mortgage default models in particular were history-based, taking history as an answer rather than as a guide, ignoring the fact that the past is only one of the possible outcomes of an event. In addition, financial models overlook the fact that the majority of investment decisions involve uncertainty, not risk, because it is impossible to predict and precisely calculate the probability of all possible investment outcomes. Financial models offer calculations, which are required to manage risk. Managing uncertainty, however, requires good judgement, not calculations – substituting one for the other can have a detrimental effect (Rizzi, 2008).

Rajan et al. (2008), as cited by Rizzi (2008), present empirical evidence that between 1996 and 2005, lender institutions increasingly neglected the role of soft information when evaluating consumer loans – i.e., they looked only at the credit scores of applicants, ignoring the more qualitative information behind the numbers. The authors empirically demonstrate that such an over-dependence on hard information causes an increase in loan default rates.

While we are aware of the different factors that contributed to the financial crisis, the focus of this study is solely on risk-taking as a decision, rather than as an inadvertent action resulting from the use of flawed risk valuation models.

1.2.4. Variables in risk-taking

Risk-taking as a decision can also be influenced by many variables, from demographic to behavioral to genetic, among which culture, gender, age, education, income, investment experience, monetary incentives, non-monetary incentives, genetic pre-disposition, individual personality traits, clinical deviations from normal behavior (such as addition to gambling), and others.
Geert Hofstede, one of the most influential names in cross-cultural analysis, points to the main characteristics of American culture: high emphasis on individualism, assertiveness, materialism, and achievement, combined with a relatively low uncertainty avoidance and short-term orientation (Clearly Cultural, 2011). All these factors encourage risk-taking, and since organizational culture exists as part of national culture, it is likely that they play a role in financial risk-taking on individual, as well as on institutional level.

Gender is also an important factor in risk-taking, with its effect especially important in the male-dominated financial industry in the United States. Academic literature in both behavioral psychology and neuroscience suggests that women are less likely than men to invest in riskier assets with higher returns (Dwyer et al., 2002). Dwyer et al. (2002) conduct empirical analysis of data from nearly 2000 mutual funds, which demonstrates that female investors take less risk in their mutual funds than male investors. However, the difference is significantly decreased when financial investment knowledge is controlled for. Other researchers suggest that risk-taking is “an attribute of masculine psychology that evolved in response to the competitive demand of primate societies” (Byrnes et al., 1999). This implies that dominant individuals are forced by competition to engage in risk-taking to ascertain their positions of power, with a greater spread between winners and losers providing a greater incentive for risk-taking (Byrnes et al., 1999). Since the American financial industry is an example of an environment where the difference between winners and losers is indeed millions of dollars, as well as significant differences in job prospects, power, influence, and respect, men in the industry are likely to engage in more investment risk-taking than women in the industry. From a neuroscientific perspective, Apicella et al. (2008) cite research that links testosterone, a hormone whose levels are much higher in men than in women, to increased financial risk-taking.

Age appears to be a factor in risk-taking behavior as well. Byrnes et al. (1999) found that while gender differences exist across all age groups, they vary significantly from group to group. Dwyer et al. (2002) also cite age as a factor in risk-taking. Jianakopolos and Bernasek (1998) have found that relative risk aversion decreases as household wealth increases, a phenomenon that is also subject to gender differences.

On a behavioral level, group think, or organizational pressure, can contribute to increased risk-taking. Group think occurs when individuals identify with the organization and accept its
actions without questioning, thus mutually reinforcing biases and incorrect beliefs (Rizzi, 2008). Thornton et al. (2006), as cited by Rizzi (2008) survey risk officers at various financial institutions, including Bear Stearns and Lehman Brothers, all of whom believe that they are safer than ever at the time of the study, because they do not doubt the financial models and other risk management tools the companies use to evaluate risk. The spectacular crashes of the two companies only two years later are still regarded as the landmark events that marked the beginning of the unravelling of the financial crisis.

On a personality level, risk-taking is a correlate of sensation seeking, albeit not the primary motive in behavior. Sensation seeking is a constellation of personality traits, defined as “the seeking of varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, and financial risks for the sake of such experience” (Roberti, 2004). The explanation for sensation seeking is based on a model that combines genetic, biological, psychophysiological, and social factors (Roberti, 2004). Also on a genetic level, there is research that suggests that some of the variation in risk preferences may be attributable to a specific dopamine receptor gene (Dreber et al., 2009).

Culture, gender, age, education, income, investment experience, non-monetary incentives, genetic pre-disposition, and individual personality traits are all relevant factors in risk-taking behavior, including risk-taking in the American financial industry prior to the financial crisis. However, they are not related to incentive pay. Thus, we leave them out in order to focus our analysis on the effects of incentive pay on investment risk-taking.

2. Background - the crisis in brief

2.1. The securitization model

The securitization model was originally invented in the 1980s, by Salomon Brothers, a Wall Street investment bank. The model was based on the then-new concept of the mortgage bond. A mortgage bond is different from traditional government and corporate bonds. While traditional bonds are a loan for an explicit fixed term, mortgage bonds are “a claim on the cash flows from a pool of thousands of individual home mortgages” (Lewis, 2010, p.8). The monetary incentive for the bank to sell a mortgage bond was that it did not have to wait for
many years to have its money back; it could have it back right away and re-invest it. Money at present is much more valuable than money in the future.

Investors also had an incentive to buy a mortgage bond – the bank paid them an interest rate on the bond for as long as the bond existed and was in their possession (a feature of all bonds), and they would also get steady money over time, as the mortgage was gradually repaid. However, since borrowers had the right to pay off their mortgages at any time, they typically did so when interest rates fell – i.e., when they could get a second loan at a lower interest rate and use the money to pay off the first, so they could then keep repaying the second with the lower interest rates. In such cases, the mortgage bond holders were left with capital to invest at lower interest rates, resulting in 1) less profit than the projected one had the original higher-interest mortgage not been paid prematurely (and the interest payments on it lost), and 2) less profitable options for re-investment of the money from the mortgage repayment.

To compensate mortgage bondholders, Salomon Brothers came up with a creative solution - it took large pools of home loans and split the payments made by the borrowers into pieces, called tranches. Those tranches were sold to different investors. Should prepayments occur, the buyers of the first tranche would receive the first wave, (i.e., lose the most, because the mortgages behind their bonds would be paid off first), but also be compensated for taking that risk with the highest interest rates on their mortgage bonds. The buyers of the second tranche would receive the second wave of prepayments, and be compensated with the second highest interest rate, and so on.

In the 1980s, the loans underlying the mortgage bonds conformed to the standards, both in terms of loan size and credit quality of the borrowers. The standards were set by one of three big government agencies: Freddie Mac, Fannie Mae, and Ginnie Mae. The loans that met the standards carried a government guarantee – if the homeowners defaulted, the government would pay off their debt. Thus, the fear of the 1980s investors was not that they would not be paid; it was that they would be paid too early and thus lose the projected income from the interest on the loan. By the mid-1990s, however, the securitization model was already being used to tap an untapped market – subprime mortgages.
2.2. The subprime mortgage market

Subprime mortgages are mortgages that do not qualify for a government guarantee, usually because the credit quality of the borrowers does not meet the standard. The idea is to extend credit to less and less creditworthy borrowers, so they can cash out the equity locked up in their real estate\(^1\). Assuming increasing real estate values, a property would have positive equity a few years after being purchased. At this point, the owner could use the property as collateral to get a new loan corresponding to the present value of the property and thus higher than the original mortgage. With this new loan, the owner repaid the original mortgage and kept whatever money was left to use at his discretion, effectively “cashing out” the equity of the property. Such a scheme was even more attractive when real estate values increased while interest rates on loans decreased, because not only did owners get a lump sum out of refinancing their debt, but they also ended up paying lower interest.

Subprime mortgages underlying mortgage bonds meant that investors in the 1990s started to fear that they would not be repaid at all. To solve this problem, the original solution to the early repayment problem was adapted. The investors holding the first tranche would be the first ones to be exposed to losses should defaults occur, and would also get the highest interest rates on their mortgage bonds. They would take the losses until their entire investment was wiped out, at which point the losses would move to the second tranche, and so on. The implications of turning home mortgages into bonds were vast – it meant that loan makers could convert their liabilities (the loans) to pieces of paper that could be sold to anyone and generate profit. The model was soon extended to credit card debt, college loans, auto loans – all much riskier than the original government-backed mortgages the model was created for. The incentive for loan makers to go into the subprime market was quite clear – not only could they charge subprime borrowers high interest rates, but they could sell off the risk to investors in the form of mortgage bonds.

2.3. The auditors

The lowest-level regulatory authority that should have been alarmed by the new model in the 1990s were the bank auditors, the independent accountants who looked at financial statements and certified that there was no fraud in the books. While auditors get paid by their

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\(^1\) Equity is the difference between the value of the mortgage used to buy the house and the market value of the house.
clients, they also hold a special industry-issued license which is revoked if it turns out that
financial statements they certified are in fact fraudulent; this means they can never work as
auditors again, which is their incentive to not cover for fraudulent practices. The problem
with the subprime mortgage bonds, however, was that accountants were unable to understand
the complicated securitization instruments of the big Wall Street firms. They could not tell
whether the firms were making or losing money or why they owned mortgage bonds (Lewis,
2010, p.11). Loan makers disclosed ever-growing earnings, but not the delinquency rates of
the home loans they originated. When confronted by the auditors, management would argue
the delinquency rate was irrelevant, as most loans were sold off to other firms to be packaged
as mortgage bonds – the risk no longer belonged to the originating institution (Lewis, 2010,
p.13). This was not completely true, as loan-making companies retained a small fraction of
their loans. However, US accounting rules in the 1990s allowed them to list as profit the
expected future value of the loans – i.e. earnings not yet made were already on the books –
legally. In addition, accounting rules allowed companies to operate under the assumption that
the loans would be repaid – and not prematurely (Lewis, 2010, p.13). Reported earnings,
therefore, were not real, but accounting-driven. The subprime mortgage lending companies of
the 1990s resembled Ponzi schemes – they needed more and more capital to generate more
and more subprime loans so their accounting-driven earnings could keep growing (Lewis,
2010, p.15). This was the incentive to make loans in the 1990s – more loans translated into
better financial statements, and most of the risk was passed on to someone else.

2.4. Minor setback in the late 1990s

The subprime lending industry of the 1990s went through an en masse failure in 1997, during
the greatest economic boom in US history, when Russia’s default and the bankruptcy of one
hedge fund caused investors to panic and deny capital to subprime lenders, causing them to
go bankrupt because they had no money left to lend. This failure, however, was attributed to
the bad accounting rules, and not to the practice of making subprime loans. The accounting
rules were changed; subprime lending as a concept remained untainted (Lewis, 2010, p.16).

2.5. The subprime market is reborn

After the 1997 wave of bankruptcies, there were no more public subprime lenders left in the
United States in the early 2000s. However, there was one consumer-lending company, a
leader in the field, with years of experience. It was engaged in the fraudulent practice of
obscuring the real interest rates on its loans. Despite the issue being exposed, the government failed to act, while the company successfully settled a class action lawsuit with the customers it had defrauded. It agreed to pay $484 million in fines. The following year, it sold itself, along with its portfolio of subprime loans, for $15.5 billion to HSBC, effectively earning millions for its CEO and once again proving that there was money to be made in the subprime business, and more importantly, that the area remained largely outside of government attention (Lewis, 2010, p.18).

By 2005, the subprime lending machine was running again, as if it had never been broken. In the mid-1990s, $30 billion had been a big year for the subprime mortgage business; in 2000, $130 billion had been lent to the subprime market, and about $55 billion were repackaged as mortgage bonds; in 2005, there were $625 billion in subprime lending, $507 billion (81%) of which turned into mortgage bonds – in a single year. As already discussed in Section 1.1.6., 2005 was also the year when compensation for executives in nondepository lenders and dealers and brokers reached one of its highest levels in years. However, this new wave of subprime lenders had learned an important lesson from the first wave that failed. The first wave had failed because of keeping a small fraction of their subprime loans on their books. This second wave was not going to keep any of their subprime loans on their books (Lewis, 2010, p. 24). The model was simple – generate as many loans as possible, then sell them off to the fixed-income departments of the big Wall Street investment banks, which would in turn re-package them into mortgage bonds and sell them to investors. By 2005, all five big Wall Street investment banks – Bear Stearns, Lehman Brothers, Merrill Lynch, Goldman Sachs, and Morgan Stanley – were in the subprime business, using special names for their subprime departments that made it difficult for the general public to see the big names behind the subprime bonds.

In 2005, the bond market was big enough to overwhelm everything else. Even since the invention of the mortgage bond model in the 1980s, the bond market had been where the money was made; the CEOs of most investment banks had their background in bonds. The bond market had experienced twenty years of boom despite the minor setback in the late 1990s (Lewis, 2010, p.25). This meant that an entire generation of managers in the financial industry – people who had their first jobs when the model was invented were likely to have reached at least middle-management level after 20 years in the industry – had never seen the model do anything other than bring profits since its invention in the 1980s. Neither had they
seen the risks inherent in subprime lending materialize since the subprime lending market was created in the 1990s. For 20 years, it had been growth and profits with no major losses and busts on the subprime front.

2.6. Shorting bonds through credit-default swaps

Back in 2004, a handful of stock investors had come up with the idea of shorting bonds. Normally, when investors expect the price of a stock to fall, they can sell it without actually owning it – with the help of a brokerage firm, they borrow it from someone else and then return the loan when the price falls and they buy it cheaper. The same model could not be applied to tranches of mortgage bonds, because they were too small to find and borrow; brokerage firms did not offer the service either. Then the already existing model of credit default swaps came into the game.

A credit default swap is an insurance policy, usually on a traditional corporate bond, with semi-annual premium payments and a fixed term (Lewis, 2010, p.29). In the event of the corporation defaulting on its debt, the insurer would pay the original value of the bonds. The most investors stood to lose was the insurance premium payments in case the corporation did not go bankrupt; the most they stood to make was the original value of the bonds if the corporation defaulted and bond holders recovered nothing. Since the premiums were quite low compared to the value of the insured bonds, it was an asymmetric bet – the potential loss was fixed and known, and the potential gain was many multiples of the loss. Credit default swaps in effect “swapped” the risk of holding the bond from the investor to the insurer and solved the open-ended risk problem for investors.

The few investors who envisioned a meltdown in the real estate market were already buying corporate credit default swaps on companies that stood to be directly affected – mortgage lenders, mortgage insurers, etc. However, this was not optimal – companies could lose money, but it did not mean they would go bankrupt, in which case a credit default swap would not bring any gains. Therefore, investors wanted a more direct way to bet against the subprime mortgage market – hence the idea of credit default swaps on mortgage bonds.

The problem was that in 2004, no financial institution offered such a product. One investor (potentially more, but the case of one is known), called several Wall Street banks to discuss
mortgage bond credit default swaps. Two, Goldman Sachs and Deutsche Bank, showed an interest; the rest didn’t know what he was talking about. In about three years, the credit default swaps on mortgage bonds was to become a trillion-dollar market (Lewis, 2010, p.31).

When the bankers at Goldman Sachs and Deutsche Bank started looking into the contract that would go with the new product of mortgage bond credit default swaps, they realized that it would be much more complicated than corporate bonds credit default swaps. Corporate credit default swaps dealt with one event – a corporation either defaulted or not. If the corporation defaulted on its debt, the insurer and the insured had to settle, sometimes with the help of the court, but the event that triggered the settlement was simple and straight-forward. Mortgage bonds, on the other hand, consisted not of a single mortgage, but of a pool of mortgages; they would not default all at once, but at different rates – so when would an insurance payment be triggered? The solution was the pay-as-you-go credit default swap. The buyer of the swap would be paid incrementally, as each mortgage went into default, as opposed to at once, if and when all mortgages in the pool went into default (Lewis, 2010, p.49).

With the terms on the new mortgage bond credit default swaps finalized, the trade began in 2005, led by Goldman Sachs and Deutsche Bank, with the big Wall Street banks entering shortly after. The problem was, the price of the insurance the banks were selling was not based on independent analysis, but on the ratings placed on the bonds by one of two rating agencies, Moody’s or Standard & Poor’s (S&P) (Lewis, 2010, p.51).

2.7. The rating agencies

Moody’s and S&P are two of the three rating agencies that evaluate a company’s likelihood of default. The third one is significantly smaller and did not have a big role in the subprime mortgage bonds rating. Ratings were originally used by investors in their decision to buy traditional stocks and bonds in different companies; after the invention of the securitization model, ratings started to be used for various securities as well, including mortgage bonds. The agencies are private entities, and they are approached and paid by companies to rate their stock, as it is virtually impossible to publicly trade stock and securities that have not been rated. Although the two slightly differ in their evaluation method, their ratings are similar – triple-A is the highest rating (with the lowest likelihood of default), and triple-B is the lowest rating a company can have and still be publicly traded. Prior to the crisis, a triple-A bond was
considered to have a less than 1-in-10,000 chance of default in its first year of existence; a triple-B one was assumed to have a less than 1-in-500 chance of default in its first year of existence (Lewis, 2010, p.24).

By 2004, the standards for rating mortgage bonds had already deteriorated – the quality of the loan pools behind the mortgage bond required for a given rating was lower than the quality that had been required in the past (Lewis, p. 27), i.e. a triple-B bond was riskier than it used to be, although the rating remained the same on paper. Wall Street investors had long interpreted the ratings to mean the likelihood of default. However, once the crisis started to unravel and the ratings proved meaningless, the agencies claimed this interpretation was wrong – the ratings should not have been taken as precise measurements, but rather as a “best guess at a rank ordering of risk” (Lewis, 2010, p.51).

2.6.1. Issues with the rating models

No matter what the ratings were supposed to be used for, there were major problems with the models used to create them. An evaluation of the risk of a mortgage pool was based on the FICO scores of the borrowers in it. A FICO score is said to measure the creditworthiness of an individual. The highest possible FICO score is 850; the lowest is 300; the US median prior to the crisis was 723. FICO scores in general were prone to manipulation on part of individuals, but this was not the main problem. The main problem was that the rating agencies did not ask the loan makers for a list of the FICO scores of the borrowers – they asked for an average score, but not for the standard deviation associated with it. To meet the requirements for a triple-A rating, the average FICO score of the borrowers in the pool needed to be around 615. There are more than one ways to arrive at an average score – this was where the loan makers saw an opportunity. A mortgage pool where most borrowers have an average score of 615, and a mortgage pool where half of the borrowers have FICO scores of 500 and the other half – of 730, both have an average of 615 – but the first one is far less likely to suffer many defaults than the second one. A person with a FICO score of less than 550 is almost certain to default and should have never been lent money in the first place, but this fact could be cleverly masked by the average FICO score of all the borrowers in the pool (Lewis, 2010, p. 99). Therefore, loan makers could keep making subprime loans as long as they found enough borrowers with high enough credit scores to bring up the average FICO score of the pool. Here lied the second loophole that loan makers exploited.
A person with a high FICO score can fall in one of two categories – people with a long history of borrowing would have a “thick-file” FICO score, and people with a short history of borrowing would have a “thin-file” FICO score. The problem with high thin-file FICO scores is that the borrower may have never failed to repay a debt because he has never had one – and is thus considered creditworthy, although in reality he may not even have income, as FICO scores do not take income into consideration. Thus, recent immigrants, for example, who generally tend to have low incomes and therefore could not have gotten loans had the original high standards been applied, were suddenly very useful to the loan makers – they could bring up the average FICO scores of the subprime mortgage pools (Lewis, 2010, pp. 98-100).

Those two factors, the use of average FICO scores for the pool behind the mortgage bonds, and the failure to differentiate between thick-file and thin-file FICO scores, lead to the complete opposite of a rational market– the triple-A bonds, supposedly the safest and therefore the most expensive ones to buy and the cheapest to insure, were also the most ineptly rated ones. The high rating was often a reflection of a hidden big standard deviation around the 615 FICO average, and those loans to borrowers with high FICO scores (supposed to be less risky) were in fact risky due to the short credit history of the borrowers. Therefore, a triple-A rated mortgage bond could contain as much risk as a triple-B rated one, although this risk was well hidden and not reflected in insurance premiums.

The question is, why did rating agencies not do a more thorough analysis of the mortgage bonds they were rating? Agencies were paid to rate the mortgage bonds by the banks that created the mortgage bonds – and they were paid by the volume (Lewis, 2010, p.73). Therefore, the less time they spent rating a bond, the more bonds they could rate; the more bonds they rated high, the happier the banks were, the more business they brought. If the ratings turned out to be wrong, nothing would happen, since there were only three agencies providing this service, making the market an oligopoly in practice, though not on paper. There was no regulatory body holding those agencies accountable either. On the other hand, if one agency rated the bonds low, the dissatisfied customer could choose to go to another one, therefore a consistent enforcement of the high rating standards would have required all three agencies to forgo their profits. Naturally, none of the agencies wanted to be the first one to do so, because there was no incentive (besides ethics) for the other two to follow the lead. Volume-based incentive pay, combined with the fear of losing business, created an incentive for the rating agencies to overlook important details in their ratings.
2.7. The investors

So far we have discussed the loan makers who originated subprime mortgages; the Wall Street investment banks who packaged them into mortgage bonds; and the insurance companies who sold insurance on the mortgage bonds to the small number of investors who were willing to bet against the subprime market. It is time to discuss the large number of investors betting on the subprime market – those who were buying mortgage bonds expecting them to bring profits. The most common investors in mortgage bonds were hedge funds - entities created to invest money on behalf of high-net-worth individuals and other institutions. A hedge fund is therefore a “middleman” who invests other people’s money and collects a fee for the service.

2.7.1. Incentive pay in hedge funds

In a typical hedge fund, portfolio managers made the decision in what securities to invest. They were also the ones who were supposed to persuade clients to join the hedge fund. Portfolio managers were typically paid a percentage fee of their portfolio’s assets off the top–i.e., they got paid simply for collecting large amounts of other people’s money in the fund (Lewis, 2010, p.44). In addition, they were paid a percentage of the profits they made for their clients. They also had their base salary, which they received regardless of performance. Performance was usually evaluated quarterly and was measured using one single indicator – how much profit the manager made for his investors. Investors received quarterly newsletters reporting on hedge fund performance. Incentive pay in the form of bonuses as a function of both volume and profit, combined with the short evaluation horizon, created incentives for portfolio managers to invest in risky assets.

The percentage of the profits they made was paid to portfolio managers at the end of the year, and sometimes even quarterly, and was not taken back even if the assets they had invested in subsequently lost all their value. Low-risk investments took years to generate the same amount of profit that high-risk ones could generate in a year. Investors themselves had become accustomed to high and quick profits and had no patience to wait for a pay-off, thus putting pressure on portfolio managers to concentrate on the short-term (Lewis, 2010, p.110).
In addition, a manager whose portfolio brought large profits every quarter would attract more investors to the fund, thus increasing the assets and the percentage fee the manager collected. Should the manager take a risk and lose, investors could leave – but the fund manager had already collected his remuneration for attracting their capital in the first place, and there was also an exit fee. The manager’s future might have been affected, but the present was not. A potential loss was in the long-run; a very real payment was in the short one. In addition, most investors were willing to forgive fund managers who took a risk and lost, but were not willing to forgive managers who did not take a risk and missed out on a potential win (Lewis, 2010, p. 112)

Of course, most managers would not want to lose investors – which would not happen if they applied the simple logic of following the same strategy as all other hedge fund managers. At a time when all hedge funds make money, a good hedge fund manager would be able to make more money while following the same strategy as everyone else – i.e., he would be doing the same as everyone else, only better. If the strategy turned out to be unsuccessful, everyone would be losing money; therefore, single managers could not be blamed and investors had nowhere else to go. Hence the incentive for hedge fund managers to follow the herd when the herd took risk.

2.8. The Wall Street culture of risk

The corporation structure effectively transfers the financial risk from management to the shareholders; however, the knowledge necessary to run a financial corporation stays with the management team. Over time, it grew too complex for the shareholders who finance the risk to understand what the risk-takers were doing – but it did not matter as long as the risk paid off. After 20 years without a major set-back, the risk-takers themselves grew oblivious to the possibility of losing and invented new financial instruments so complex that eventually they themselves did not fully understand their creations (Lewis, 2010, p.258).

Shareholders, who had no knowledge of the financial industry, liked the quick profits risk was bringing, got accustomed to them, and started demanding higher and higher ones in increasingly shorter time. Since corporations had to keep their shareholders happy, they shifted their focus to the short run – investment was no longer a strategic activity, it was a cash-flow one. A short-term win was enough to justify a long-term loss.
The other problem was that because of the complex financial instruments, consequences were so far removed from the original action that “the mind never connected the one with the other” (Lewis, 2010, p.251). The teaser-rate loans would not go bad immediately, but after few years when the initial low rate switched to a much higher one. Even then, it would be years and numerous foreclosures and court hearings before the bonds based on those loans would go bad, and even more years before the credit default swaps based on those bonds went bad after someone finally proved there was no money to pay off the loans behind the bonds. Even if there were consequences, they would not manifest themselves until years later. Bonuses, on the other hand, manifested themselves at the end of the year.

2.9. An incentive-driven crisis

The current crisis can be viewed as the crisis of misaligned incentives. Loan makers had an incentive to lend money to borrowers who clearly could not pay it back – loan makers were paid by the volume, and the risk of making subprime loans was passed on to someone else in the form of mortgage bonds. Subprime borrowers had an incentive to take the money – they had the next 30 years or so to repay it, and in a market with rising real estate prices, they could always refinance and get even more money. Their FICO score would deteriorate if they missed payments, but since credit was being extended to less and less creditworthy borrowers, a low FICO score would not matter much. Rating agencies had an incentive to rate mortgage bonds as safer than they were – they too, were paid by the volume and by the same people who created the product to be rated. There was no regulatory body to hold the agencies accountable either. Insurance companies had an incentive to insure the mortgage bonds (i.e., to sell credit default swaps) – the insurance premiums seemed like free money, since no one thought the insurance would ever have to be paid out.

A look through the complicated documentation that was available for all mortgage-backed securities would have revealed the real risk behind them. Still, no one had an incentive, at least not a monetary one, to dig for more information.

3. Methodology

3.1. Structure

So far, we have explained the need for research on incentive pay, formulated our research question, and set our delimitations in Section 1. In Section 2, we have taken a look at the
financial crisis from an incentive stand-point, discussing the incentives of the different market players in the mortgage bonds market. Section 3, the current one, presents the structure of the thesis, the approach we plan to take, as well as some theoretical considerations about the philosophy of research.

In Section 4, we discuss the two main postulates of the neo-classical economic paradigm – the Subjective Expected Utility Theory (SEU), and the Efficient Markets Hypothesis (EMH). We challenge the unbounded rationality assumption on which both of them are based by discussing observed cognitive biases and the use of heuristics in decision-making, as well as the role of emotions in decision-making from a behavioral perspective. Next, we introduce prospect theory, the main contribution of behavioral finance, and discuss two phenomena closely related to it – the disposition effect, and the equity risk premium. We introduce empirical evidence in support of as well as against prospect theory, and present a critique of it. Next, we introduce neuroeconomics, which represents a paradigm shift to viewing economic agents as biological creatures. We discuss the arguments in support of and against introducing neuroscientific research to the field of economics, and discuss the role of emotions in decision-making, which is mostly revealed through neuroscientific research.

In Section 5, we adopt a behavioral economics perspective to describe how incentives affect economic decision-making involving risk in ways that are not accounted for by neo-classic theory. Related to the role of incentive pay on risk-taking, we discuss the behavioral phenomena of mental accounting, house money effect, herding, and choking under pressure. We also discuss the incentives to herd in bull and bear markets, the effect of level of reward on performance, and the effect of a convex-shaped incentive pay structure on risk-taking. In Section 6, we discuss the deviations from the neo-classical time-discounting function, such as the common difference effect, framing, sign effect, magnitude effect, improving sequence preference, myopic loss-aversion and hyperbolic discounting. We also explore the link between short-term performance and accountability.

Section 7 moves to a neuroscientific perspective to discuss the effect of incentives on the neural processes in the brain. We look at the neural basis of prospect theory, discussing the reward approach and loss avoidance structures of the brain. We draw on theories that suggest that the processing of gains and losses is carried out in different parts of the brain, as well as on theories that suggest that it is carried out in the same areas of the brain. We also explore
the function of dopamine in reward-related activities of the brain, the function of serotonin in loss-related activities of the brain, and the juxtaposition between the two hormones.

Section 8 addresses intertemporal choice from a neuroscientific perspective. We discuss the different dimensions of intertemporal choice, with a main focus on time discounting, as this is the dimension relevant to our research question. Within intertemporal choice, we present the brain structures and processes involved in time discounting of immediate vs. delayed rewards, immediate vs. delayed losses, and delayed rewards vs. delayed losses. Next, we discuss the role of perception of time, arguing for the significance of the year as a unit of time, as rewards to be received within one year are discounted at lower rate than rewards to be received outside the scope of one year. Finally, we present different models of time discounting, arguing that neuroscientific evidence points to a quasi-hyperbolic time-discounting function.

In Section 9, we combine the findings of our research from behavioral and neuroscientific perspectives to answer our research question, look at the limitations of our study, and discuss the managerial implications of our results. A visual representation of the structure of our thesis is presented in Fig.9.

| 1. Introduction, problem statement, research question, and delimitation | * Impact of the financial crisis on the financial industry  
* Statistics on compensation structure and amount in the American financial industry  
* Topic delimitation – factors that contributed to the financial crisis, incentive pay in different types of financial institutions, factors that influence risk-taking |
| 2. Background - the crisis in brief | * The securitization model  
* The subprime mortgage market  
* Credit-default swaps  
* The investors  
* Incentive pay in hedge funds  
* The Wall Street Culture |
| 3. Methodology, structure, and research philosophy, research method | * Structure  
* Positivism vs. interpretivism  
* Inductive vs. deductive approach  
* Secondary research |
| 4. Theoretical framework | Neo-classical economic paradigm  
* Homo economicus  
* Subjective Utility Theory (SEU)  
* Efficient Markets Hypothesis (EMH)  
Behavioral economics paradigm  
* EMH vs. the limits to arbitrage  
* Heuristics  
* SEU vs. bounded rationality  
* Emotions and rationality  
Neuroeconomics paradigm  
* Economic agents as biological creatures  
* The role of emotions in decision-making: consequentialist approach vs. |
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| 5. Behavioral economics perspective on incentive pay | * Bounded rationality
* Cognitive biases and the use of heuristics
* Role of emotions in decision-making | * SEU vs. prospect theory
* Empirical evidence in support of prospect theory
* The disposition effect
* The equity risk premium
* Critique of and empirical evidence against prospect theory | anticipatory feelings approach
* Emotions and prioritization
* Emotions and focus – somatic markers theory
* Critique of neuroeconomics – behavioral sufficiency phenomenon and emergent phenomenon |
| 6. Behavioral economics perspective on intertemporal choice | * Mental accounting and framing
* The house money effect
* Incentives and risk-taking
* Herding – herding and forecasting, herding and markets
* Incentives to herd in bull and bear markets
* Choking under pressure phenomena
* Effect of level of reward in performance
* Convex-shaped inventive pay structure and risk-taking | * Neuro-classical time-discounting function
* Deviations from the neo-classical time-discounting function – common difference effect, present-bias, hyperbolic discounting, framing, sign effect, magnitude effect, improving sequences, self-control, myopic loss-aversion, incentive pay for short-term performance
* Short-term performance and accountability |
| 7. Neuroeconomics perspective on incentive pay | Gains and losses processed by separate systems in the brain | Gains and losses processed by the same system in the brain | * Processing of rewards in the brain
* Dopamine – dopamine, liking, and wanting, dopamine and learning, dopamine and risk-taking
* Processing of losses in the brain
* Serotonin
* The amygdala and loss processing |
| 8. Neuroeconomics perspective on intertemporal choice | Intertemporal choice in the brain | Time discounting process in the brain | Perception of time
* Neural mechanism of intertemporal choice
* Dimensions of intertemporal choice
* Anticipation
* Self-control
* Representation (framing)
* Delay discounting |
| | * Immediate vs. delayed rewards
* Immediate vs. delayed losses
* Delayed rewards vs. delayed losses. | * The significance of the year as a unit of time
* Linear discounting function
* Hyperbolic discounting function
* Quasi-hyperbolic function |
| 9. Conclusion and limitations | * Experiments on subjects other than financial industry professionals
* Western-centric view
* Narrow focus |

Source: own figure

Fig.9. Structure of the current research paper
3.2. Philosophy of research

Different types of research methodologies are associated with the epistemology to be adopted for a specific project. Considering the three most distinguished research philosophies, positivism, interpretivism, and realism, the current study takes a stance closer to realism.

According to Blumberg (2005), positivists see the world as an external and objective place where the researcher is neutral and does not influence the research, which in itself is value-free. Positivists develop knowledge either by reducing phenomena to simple elements representing general laws or through the accumulation of verified facts. An objective positivistic approach usually adopts quantitative analysis. Interpretivists, on the other hand, believe that the social world is constructed and given meaning subjectively by people. Interpretivists believe that the researcher is part of what is observed during the research, which itself is driven by interests. The researcher’s own values influence research findings because they are created through researcher’s interaction with the analyzed phenomenon. Consequently, an objective analysis, which is the main premise of positivism, is impossible, because the researcher is also part of the research process. The role of a researcher in the interpretivism philosophy is to study social constructions of individuals and present his or her own interpretation of them. Consequently, in order to describe perceived truth, interpretivists rely on subjective observation.

Realism combines ideas of both positivism and interpretivism. Similarly to positivism, it acknowledges the existence of a reality independent of human beliefs and behavior; similarly to interpretivism, it recognizes that “understanding people and their behavior requires acknowledgment of the subjectivity inherent to humans” (Blumberg et al., 2008, p.20). Therefore, to realists, research entails both the identification of external, objective factors describing general forces and processes that influence people, as well as the investigation of how people interpret and give meaning to their surroundings. Critical realism further acknowledges a certain gap between the researcher’s concept of reality and the actual objective but unknown reality. Critical realism holds that research cannot be (entirely) value-free, as it is conducted within a broader framework based on the researcher’s current knowledge and perception of reality. According to critical realism, different researchers, having a different perception of reality, as well as varying degrees of existing knowledge and
frameworks at their disposition, are likely to conceive different approaches when
investigating the same “objective” reality.

In the current study, we take a positivist stand and strive to discuss issues objectively,
presenting various points of view, as well as evidence both in support of and against the
theories we use. However, by virtue of using secondary research, we recognize that the
original research findings themselves may have been influenced by the opinions and values
of the respective researchers. The overall approach is therefore realism.

3.3. Reasoning approach

There are two methods of reasoning when addressing a research question: deductive, which is
a line of arguments, and inductive, which is a line of discovery. Inductive reasoning by its
very nature is more open-ended and exploratory, especially at the beginning. Deductive
reasoning is narrower in nature and is concerned with testing or confirming hypotheses.
However, most social research involves both inductive and deductive reasoning processes at
some point in the project (Andersen et al., 2001, pp.32-33). The current study is also a
combination of the two. It uses a deductive approach to argue for the need of an alternative
framework for studying the role of incentive pay in the financial crisis, and then switches to
an inductive approach to explore the link between incentive pay and increased risk-taking
from behavioral and neuroscientific perspectives. At the end, it goes back to deductive to
argue for the managerial implications of the results. The change in reasoning approach is
presented in Fig.10.

In addition, the secondary research on which the current study is based also utilizes a mixture
of the two approaches - inductive approach in experiments that test different hypotheses, and
deductive approach in research that argues for the superiority of one theory over another.

Fig.10. Inductive and deductive reasoning in the research process
3.4. Research method

We have chosen to base this study on secondary data, major sources of which, classified according to Zikmund (2003), are presented in Table 1.

<table>
<thead>
<tr>
<th>Type of secondary data</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal and proprietary data</td>
<td>• Does not apply, as the study does not involve a particular company</td>
</tr>
<tr>
<td>External data</td>
<td>• Well-established electronic academic databases, such as Business Source Complete, Science Direct, PsychInfo Search and PubMed</td>
</tr>
<tr>
<td></td>
<td>• Reliable media sources with proven reputation in the business world, such as The Wall Street Journal, Newsweek, and The Economist</td>
</tr>
<tr>
<td></td>
<td>• Textbooks and books by established authors in the business world</td>
</tr>
</tbody>
</table>

Source: Own table

Table 1. Sources of secondary data

Compared to primary data, secondary data is more cost effective and can be gathered relatively quickly. It also has the advantage of presenting a broader spectrum of perspectives, thus bringing more objectivity to the study, which is especially important in the case of complex, relatively little-studied topics. In addition, secondary research allows researchers with limited experience to make use of the expertise of established names in the field. One of the main problems associated with secondary data is that it may be outdated or not entirely relevant. This concern is especially valid in our case, since the financial crisis is a relatively recent phenomenon that has not been studied in much detail yet. At the same time, it has fundamentally changed the financial industry and markets; therefore some sources of secondary data might not be relevant anymore. In addition, due to the extensive media coverage and the emotionally charged debates related to incentive pay, caution must be taken to distinguish between information based on facts, and information based on opinions. To ensure high quality of secondary research, only reputable sources with established reputation in the academic and/or business world will be used.

4. Theoretical framework

4.1. Neo-classical economic paradigm

Two key building blocks of the neo-classical economic paradigm are the Subjective Utility Theory (SEU) model, based on the assumption that people behave rationally, and the Efficient Markets Hypothesis (EMH), based on the assumption that markets are efficient
because people behave rationally. Neo-classical economists disregard the many instances of irrational behavior and market imperfections to arrive at the theoretical concept of the rational investor whose role is to simplify economic analysis. Neo-classical economic theory suggests that emotions and rational decision-making are mutually exclusive, and therefore excludes emotions from economic models. In this section, we present the main characteristics of the neo-classical paradigm, look at its limitations, then present the alternative paradigm of behavioral economics/neuroeconomics, and look at its limitations. Based on our discussion of the two paradigms and their limitations, we select a paradigm to use in our analysis of the effect of incentive pay on risk-taking during the financial crisis.

4.1.1. Homo economicus

Traditional economic theory is based on the concept of Homo economicus, or the idea that economic subjects are “calculating, unemotional maximizers” (Mullainathan and Thaler, 2000). Homo economicus is a rational human being who makes choices by maximizing his utility function and does not involve emotions in the decision-making process. Another characteristic of homo economicus is self-interest – altruism is an unknown. The Homo economicus concept is the basis of three fundamental theories in modern economics—SEU model, the rational expectations hypothesis, and EMH, all developed by economists of the Chicago school of thought.

4.1.2. Subjective Expected Utility model (SEU)

The EU model, first developed by von Neumann & Morgenstern (1947), a model for decision-making under risk, and its modification, the SEU model for decision-making under uncertainty, developed by Savage in 1954 are the two models on which most models in economics and finance are based (Levy and Levy, 2002). Real-life decisions are rarely decisions under risk – a point which is discussed in greater detail in Section 4.5. Therefore, we focus on the SEU model in the current study. Hanoch (2002) points to the several assumptions behind the SEU model: 1) individuals can assign values to various stimuli or events in both present and future scenarios based on their preferences, 2) individuals deal with well-defined options which they evaluate and from which they choose, 3) individuals are able to provide uniform mutual probability distribution functions for all events, and 4)
individuals choose the option with the highest expected utility based on the utility function they have created.

Although the EU and the SEU models were only developed in mid-20th century, the notion of expected utility dates back to Bernoulli, who in 1738 presented the St. Petersburg paradox as an alternative to the irrationalities of expected value theory. Bernoulli’s idea was to substitute expected value with expected utility, introducing the idea of diminishing marginal utility, which resulted in the transformation of the utility function from linear to concave (Weber and Johnson, 2008). As shown on Fig.11, the present utility function has an upward slope, meaning that more money translates into higher utility (Rajsic, 2009). However, after a certain point, because of the concave shape of the function, one more unit of money does not yield as high of an utility as the unit before – i.e. marginal utility decreases with the increase of wealth.

The shape of the subjective utility function brought along the notion of risk-aversion (Rajsic, 2009). Risk-averse individuals prefer a certain smaller amount to an uncertain bigger one that could be won in a fair gamble, as demonstrated by the concave function on Fig.11. In contrast, risk-loving individuals have a convex utility function (shown on Fig.11), because they prefer a fair gamble to a certain outcome, while the linear function is characteristic for risk-neutral subjects, who are indifferent between the two options (Rajsic, 2009).

Source: Rajsic, 2009

Fig.11. Concave, linear, and convex utility function suggested by SEU and EU respectively
The SEU model is closely related to the rational expectations hypothesis, which postulates that “a market economy should be viewed as a mechanical system that is governed, like a physical system, by clearly-defined economic laws which are immutable and universally understood” (Kaletsky, 2009). The theory’s main point is that individuals make choices based on the rational expectations they have about the future. Sargent (2007) claims that “in recurrent situations, the way the future unfolds from the past tends to be stable, and people adjust their forecasts to conform to this stable pattern”. Therefore, the future will adapt to the past through the expectations of economic subjects which lead them to select certain choices, and the result will be the manifestation of the expectations (Sargent, 2007). The theory is widely used by economists, and has been incorporated in various other economic theories, including the Efficient Markets Hypothesis (Sargent, 2007).

4.1.3. Efficient Markets Hypothesis (EMH)

The Efficient Markets Hypothesis (EMH) is known from the work of Eugene Fama in the 1960s. An efficient market is one where “securities represent all available information, where new information is incorporated quickly and accurately, and where the average investor cannot consistently beat the market return” (Mutuc, 2010). Since an investor cannot consistently outperform the marker, the analysis of stocks and markets would appear ineffective; hence, the best option lies in holding a market portfolio (Shleifer, 2000).

Fama (1965), as cited by Mutuc (2010) bases his work on three specific beliefs about investor behavior: 1) investors are “rational”, meaning that they value securities based on risk-adjusted, net present future cash flows, 2) trades are random, thus cancelling any irrational behavior, and 3) rational arbitrageurs will seek to make profit out of irrational behavior and correlated strategies, thus eventually bringing security prices close to their fundamental value (Mutuc, 2010). The definition of efficient markets suggests that investors “have homogenous prior beliefs and are guided by probability calculations about information that is available to everyone else” (Mutuc, 2010).

Similarly to the rational expectations hypothesis, the EMH assumes economic subjects to be rational, but unlike the rational expectations hypothesis, EMH makes an allowance for some irrational behavior. However, it disregards irrational behavior’s effect on markets as a whole. Arbitrage is a key component in EMH, because it is arbitrage that safeguards against
irrational behavior and guarantees market efficiency (Shleifer, 2000). A critique of both SEU and EMH, including the limits to arbitrage, is presented in Section 4.2, as it comes from the behavioral economics paradigm.

4.1.4. Empirical challenges to SEU and EMH

With time, empirical evidence challenged both SEU and EMH. Mutuc (2010) cites the work of Grossman and Stiglitz (1980) who demonstrated that security prices cannot fully reflect all available information in competitive trading markets. De Bondt and Thaler (1985) proved that individuals’ tendency to overreact to unexpected news and developments affects markets. Various studies have shown that individuals display loss aversion, which should not be the case if they were rationally calculating their expected returns. The empirical evidence eventually lead to the realization that people’s financial perceptions are influenced by emotional and cognitive processes (Steenbarger, 2009). In this sense, behavioral economics and its sub-field of behavioral finance², defined by Shleifer (2000) as “the study of human fallibility in competitive markets”, are useful in understanding and adapting the neo-classical economic paradigm to real-world investor behavior.

4.2. Behavioral economics paradigm

Ritter (2003) defines behavioral finance as “the paradigm where financial markets are studied using models that are less narrow that those based on Von Neumann—Mortgenstern expected utility theory and arbitrage assumptions”. Behavioral finance has two building blocks, cognitive psychology and the limits to arbitrage. It uses models in which some agents are not entirely rational, thus introducing the idiosyncrasies of human behavior to the neo-classical economic paradigm. Behavioral finance is an especially advantageous framework for the analysis of the financial crisis, as it “focuses on the application of behavioral economics to conditions of risk” (Goetz and James, 2008). Behavioral finance points to the limitations of EMH and SEU – the limits to arbitrage and bounded rationality, and offers an alternative model of decision-making under uncertainty – prospect theory.

² The terms behavioral finance and behavioral economics are used interchangeably in the current study because of their close interconnectedness.
4.2.1. EMH vs. the limits to arbitrage

As discussed in Section 4.1.3, arbitrage is a key concept in the theory of efficient markets. Arbitrage opportunities arise whenever there are misvaluations of financial assets (Ritter, 2003). In theory, economic subjects find these misvaluations and exploit them to make a profit, but in practice, it is not easy to reliably make abnormal profits doing so. There are two types of misvaluations: recurrent short-term ones and non-repeating, long-terms ones (Ritter, 2003). The first kind are arbitrageable, which is why hedge funds and the like keep them from ever getting too big, effectively making markets efficient. However, as Shleifer and Vishny (1997) point out, the efforts to make money off misvaluations will make some markets efficient, but will have no effect on others. The second kind of misvaluations, however, is impossible to arbitrage, because the peaks and troughs cannot be identified until they have passed. The current financial crisis is an example of such misvaluation – it is a low-frequency event, has long-term effects, and was only indentified after the peak had passed and the trough had been reached. Evidence from high-frequency events supports the efficient market hypothesis, but evidence from low-frequency ones does not. Besides the current financial crisis, other notable examples of misevaluations include the undervaluation of the world-wide stock markets from 1974 to 1982, the Japanese stock price and land price bubble of the 1980s, the Taiwanese stock price bubble that peaked in February 1990, the stock market crash of October 1987, and the technology, media, and telecom bubble of 1999-2000 (Ritter, 2003).

In theory, there should be no risks and no capital involved in exploiting arbitrage (Shleifer and Vishny, 1997). However, empirical evidence points to the contrary – there are risks and costs associated with arbitrage. When arbitrageurs lose money in the short term, they need to hold the security for a period of time until they turn a profit, which locks in capital and manifests itself in the form of opportunity costs. There is also the risk that the security will never increase in value, thus leading to a loss (Shleifer and Vishny, 1997). In practice, the risk of a loss in arbitrage is high because of the many different factors involved – for example, different markets have different trading hours, settlement dates, and delivery terms (Shleifer and Vishny, 1997).

The classical arbitrage model assumes many small economic agents, who “act in ways that drive prices of securities toward their fundamental values.” (Mutuc, 2010). In practice,
however, small agents do not have the information necessary to take part in arbitrage. Arbitrageurs are more likely to be professionals, such as hedge fund managers, who have access to relevant information and manage big portfolios of money that is not theirs. This leads to agency problems, which can pose further limits to arbitrage in cases where the agent has a different purpose than the principle (Shleifer and Vishny, 1997).

4.2.2. Heuristics

People’s cognitive biases, such as using heuristics, pose further limits to arbitrage (Chan et al., 2004). Heuristics are rules of thumb that people use in complex situations in order to save cognitive resources and facilitate information processing (Oxoby, 2009). The use of heuristics becomes problematic in times of change, because people tend to ignore new information, relying instead on outdated assumptions. There are many kinds of heuristics, but the two that pose particular limits to arbitrage are the representativeness heuristic and the conservatism heuristic (Chan et al., 2004).

Representativeness heuristic

Representativeness heuristic is defined as “the tendency of individuals to classify things into discreet groups or categories based on similar characteristics (Chan et al., 2004). Because people focus on similarities, they diverge from rational reasoning in various ways – failing to consider sample size or quality of information, failing to consider the base rate, and failing to realize that extreme observations, such as several continuous years of outstanding performance, are unlikely to repeat themselves (Chan et al., 2004). The recent financial crisis is ample in examples of all three failures – investors failed to question the quality of information given to them by the rating agencies – in fact, credit ratings are an heuristic in itself; investors also failed to consider the base rate – namely, the actual value of the mortgages behind the mortgage bonds; finally, investors failed to realize that the upward trend in housing prices, which was feeding the mortgage boom which in turn sustained the securitization model, could not continue forever. In short, representativeness implies that investors place firms in discrete categories based on consistency of past performance, ignore new information in an attempt to preserve the initial placement, and form biased expectations about the future performance of the firm based on over-extrapolation of past data, which results in either overpricing or underpricing (Chan et al., 2004). Such biased processing of
information can lead to systematic misvaluations that investors cannot exploit (and therefore correct), because they cannot see them.

**Conservatism heuristic**

The second heuristic that poses limits to arbitrage is the conservatism heuristic, the exact opposite of the representativeness heuristic. Conservatism is the tendency of individuals to adjust their beliefs to new information too slowly, which means that they overuse their prior beliefs and underuse new evidence. Conservatism may also be regarded as overconfidence in one’s prior information. In terms of pricing, it causes under-reaction, thus predicting momentum in returns (Chan et al., 2004).

Both the representativeness and conservatism heuristic are related to biases resulting from over-inference from short sequences of new information, which in turn generate both under-reaction and over-reaction in the pricing of securities and other financial assets. Heuristics in general are also an example of the role of emotions in decision-making, which is discussed in greater details in Section 4.3.

**4.2.3. SEU vs. bounded rationality**

The unbounded rationality assumption behind SEU, the second building block of neo-classical economic theory, has also been repeatedly challenged. Hanoch (2002) refers to the work of Herbert Simon published in 1955, where he argues that “rationality is constrained, hence bounded, since [people] possess limited computational ability and selective memory and perception”. Hanoch (2002) goes further to state that the SEU model has a limited explanation power and “does not provide an accurate description of the human mind”. As already described, the assumptions behind the SEU model are: 1) individuals thoroughly examine the entire range of possibilities before making a decision, 2) individuals are aware of all options open to them, both at present and in the distant future, 3) individuals are able to comprehend the consequences of each option and to assign a joint probability distribution to future states of the world, and 4) individuals are able to reconcile all their conflicting values and goals into a single coherent utility function (Hanoch, 2002). Researchers have presented numerous challenges to these assumptions. Levi (1997) holds that all possible alternatives are not known, and that even among the known alternatives, not all outcomes of each alternative are known. Furthermore, some information never reaches the decision-maker, and some of
the information that does is deemed insignificant and disregarded. There is also the possibility that the information is too vast or too complicated for any individual to process (Hanoch, 2002).

March (1978), as cited by Hanoch (2002), points out that the properties of taste tend to be depicted in standard theories of choice by the normative description of “absolute, stable, consistent, precise, exogenous, and relevant”. However, the observed characteristics of taste in individuals show it to be inconsistent, varying through life, partially endogenous, and not always taken into account when a choice is made – for example, when social norms and expectations contradict the individual choice.

4.2.4. Bounded rationality model

Hanoch (2002) quotes Simon (1983), who, lead by the limits to SEU, states that “SEU theory has never been applied, nor will it, by any human”. Simon offers the Bounded Rationality (BR) model as a way to more accurately reflect human decision-making. The BR model looks at the effort invested in each decision, claiming that the resources individuals devote to decision-making are not the same in all situations. For example, the time and mental resources spent on an investment decision depend on the relative size of the investment. Furthermore, people do not have to make choices that reach far into the future and that are interconnected – on the contrary, the present is defined by the unique nature of each choice individuals face, and individuals make choices regarding their different needs at different times – for example, satisfying hunger and investing money are not decided upon at the same time. Problems and needs can and do occur at the same time – individuals, however, are able to prioritize and attend to them one at a time, as opposed to all at once (Hanoch, 2002).

Since people are unable to obtain, process, and correctly incorporate all the information pertaining to a given decision, the BR model suggests that instead of selecting the optimal (utility-maximizing) option, people look for a satisfactory (good enough) option. Hanoch (2002) cites Gigerenzer and Todd (1999) who define satisficing as “a method for making a choice from a set of alternatives encountered sequentially when one does not know much about the possibilities ahead of time”. Although optimal solutions can and do exist, people’s limited cognitive abilities render it difficult, if not impossible, to reach them. Satisficing is a
mental shortcut, a search rule that puts a stop to the search process once an alternative that meets or exceeds the desired level of outcome has been found (Hanoch, 2002).

4.2.5. Emotions and rationality

Since individuals possess bounded rationality, a large body of research suggests that emotions serve as an aid to rational decision-making, functioning as an information-processing mechanism guided by an internal logic. The strongest evidence in support of the integral role of emotions in decision-making comes from neuroscientific research findings and is presented in Section 4.3. However, from a behavioral perspective, there are many observed behavioral phenomena that suggest that emotions play a role in decision-making, and not always one that leads individuals in the same direction as cognitive evaluation.

Research mostly associated with clinical psychology has called attention to the fact that cognition and emotion do not always converge. The conflict between emotions and cognitive evaluation can lead to pathologies in decision-making and behavior. Loewenstein et al. (2001) cite Ness and Klaas’ (1994) research on anxiety, which demonstrates that in risky situations, emotional responses not only differ from cognitive evaluations of risk in terms of severity, but also often overpower the cognitive response, leading to maladaptive behavior. Fear causes people to slam on the breaks and steer abruptly instead of driving off to the shoulder of the road; fear causes dry mouth and loss of words when they are most needed during public speaking; fear immobilizes people when they have the greatest need for strength, causes insomnia when energy is most needed, and causes sexual dysfunction, a clearly maladaptive behavior from an evolutionary standpoint. Most people will be able to give examples of times when they have experienced the destructive effect of their emotions that they wish, but are unable to, turn off (Loewenstein et al., 2001).

More evidence for the powerful role of emotions and their divergence from cognitive evaluations comes from the large number of people who suffer from fear- and anxiety-related disorders. Even people who do not have full-blown phobias often experience anxiety about outcomes they rationally recognize as highly unlikely, such as a plane crash, or not particularly terrible, such as public speaking. At the same time, people are not afraid of outcomes that are much more likely and have much more severe consequences, such as car accidents. Divergence between emotional responses and cognitive evaluations of risk is the
cause of intrapersonal conflict, leading people to utilize powerful techniques in order to override their emotional responses (Loewenstein et al., 2001).

Although emotions can in certain cases work as an obstacle rather than an aid to decision-making, such cases are the exception that confirms the rule. Emotions have a very prominent role that aids decision-making in various ways, which are discussed in detail in Section 4.3.

4.2.6. SEU vs. prospect theory

A major contribution of behavioral finance is prospect theory. First introduced by Kahneman and Tversky in 1979, it has become a largely accepted alternative to SEU and EMH, mostly due to the persistence of observed anomalies in financial products trading (Mutuc, 2010). Observed anomalies include 1) loss aversion and its most notable manifestation in financial markets - the disposition effect, 2) the house money effect, and 3) the equity risk premium. Prospect theory differs from SEU in several aspects important to finance and management. First, while SEU assumes that investors base their decisions on total wealth and associated probabilities, prospect theory suggests that people think in terms of change in wealth, or “perceptions of losses and gains relative to a reference point” (Mutuc, 2010). The reference point depends on how the situation at hand is presented – i.e., investment decisions can be influenced by the framing of alternative outcomes. Second, unlike SEU, which is normative, prospect theory is descriptive – its value lies in its ability to explain experimental results, which show departures from expected utility theory (Kalayci and Basdas, 2010). Third, prospect theory introduces an S-shaped valuation curve (presented in Fig.12), which suggests that “the disutility of a loss is greater than the utility of an equivalent gain” (Kalayci and Basdas, 2010). This means that people are more averse to a potential loss than they are attracted to a same-size gain, which should not happen were people in fact rationally calculating outcomes when making decisions, as SEU theory predicts.

![Fig.12. Value function suggested by prospect theory](source: Kalayci and Basdas, 2010)
4.2.7. Empirical evidence in support of prospect theory

There have been many attempts to test prospect theory, both experimentally and empirically, with most results supporting the theory. In a study of the behavior of 128 firm managers in the United States, Payne et al. (1984) found that the subjects exhibit risk-averse behavior for prospects involving only gains, and risk-seeking behavior for prospects involving only losses (Kalayci and Basdas, 2010). Budescu and Weiss (1987) examined the reflection effect and the shape of the value curve as proposed by prospect theory using a small sample of students and found that it held true (Kalayci and Basdas, 2010). However, the small sample size and the characteristics of the participants (students instead of financial professionals) are significant limitations of this study. Olsen (1997) used 100 Chartered Financial Analysts to support the findings of prospect theory – subjects exhibited loss-aversion and a change from risk-aversion in gains to risk-seeking in losses (Kalayci and Basdas, 2010).

4.2.8. The disposition effect

The original prospect theory holds that for small monetary amounts, people value losses about twice as much as gains of the same size. Shefrin and Statman (1985), as cited by Kalayci and Basdas (2010), extend this behavioral pattern to a broader theoretical concept called the disposition effect. The disposition effect is a form of loss aversion expressed through the unwillingness of people to realize paper losses, which leads to selling of winning securities/investments too early and holding on to losing ones for too long. In fact, the disposition effect is the most well-documented departure from SEU in literature next to the equity premium puzzle, discussed next. Shefrin (2000), as cited by Mutuc (2010), gives two prominent examples of the disposition effect – Nicholas Leeson of Barings PLC, who held on to his losing securities long enough to lose more than 1.4 billion USD in underground trading, causing the bankruptcy of Barings PLC, and Apple, who took more than 10 years to discontinue its personal digital assistant despite consistently poor sales figures. Research using data from financial markets finds various examples of the disposition effect. Mutuc (2010) points to a study by Shefrin and Statman (1985) who used datasets on individual stock trades and mutual funds to show that investors sell losing investment most frequently at the end of the year, reasoning that the tax incentive to do so offsets the disposition effect. Another study by Odean (1998), also cited by Mutuc (2010), reconstructs portfolios using purchase prices and dates in the NYSE, AMEX, and Nasdaq to look at realized gains and
losses as a proportion of total gains and losses, respectively, and finds that investors sold winning investments more often than they sold losing ones. Frazzini (2006) used data from mutual funds and a measure of the current stock price’s percentage deviation from the reference price\(^3\) to demonstrate that stocks held by losing funds had more unrealized losses (Mutuc, 2010).

*Other potential explanations of the disposition effect*

It should be noted, however, that apart from prospect theory, there are other potential explanations of the disposition effect. Both Zuchel (2001) and Kaustia (2004), as quoted by Mutuc (2010), claim that individuals maximize not only expected outcomes, but also their self-image. In a losing situation, where negative feedback is given frequently, investors justify their decisions by standing by them – i.e., they continue to hold losing securities/investments. O’Connell and Teo’s (2009) study of large institutional investors finds the same results, potentially due to the public availability of information about the performance of large institutional investors (Mutuc, 2009).

4.2.9. *Equity risk premium*

Prospect theory has direct implications for the way assets are priced, because it regards individuals as loss averse, and not as utility-maximizing. Equity risk premium puzzle, first introduced by Mehra and Prescott (1985), refers to the fact that historically, investors have required unusually high returns on equity stock compared to government bonds in the US\(^4\), which suggests that they are risk averse (Mutuc, 2010). The reasons behind the puzzle, according to Benartzi and Prescott (1985), are loss aversion and frequent (annual) evaluation of returns, two factors that combine to form myopic loss aversion. Loss aversion shifts the utility function from maximizing the utility of consumption to maximizing the utility of returns, and frequent evaluation makes people demand large premiums to hedge against volatility (Mutuc, 2010). Berkelaar and Kouwenberg (2009) conclude that a loss averse investor will act to keep her wealth from falling under a perceived critical level. At low levels of wealth and short-term horizons, this induces gambling behavior, as investors attempt to

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\(^3\) Reference price is defined as “the number of shares held by the original purchaser multiplied by the price per share of the stock holding by month’s end” (Mutuc, 2010).

\(^4\) Government bonds in the United States are considered risk-free, making their return the baseline return rate. Return rates above this rate are considered compensation for the risk inherent in other securities.
break even by making high-risk, high-return investments. The other extreme also induces gambling behavior – at high levels of wealth, investors act like probability maximizers, ignoring volatility in an attempt to surpass a perceived desired wealth level, thus also making high-risk, high-return investments (Mutuc, 2010).

4.2.10. Evidence against and critique of prospect theory

Some researchers have raised important issues regarding prospect theory that are especially relevant to the topic of the current study, because they are related to decisions in investment settings. Levy and Levy (2002) question the methodology of experiments that confirm the validity of prospect theory, claiming that tasks that involve either only negative or only positive outcomes “virtually do not exist in practice, and certainly are not common in the financial markets”. Such an unrealistic framing of the bets leads to potential biases due to the certainty effect. When researchers consider the value function, they aim at characterizing its shape (concave or convex) for both positive and negative outcomes. This is usually done through finding the certainty equivalents of two positive outcomes, and then separately finding the certainty equivalents of two negative outcomes, thus investigating the shape of the value function in the two ranges separately (Levy and Levy, 2002). Researchers use non-mixed bets, because for mixed bets (i.e., bets that contain both positive and negative outcomes), there is no simple way to determine whether the shape of the value function is concave or convex. In other words, under the certainty equivalent framework, no conclusions can be drawn regarding the shape of preference in mixed bets. In addition, experiments involving non-mixed bets present subjects with unrealistic expectations, because in real life practically all investments yield an uncertain distribution of outcomes including both gains and losses. It is possible that such unrealistic, hypothetical distributions that investors almost never face in real life, distort the results.

As a response to the methodology issues of previous experiments testing prospect theory, Levy and Levy (2002) conducted an investment decision-making experiment using a prospect stochastic dominance approach, which can be applied to any S-shaped value function, and which can be employed with mixed prospects, with no certainty effect, and with change of wealth, rather than total wealth. Stochastic dominance is a way of ranking the probability distribution of one prospect (outcome) as superior to the probability distribution of another prospect (outcome). Since it is a ranking of probability distributions, it implies that all
prospects are included. Furthermore, if one probability distribution dominates another by first-degree stochastic dominance or by second degree stochastic dominance when the outcomes are given in terms of change of wealth, then the dominance relation holds true for total wealth as well, for every initial wealth level (Levy and Levy, 2002)\(^5\).

Levy and Levy’s (2002) conducted several experiments as part of the same study, all based on various tasks involving hypothetical investment situations. It is important to note that the subjects were business school students, faculty teaching in business and/or economic departments, and practitioners - financial analysts, mutual fund managers, and portfolio managers. One of the experiments involved three tasks – the first two mirrored prospect theory, i.e., one compared a positive prospect to a certain positive outcome, and the other compared negative prospect to a certain negative outcome. The final task involved two uncertain prospects with a mixed outcome. The researchers found no significant differences between subject populations, but obtained a striking result in the mixed outcomes task – 76% of the same subjects who confirmed the S-shaped value curve in the first two tasks (i.e., were risk-seeking for losses and risk-averse for gains), rejected the S-shaped value function when confronted with mixed prospects compared to uncertain outcomes. These results lead the authors to suggest that the S-shaped value function proposed by prospect theory occurs due to the certainty effect and does not reflect real-world investor behavior.

Kalayci and Basdas (2010) empirically demonstrate that prospect theory does not hold true for traders in the Swiss energy industry. Surveying a small sample size of 22 power traders, the researchers found that the house money effect (the tendency of individuals to become more risk-seeking following a win), and the reflection effect (risk aversion in gains becoming risk seeking in losses) does not hold true. Regardless of past experience, the traders were always risk-averse. Such findings could be due to the financial crisis – the study was conducted in 2010, after the crisis had caused a significant rise in risk aversion in the financial sector (Kalayci and Basdas, 2010). Other significant limitations are the lack of a control group in the experiment, the small sample size, and the fact that all participants worked for the same company in the same country, leaving them prone to relatively homogenized attitudes towards risk.

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\(^5\) First-degree stochastic dominance is one where gamble A gives at least as high a probability of obtaining at least outcome \(x\) as gamble B does for any \(x\), and for some \(x\), gamble A gives a higher probability of obtaining at least \(x\) than gamble B does. Second-degree stochastic dominance is one where gamble A is more predictable than gamble B and has a mean at least as high as B (Hadar and Russell, 1969).
4.3. Neuroeconomics paradigm

Neuroeconomics is defined as “the convergence of the neural and social sciences, applied to the understanding and prediction of decisions about rewards, such as money, food, information acquisition, physical pleasure or pain, and social interactions” (Clithero et al., 2008). Neuroeconomics goes a step beyond behavioral economics in that it not only seeks to incorporate actual human economic behavior into existing neo-classical economic models and theories, but also “to identify the physiological causes underlying [human economic behavior]” (Goetz and James, 2008). Neuroscientific research explores the functions of the brain in order to uncover neural substrates of decision-making, including economic decisions under risk and uncertainty. It “attempts to open the ‘black box’ of the human brain to uncover the physiological processes taking place when economic decisions are made” (Goetz and James, 2008). It incorporates a wide array of technological approaches, such as functional magnetic resonance imaging (fMRI) studies, brain lesion studies, pharmacology, and molecular biology. Evidence that neuroscience improves the understanding of economic concepts and phenomena comes from a wide range of experimental research, including the identification of brain regions involved in tracking loss aversion, coding for subjective value, and resolving uncertainty during decision-making (Clithero et al., 2008).

Neuroeconomics is fundamentally different from both neo-classical and behavioral economics, because it views economic agents as biological creatures, and adds an evolutionary perspective to the discussion on rationality (Clithero et al., 2008). Behavioral economics is descriptive in nature, while neuroeconomics can put the causal link behind behavior by looking at the biological processes behind different decisions and actions observed by behavioral economics.

4.3.1. The role of emotions in decision-making

Neuroscientific studies provide evidence in support of behavioral economics’ observation that decision-making is not a completely rational process. Emotions not only play a role in the decision-making process, but they are an integral part of it on a biological level. Most models of decision-making in both neo-classical economics and behavioral economics are consequentialist, in the sense that they assume that people makes decisions on the basis of the evaluation of the expected consequences. SEU-type theories intentionally disregard emotions as irrelevant to the decision-making process – choice, under risk or otherwise, is a cognitive
process, albeit an imperfect and biased one (Loewenstein et al., 2001). The consequentialist approach to decision-making is shown on Fig.13.

Loewenstein et al. (2001) divide emotions into two types – anticipated and anticipatory. Anticipatory emotions are visceral emotions (fear, dread, anxiety) that occur immediately in response to a stimulus carrying risk or uncertainty. Anticipated emotions are emotions that people expect to feel in the future. Behavioral economics, while integrating emotions in the decision-making process, does so only in relation to anticipated ones. Individuals predict how they will feel about different incomes in the future and take this into account when making a decision, essentially turning anticipated emotions into a consequence to be evaluated in the cognitive process of decision-making. As shown on Fig.14, behavioral economics incorporates anticipated emotions in the decision-making process, but does not depart from the consequentialist approach. For example, in behavioral research on the role of affect in risky decisions conducted by Isen et al. and cited by Loewenstein et al. (2001), participants were presented with a simple gambling task after being put in a good mood by receiving a small present. Results showed that happy individuals were more optimistic about their odds of winning than the control group, but nevertheless less likely to take the gamble. Using inherently consequentialist reasoning, the researchers explained their observation with the mood maintenance hypothesis - happy individuals are reluctant to take risks, because losing may ruin their mood. While researchers recognized the role of emotions in decision-making, they only considered the anticipated negative emotions, and not the current positive ones, as influencing the decision-making process.

Source: Loewenstein et al., 2001

Fig.13. Consequentialist approach
Neuroscientific research has brought the focus on anticipatory emotions in decision-making. In contrast to the view that emotions are detrimental to rational choice because of their inherent irrationality, neuroscientific studies have provided ample evidence of the informational value of emotional inputs and of the decreased quality of decisions when such inputs are blocked (Loewenstein et al., 2001). Fig. 15 presents the anticipatory feelings approach, which recognizes the interaction between emotion and cognition in the human decision-making process.

*Emotions and prioritization*

Since people rarely have only one goal in mind, they need a way to prioritize and postpone all their different goals. While there are various mechanisms implicated in this process, the current focus is on emotions. Emotions are a way to overcome the constraints on mental
resources, a concept largely ignored by economists. Attention in particular is an extremely limited resource – there is only a limited amount of incoming information one can attend to. One way in which emotions help the decision-making process is by diverting the current course of action in order to pursue a newly introduced, more pressing objective. From an evolutionary standpoint, emotions developed to divert an organism’s resources to goals with higher survival value (Hanoch, 2002). Similarly to physiological reactions, like hunger or thrust, emotions inform individuals of changes in the environment that need to be attended to. LeDoux (1994) suggests that evolution has lead to the development of two ways in which information can be processed – via the emotional channel, which is quick, but less precise, and via the rational channel, which is slower, but more precise. However, individuals cannot consciously choose which channel to utilize – that decision is made without awareness. Very strong stimuli that can be immediately characterized as a threat to survival automatically activate the emotional channel, but it can also be activated by any threat to a current goal, not just to survival. Stimuli that cannot be immediately assigned to a predetermined criterion require a more elaborate evaluation – thus, the rational channel is activated. This is one reason why people find it so difficult to overcome their fears, although they rationally understand there is no reason to be afraid – the moment the brain recognizes a stimulus as a threat, the emotional channel is automatically activated and the decision cannot be “delegated” to the rational channel only. It should be noted that the fact that the emotional channel carries out the processing of pressing stimuli does not mean it arrives at better decisions – in fact, many examples where it does not were discussed in Section 4.2.4. – but it reacts first, because people evolved that way (Hanoch, 2002).

It may appear that emotions can help set priorities only in extreme cases, but empirical research suggests that people often choose based on affect rather than cognition. During a consumer-research experiment, subjects had to choose between chocolate cake (associated with favorable affect, but less favorable cognition, i.e. unhealthy food) and fruit salad (associated with less favorable affect, but favorable cognition, i.e. healthy food). Subjects who had less information were more likely to choose the cake, suggesting, according to the authors, that “under conditions where the consumer does not allocate processing resources to the decision-making task, she/he is more likely to choose based on affect rather than on cognition” (Hanoch, 2002). Slovic et al. (2004) cite the work of Ganzach who, in a study very relevant to the topic of the current one, found evidence that analysts base their judgement of the risk and return of unfamiliar stocks on a global attitude – if the stocks are
globally perceived as good, they are deemed to have low risk and high return, but if they are perceived as bad, a correlation between judgements of high risk and high return appears.

Research on high-risk sports further supports the notion that emotions play a significant role in decision-making. Participants in such sports rarely have the know-how to evaluate all the information that is coming their way – for example, the decision to make the first sky jump or go rafting are rarely based on cost-benefit analysis. While the costs are relatively easy to indentify – time, money, injury, and potential death, the benefits are nearly impossible to envision and quantify, because they have never been experienced before. Participants in risky sports rarely have all the facts necessary to carry out a decision-making process as explained by SEU (Hanoch, 2002).

Hanoch (2002) cites the work of Shackle, who has introduced the potential surprise theory as another line of argument against SEU. The theory argues that instead of calculating the potential outcomes, people imagine them, basing their decisions on a comparison of imagination. Expectations are thoughts taking place in the present, but dealing with content in the future – thus, emotional values attached to the imagined situation in the future can affect decision-making at present. Schwartz and Clore, also cited by Hanoch (2002), argue for the existence of a “how do I feel about it” heuristic, claiming that people rarely question their present emotional state, but consider their emotional responses to a future event. Imagining outcomes that involve a strong negative reaction may lead to their exclusion from the range of options, while outcomes with a strong positive reaction are more likely to be considered. For example, when deciding how to invest money, one imagines the risks and benefits associated with it. If this produces an intense fear of a loss as a result of a particular option, then this option is more likely to be excluded and a safer one chosen instead.

A very strong argument in support of the fact that emotions are part of decision-making comes from Damasio’s work with patients who, after suffering damage to their frontal lobes, have become unable to experience emotions while retaining all their cognitive abilities. In a series of experiments, Damasio and his colleagues demonstrate that such patients are generally incapable of making decisions, and in the rare cases when they do so, the decisions are wrong. The explanation provided by the researchers is that the patients’ inability to assign emotional values to the future outcomes of their decisions renders these outcomes meaningless, thus leaving them out of consideration (Hanoch, 2002). In one particular
instance, a patient spent half an hour deliberating over when to set his next appointment. He evaluated an astounding number of parameters, “from alternative appointment times to variants in weather conditions” (Hanoch, 2002), and would have continued had the researchers not intervened. This incident illustrates the limits to pure reason – in the absence of emotion, there is no stopping mechanism – thus one can go on generating more and more options even to the most trivial of decisions, without actually choosing any of them.

**Emotions and focus – somatic markers theory**

Decisions can be affected by an endless number of factors. Neo-classical economic theory assumes that people rationally consider all factors related to a decision, but in practice, people only consider those variables they deem relevant – it is virtually impossible to identify all potential factors, predict their influence, and assign an exact absolute value to their importance (Hanoch, 2002). There rarely are absolutely wrong or absolutely right objective criteria to use when determining which of the endless factors involved in a decision should be taken into consideration. Therefore, individuals need a way to determine the saliency of each variable. Damasio, as cited by Hanoch (2002) suggests that one way to do it is to involve emotions in the process of determining the saliency of various options, thus giving rise to the somatic markers theory. The somatic markers theory postulates that “most self-regulatory actions and decisions are affected by the bodily reactions, called somatic markers, that arise from contemplating their outcomes” (Gazzaniga and Heatherton, 2006). In other words, when contemplating an action, a person experiences an emotional reaction depending on the past history of the action’s outcome (or the outcome of similar actions), even before the outcome is rationally evaluated. These emotional reactions then influence the motivation to consider or not to consider the option – in cases of extreme negative reactions, the outcome may be immediately dropped. In this sense, somatic markers to not engage in deliberation – instead, they act to limit the set of options and leave fewer to cognitive deliberation. They are “a system of automated qualification of predictions”, which serves to reduce the number of scenarios to be evaluated by the limited cognitive resources (Hanoch, 2002).

**4.3.2. Critique of neuroeconomics**

Opponents of neuroeconomics point to the difficulty in interpreting neuroimaging data due to the lack of functional specificity of brain regions, at least at the level currently accessible to neuroimaging technology. This lack of specificity often makes it difficult or impossible to
arrive at definitive conclusions about links between brain areas and behavior. In addition, the transferability of research findings on non-human subjects to people has been questioned. Concerns about poor statistical practices have also been raised, as fMRI studies do not involve large number of subjects, and are not easy to replicate due to the complex expensive technology and trained staff necessary to carry out such studies. In contrast, social sciences often rely on observation and inexpensive laboratory experiments that involve large and diverse samples and non-invasive, self-reporting techniques (Clithero et al., 2008).

On a more abstract level, the two main arguments against neuroeconomics are behavioral sufficiency and emergent phenomenon.

Behavioral sufficiency

There are economic theorists who do not believe that neuroscientific findings can disprove economic models, since economic models make no assumptions about the neural processes underlying economic behavior. Data about such processes bears no relation to economic models, thus it can neither support nor refute any economic model (Clithero et al., 2008). The only way to falsify an economic model is to manipulate the environment and observe behaviors contrary to the ones predicted by the model. In this sense, behavioral data gathered through either observation or experiments is a necessary and sufficient condition to disprove economic models. Economists need to predict behavior, which they can do based on observed behavior – there is no need for them to reveal the underlying mechanisms that lead to the behavior, especially since behavioral data can be collected easily and at a low cost, unlike neuroscientific data, the collection of which requires more resources.

While in theory it is true that future behavior can be predicted based on past behavior without understanding the neural mechanisms behind, the behavioral sufficiency argument rests on the assumption that all data needed to support or reject an economic model can be identified and collected. In practice, however, economic behavior is immensely complex and affected by numerous factors that have both individual and combined effects. To identify all factors and experimentally collect high-quality data for all potential combinations of all their potential individual and combined effects on economic behavior would be expensive and time consuming at best, and impossible at worst (Clithero et al., 2008). This is where neuroeconomics can add value – it can direct behavioral research by identifying underlying
mechanisms common to multiple factors and mapping specific neural mechanisms to specific forms of choice to add efficacy to behavioral economics (Clithero et al., 2008).

*Emergent phenomenon*

The emergent phenomenon targets the methods used by neuroscience, which place human or animal subjects in artificial economic settings to elicit a desired behavior—a relevant example is studying the differential processing of gains and losses in the brain. In essence, neuroscientific studies create toy models of real-world phenomena in order to test the neural mechanisms behind. Toy models have been long used as valid methods in both natural and biological sciences, but they have only recently been introduced to economics, where researchers create model markets mirroring real-world ones in order to test and better understand economic behavior. Similarly, neuroscientific research settings closely resemble real-world settings, and researchers believe that mechanisms utilized in such settings are also utilized in the real world (Clithero et al., 2008).

Small sample size is another issue in neuroscientific research. Critics point out that data on neural mechanisms collected from a few subjects is not generalizable to the behavior of millions. This argument is referred to as the emergence phenomenon, or the belief that an understanding of a mechanism is not relevant to the understanding of a phenomenon at societal level (Clithero et al., 2008). The argument rests on the assumption that emergence not only exists, but also subsumes any influence from lower-level data. Yet, economists themselves recognize that emergence may not be ubiquitous among all economic phenomena. There are economic models that have emergent properties, which restrict their use, but do not render them logically invalid (Clithero et al., 2008). Similarly, neuroscience does not claim that understanding one mechanism provides a complete explanation of broad phenomena, but it certainly makes valid contributions to the understanding of them.

**4.4. Selecting a theoretical framework**

Based on the preceding discussion on the merits and limits of neo-classical economics, behavioral economics, and neuroeconomics, we have chosen to utilize a combination of behavioral economics and neuroeconomics to analyze the role of incentive pay in the financial crisis. Since the crisis is in fact an example of the fallibility of human behavior, behavioral economics is an especially advantageous framework to use, as it is concerned with
analyzing phenomena that disprove the rationality assumption behind neo-classical economics. At the same time, behavioral economics is characterized by a largely descriptive approach – it can help identify the phenomena that occurred during the financial crisis, but it cannot explain why they occurred. This is where neuroeconomics can add value – it can point to the neural mechanisms that directed the risk-taking behavior prior to the crisis.

4.5. Defining risk-taking: risk vs. uncertainty

Researchers differ in their definition of risk, but most use concepts such as goals, values, options, and outcomes (Byrnes et al., 1999). Risk-taking occurs when a certain choice can lead to more than one outcome, and one or more of the possible outcomes is undesirable (Byrnes et al., 1999). Schubert (2006) provides a similar definition, where “we talk about risk when we have to make decisions or choices between different alternatives with uncertain future consequences”. A distinction should be made between pure risk and uncertainty. Strictly speaking, risk involves quantifying the probability of each outcome, while uncertainty occurs in cases when the probabilities are unknown, thus making it possible for alternatives to only be ranked in terms of likelihood (Schubert, 2006).

Both in life and in business practice, however, instances of pure risk are very rare, as it is very difficult to imagine and quantify all potential outcomes of every action. Risk most often stands for uncertainty, and risk avoidance is in fact uncertainty avoidance. Therefore, since the current study is set in a business context, no distinction will be made between risk and uncertainty, as well as between risk aversion and uncertainty avoidance.

5. Behavioral perspective: incentive pay

5.1. Risk attitudes

The concept of “risk-attitude”, the parameter used to differentiate between various choice behaviors, represents the curvature of the utility function and it is derived from an individual’s choices. It can be assumed that the noun “attitude” points to a specific personality trait, but it has been established that an individual’s risk attitudes vary as well, depending on the decision she has to make (Weber and Johnson, 2008). According to prospect theory, important factors to consider are changes in the reference point, which in
turn affects risk attitudes, and the differences in loss aversion for different kinds of outcomes (Weber and Johnson, 2008).

5.2. Mental accounting and framing

Although neo-classical economics sees rational individuals as risk averse, behavioral economics offers models that link the risk attitude of an individual to the manner in which the risks are framed (Elton et al., 2007, p.486). Managers who know they will receive a bonus regardless how their investment performs in the long-run may frame investment opportunities as certain gains, even if investments in reality carry excessive risk.

One of the main contributions of prospect theory is the replacement of the neo-classical absolute-value-based evaluation with evaluation based on gains and losses relative to a reference point, which in turn has introduced the concept of mental accounting (Weber and Johnson, 2008). Mental accounting is an important cognitive process that people use to categorize financial outcomes into different accounts, similarly to the way financial accounting is done in organizations (Thaler, 1999). For example, if investors fail to consider a portfolio of assets as an entirety, and put the assets into different mental accounts where they will be evaluated separately, the decisions they make may not be optimal – for example, investors might treat part of the portfolio as designated for gambling, while another part might be treated more conservatively (Elton et al., 2007, p. 489).

Thaler (1999) claims that the properties of prospect theory’s value function are important to understanding mental accounting. Since the function is defined over gains and losses, it focuses changes in values, which points to the “piecemeal” nature of mental accounting. People tend to evaluate every transaction separately from all the others. Moreover, the diminishing sensitivity observed in both gains and losses makes the differences between small amounts (e.g. $10 and $20) seem bigger than the same difference between larger amounts (e.g. $1000 and $1010).

Thaler and Johnson (1990) introduce the concept of editing rules, defined as “specific alternative representations of prospects that can emerge from the editing phase”. To study these rules, they present two different framings of a gambling decision: 1) A two-stage gamble, presented as follows: “You have just won $30 and have to choose between option (a)
not receiving any further gain but also not losing any money, and option (b) a gamble with a 50% chance of winning $9 and a 50% chance of losing $9”, and 2) A one-stage gamble presented as a choice between (a) a sure gain of $30 and (b) a 50% chance of winning $39 and a 50% chance of winning $21.

Based on the results of their study, Thaler and Johnson (1990) conclude that there are two types of editing rules. One combines prospect theory and memory – choices are affected by prior outcomes considered in the evaluation. Under this rule, both the two-stage gamble and the one-stage gamble are regarded as a sure win of $21 with a 50% chance of increasing the gain to $39. The second type of editing rules – prospect theory without memory – implies that current and future choices are not affected by prior outcomes. Under this editing rule, the representation of gambles becomes important. The two-stage gamble is seen in two steps, (1) you have won $30 and (2) now you can take the 50-50% gamble of winning or losing $9, while the one-stage gamble is regarded as a sure win of $21 with a 50% chance of increasing the gain to $39.

The way people select which rules to apply is an important factor in decision-making. Thaler and Johnson (1990) discuss two options: concrete editing and hedonic editing. In concrete editing, subjects “accept the problem as presented to them” (Thaler and Johnson, 1990) – i.e., they will be affected by previous outcomes if reminded of them, like in the two-stage gamble set-up. Hedonic editing is an alternative editing rule under which individuals edit gambles “in a way that would make the prospects appear most pleasant” (Thaler and Johnson, 1990). Thaler and Johnson (1990) and Thaler (1999) present the following principles of hedonic editing, which are derived from the shape of the prospect-theory value function:

- segregate gains: following the concave shape of the gains part of the function
- integrate losses: following the convex shape of the losses part of the function
- integrate smaller losses with larger gains: to compensate for loss aversion
- segregate small gains from larger losses: following the shape of the gain function, “the utility of a small gain can exceed the utility of slightly reducing a large loss” (Thaler, 1999).

Even though the hedonic editing hypothesis seems appealing, it has two significant limitations. It assumes a decision-maker’s active role in the editing of potential outcomes, but in practice people have limited resources and are unlikely to go through a conscious,
elaborate cognitive evaluation of each decision. The assumption of objective editing for different representations with the goal of making them appear the most pleasant is also questionable, because in reality, the framing of alternatives when they are presented to individuals already defines them as either pleasant or not. Because of the shortcomings of hedonic editing, Thaler and Johnson (1990) introduce another hypothesis – the quasi-hedonic editing, which assumes that since subjects have problems integrating losses, they do not integrate subsequent losses with the initial loss, but integrate subsequent losses with prior gains (Thaler and Johnson, 1990).

There may be alternative explanations for the results of this study. The authors propose the following two: 1) losses and gains place people in different moods – negative after losses and positive after gains, which in turn affects the decision-making process, and 2) initial losses affect how people feel about their luck – they might perceive the chances of winning as lower compared to actual probabilities. However, both of these explanations fail to explain the different effect of the one-stage formulation of the gamble (Thaler and Johnson, 1990).

The quasi-hedonic hypothesis is in line with prospect theory’s value function, which suggests that people are risk-averse in gains, but become risk-seeking in losses. Since prior and subsequent losses are not integrated, people do not recognize that the losses are adding up. However, when integrating subsequent losses with prior wins, people recognize that they are losing the money they have just won.

5.4. The house money effect

Closely related to the concept of mental accounting and to the value function of prospect theory is the house money effect. It refers to the fact that in some cases, individuals are more willing to accept gambles following a prior gain, and less willing to do so following a prior loss, a phenomenon seemingly in contradiction to prospect theory’s view that people are risk-averse in gains and risk-seeking in losses. Barberis et al. (2001) explain the house money effect by the fact that it is easier to bear a relatively small loss after having won, while it is painful to lose after having lost already in the past. Following an initial gain, if the size of the loss is smaller compared to the gain, the loss will be integrated as reduction in gains and its effect will diminish, thus inducing risk-seeking behavior. In addition, people do not take ownership of “house money” – if the gain is not theirs, it is easier to gamble with it. There is
also the fact that in the case of a prior loss, a gamble offers the possibility of break-even, which allows for the exclusion of part of the outcome (another loss) from consideration, thus making the gamble more attractive (Thaler and Johnson, 1990).

Applying this to managerial decision making, the house money effect would imply that managers who have been rewarded recently for taking an investment risk are more likely to take a bigger one next time – the incentive pay they obtained is theirs, while they are using house money to make the next investment which might bring them more incentive pay. In addition, if a manager is afraid that she will not receive her incentive pay following an investment loss, she may attempt to “break even” on the investment in order to get her pay.

5.5. Incentives and risk-taking

According to neo-classical economic theory and agency theory, strong incentives make the biases in human behavior disappear (Fernandes et al., 2009). However, Fernandes et al. (2009) conduct a study that shows that incentives received through compensation schemes can sometimes lead to risk-seeking behavior. Part of the problem could be that companies purposefully choose performance metrics that encourage risk-seeking.

Fernandes et al. (2009) apply prospect theory to their research of mutual fund managers. They believe that an individual’s risk attitude cannot be assumed from the beginning but it is influenced by the way a problem is framed. To define a reference point to separate the gain and loss side, the authors use benchmarks from mutual funds returns. What they assume is that the behavior of managers will show escalation of commitment due to the disposition effect already discussed in Section 4.2.7. If managers have experienced previous losses, they show risk-seeking behavior because they find themselves on the convex side of the value function. The authors cite research that confirms this phenomenon – investors tend to sell “winner” stocks more often than “loser” stocks (Fernandes et al., 2009).

In their study, Fernandes et al. (2009) look at actively and passively managed mutual funds which have different kinds of compensation policies. The authors use a large sample of mutual funds from both developed and emerging markets. The managers of passively managed funds do not receive incentive pay and are risk-averse. In the actively managed funds, incentives influence risk attitudes depending on how difficult it is to outperform the
benchmark. If it is likely that the fund will do better than the benchmark, incentives make the manager risk-averse. On the contrary, if it is hard to outperform the benchmark, incentives lead to risk-seeking behavior (Fernandes et al., 2009).

Another factor that influences risk attitudes is the evaluation horizon. During the same evaluation horizon, poorly performing managers in one period are inclined to choose riskier investments in the next period, while well performing managers tend to be less risk-seeking (Fernandes et al., 2009). The implications of the evaluation horizon from a behavioral perspective are explained in greater detail in Section 6.

5.6. Herding

Fernandes et al.’s (2009) research brings about another important issue with incentive pay in the American financial industry – peer performance. Rizzi (2008) suggests that the incentive pay system in the financial sector contributes to the behavioral phenomenon of herding, because compensation is tied to peer performance. Herding “occurs when a group of individuals mimic the decisions of others” (Rizzi, 2008). It gives the illusion of safety by hiding in the crowd, and it is based on the social pressure to conform – by herding, individuals avoid looking bad if they fail while perusing an alternative action. Failing along with the group is preferable, because it can always be blamed on the group, thus allowing the individual to keep her reputation and job. So prevalent is peer comparison in the banking industry, that it has lead to the famous statement that “it is better for a banker’s reputation to fail conventionally than to succeed unconventionally” (Rizzi, 2008). In addition to the non-monetary factors such as reputation, incentive pay based on peer comparison gives a monetary incentive to stay with the crowd – managers only need to marginally outperform the crowd by doing the same thing, only slightly better. Even though managers as individuals may recognize the market risk, it pays off to stay with the crowd. Managers manage their career risk by holding on to an index, effectively converting principal loss into benchmark risk (Rizzi, 2008).

5.6.1. Herding and forecasting

Relative performance metrics like peer comparison are not based on absolute value creation, but on a constantly changing base whose performance has never been measured in absolute
terms. This leads to poor forecasting abilities – as long as experts are rewarded based on a comparison to their peers, they will tend to play it safe by extrapolating past performance data and staying close to the crowd, even after circumstances have changed and past performance data is no longer a valid factor in future performance. Individuals not following their peers suffer when the peer group wins, and, in a time of market boom, conservative managers miss out on the short-term high returns that the group delivers. They often feel pressure to either become less risk averse or leave, as demonstrated by Lewis (2010, p.13) who quotes a former portfolio manager in an investment bank, “You could be positive and wrong….but if you’re negative and wrong, you get fired”. The opposite is also true – institutions risk losing their best managers if their risk-taking attitude is curtailed. The pressure to herd during the financial crisis is illustrated by Morgan Stanley, whose management used to refuse to participate in structured securities, such as mortgage bonds. The performance of the firm suffered relative to its peers, and so did the compensation of its managers and employees. As a result, the management team was replaced in 2005, with the new team vowing to match its peers in their chase to the top of high-risk, high-returns investment and regain market share – a vow well achieved, since in 2008, at the height of the crisis, Morgan Stanley recorded record losses (Rizzi, 2008).

5.6.2. Herding and markets

Herding is a problem not only at institutional level, but also at market level, as it leads to more uniform decisions, which amplify the credit cycle effects (Rizzi, 2008). The cycle begins with an increase in credit availability, which in turn leads to an asset price increase. Investors and managers alike rush in for fear of missing out on the opportunity to outperform their peers and use rising asset values to support an even bigger credit expansion, which in turn keeps pushing asset prices up. The cycle continues until an event occurs that triggers a decline in asset prices. As asset prices decrease, losses trigger a decline in credit, which in turn causes investors and managers to rush out, fearing that they will underperform their peers if they stay. The result is strained market liquidity (Rizzi, 2008).

Related to incentive-pay-induced herding behavior is the informational cascade effect. A cascade is “a series of self-reinforcing signals obtained from the direct observation of others” (Rizzi, 2008). Such signals are treated as information, although they may be noise. In the absence of herding, an individual will observe different behaviors, leading her to question her
decisions. However, when herding is present, individuals fall victim to the perception of positive feedback by observing everyone around doing the same thing – the decision must be right, since no alternatives are observed. This is referred to as momentum investing, which can produce self-fulfilling prophecies in the short-term (Rizzi, 2008).

Another issue with incentive pay is the fact that it is based entirely on outcome, completely ignoring the decision process. However, actions and outcomes can be unrelated. In order to value risk correctly, one needs to consider the value of the options not purchased to hedge the position (Scholes, 2000). If this is not done, incorrect capital allocation incentives are created – i.e., the lucky “fool” is rewarded with incentive pay and given more capital to invest until the lucky streak ends. The decision-making process does not need to be logical, as long as the end result is positive – this is the line of thinking inherent in the incentive-pay system that encourages excessive risk-taking and even pure gambling behavior. Examples of such misalignment of incentives include the apparently lucky real-estate experts at Bear Sterns and Lehman Brothers – both institutions spectacularly collapsed at the hands of the very same people who only few years before had lead them to stardom (Rizzi, 2008).

5.6.3. Reputational herding

Graham (1999) introduces the term “reputational herding” to refer to the hypothesis that an individual manager’s risk-taking behavior is affect by the risk-taking behavior of other managers in her peer group. His theoretical model suggests that managers with high reputation and salary will herd to protect their current status and pay (Boyson, 2010). It is interesting to note that while herding in itself is an example of risk-averse behavior, it can paradoxically lead to excessive risk-taking when the herd as a whole is taking risks. Graham’s (1999) empirical study based on hedge fund managers supports his model, and so does Li’s (2002) – there is a tendency for herding to increase over a manager’s career. Other empirical research in labor economics, financial economics, and management has arrived at similar results. However, there are some empirical studies that arrive at the opposite conclusion – they show a decrease in herding as managerial experience increases (Boyson, 2010).
5.6.3. Incentives to herd

Boyson (2010) offers a different view on herding, where he considers a manager’s incentives to herd. There are two incentives that affect a manager’s tendency to herd – 1) avoiding termination and 2) achieving high returns and increasing the size of the fund. The second incentive is directly related to incentive pay – part of hedge fund managers’ compensation comes in the form of incentive fees, which are based on fund performance, and part of it comes from management fees, which are based on firm size (Boyson, 2010). Thus, managers have incentives to increase fund returns, both in order to keep their jobs and increase their compensation. Normally, managers’ tendency to herd would prevent them from deviating too much from the herd by investing in high-risk assets in an attempt to maximize fund inflows through the high returns. However, when the herd is already going in the direction of excessive risk-taking, investing in high-risk, high-return assets is not a deviation anymore – in fact, not investing in high-risk, high-return assets becomes the deviation. Paradoxically, it is the hedge fund managers’ risk-avoidance behavior (herding) that reinforces the excessive investment risk-taking already incentivized by their compensation schemes. By the means of regression, Boyson’s (2010) shows that more experienced hedge fund managers are more likely to both be terminated and experience no increase in fund inflows if they deviate from the herd. This suggests that in situations where the herd takes on excessive risk, such as the recent financial crisis, experienced managers, who are normally considered better fit to deal with risky investments that require judgment due to their inherently high level of uncertainty (Rizzi, 2008), are also the ones who have the highest incentives to take on excessive risk.

Boyson (2010) points out that his findings about hedge fund managers are in contrast to evidence from the mutual funds industry, where more experienced managers herd less. Kempf et al. (2009) use an approach similar to Boyson’s (2010) to look at the incentives of mutual fund managers. They also divide the incentives into two categories – “compensation incentives”, or a manager’s desire to earn high compensation, and “employment incentives”, or a manager’s fear of losing her job. Their empirical study shows that the risk-taking behavior of mutual fund managers depends on the performance of the funds they manage. On one hand, compensation incentives lead managers of funds performing poorly in the interim to increase their funds’ risk relative to managers to funds performing well in the interim. On the other hand, employment incentives lead managers of funds performing poorly in the
interim to decrease their funds’ risk relative to managers of funds performing well in the interim.

Similarly to hedge fund managers, mutual fund managers’ compensation depends on both size of the fund and performance of the fund throughout the year. Since size of the fund is linked to inflows, there is a convex relationship between the fund’s part performance and the compensation of the manager. Such a relationship can lead to “midyear tournaments” between managers, where the managers of funds with poor performance at mid-year take on more risk in the second part of the year – they do not have much to lose in terms of performance and thus compensation, while taking on more risk increases the chance of them catching up with the funds performing well at mid-year (Kempf et al., 2009). However, mutual fund managers also face the fear of losing their jobs. The employment incentives work in the exactly opposite way of compensation incentives – if managers of funds performing poorly at mid-year take on more risk in the second half of the year, they risk performing even worse and potentially losing their jobs. In contrast, managers whose funds are performing well at mid-year have a compensation incentive to lock in their position and stay safe by not taking on too much risk in the second half of the year. At the same time, employment incentives are of little importance to such managers and therefore do not have a significant effect on their strategy (Kempf et al., 2009).

5.6.4. Incentives to herd in bull markets vs. bear markets

Employment incentives and compensation incentives work together to influence fund managers’ strategies. The relative weight of each type of incentive depends on the expected increase in compensation due to reaching a top position, as well as on the expected cost of a job loss, both of which in turn depend on the market environment (Kempf et al., 2009). During and right after bear markets, the inflows into funds are generally low, and the size of funds grows only slightly. Compensation incentives are therefore weak – bonuses based on fund performance and on fund size are both low. On the other hand, employment incentives are strong – the low inflows in bear markets lead to fund closures, with poorly performing funds the first to go. Empirical research has shown that job loss is indeed more likely after bear markets than after bull markets (Kempf et al., 2009). In contrast, during and right after bull markets, compensation incentives are strong, since large aggregate inflows ensure high bonuses for fund managers. Employment incentives are weak, because few funds are closed.
in bull markets, and even if a manager loses her job, there are many job options. Thus, which incentive dominates depends on the market – compensation incentives dominate in bull markets, while employment incentives dominate in bear markets. The more bullish or bearish the market, the more pronounced the effect of the respective incentive (Kempf et al., 2009).

Kempf et al.’s (2009) analysis of portfolio holdings data of US equity mutual funds between 1980 and 2003 shows that in bull markets, managers of funds performing badly at mid-year do indeed increase risk-taking relative to managers whose funds are performing well at mid-year. The environment prior to the financial crisis is an example of a very pronounced bull market, where poorly performing managers would have been influenced by the compensation incentive to increase their risk-taking. In general, fund managers’ risk adjustment in response to either type of incentive may result the creation of portfolios with sub-optimal risk-return characteristics, which is not in the best interest of the investors. If large enough, the effect can cause inefficient price formation in asset markets (Kempf et al., 2009).

5.7. Choking under pressure phenomenon

The intuitive view on incentive pay would be that higher incentive pay leads to increased motivation and effort, and consequently to better results, because motivation is supposed to improve performance. However, the observed phenomenon of choking under pressure speaks to the contrary. Choking under pressure refers to the less-than-optimal performance observed in response to high reward contingencies. Payment in the form of a percentage of high-value investment portfolio should the portfolio increase in value is a typical example of a high reward contingency, which makes this phenomenon relevant to incentive pay in the financial industry.

Deteriorating performance due to excessive incentives has been long been documented. The effect was studied by Yerkes and Dodson in 1908 in an experiment on rats that were given shocks of different intensity in different locations of their cage (Ariely et al., 2005). The shocks of intermediate intensity were the ones that taught the rats to differentiate most quickly the safe vs. the unsafe areas of the cage. The experiments lead to the formulation of the Yerkes-Dodson law, which states that there are optimal levels of arousal that have positive effects on performance, while deviations, either positive or negative, from these levels lead to deteriorating performance. An excessive level of motivation increases arousal to levels that are not optimal, thus negatively affecting performance (Ariely et al., 2005).
Another factor that contributes to the negative relationship between motivation and performance is increased self-consciousness – another side effect of increased motivation. Self-consciousness can be further increased by the presence of an audience, because the motivation to do well is amplified by the motivation to do well in front of people (Ariely et al., 2005). When tasks involve automatic skills, factors such as monetary incentives, competition, and the presence of an audience can make people shift from automatic to controlled processes that involve conscious thinking and that are less effective – a phenomenon that points back to the fact that some choices are better processed subconsciously. Sports are a good example of automated tasks – for instance, conscious thinking about how to kick a ball can impair someone’s ability to actually do so well. As a result, sports are a very popular field of the study of choking under pressure.

Dohmen (2005) performed a study on professional soccer players’ performance on penalty kicks. This task is complex, but it is very typical for a professional soccer player, and is usually automated through practice. In addition, it is very simple to measure if a soccer player has succeeded or failed at the task. Although the study was aimed at providing real world evidence on the detrimental performance effects of high rewards, it did not confirm the validity of the choking under pressure hypothesis. However, it did demonstrate that the presence of an audience is related to choking under pressure. The author points at various limitations of his study, thus leaving open the possibility that the conditions under which the study was performed may have affected the outcome (Dohmen, 2005).

It should be noted that choking under pressure has not been given much attention from economists (Dohmen, 2005). In the field of economics, it is especially important to study how performance-contingent monetary incentives (incentive pay), especially the high amounts given to top employees of financial institutions, affect performance (Ariely et al., 2005). Since the size of compensation to be earned does increase the pressure to perform, it is necessary to understand how professionals perform under pressure in order to be able to design effective incentive schemes (Dohmen, 2005). Although in recent years the interest in the subject has brought along more research, the number of available studies on choking under pressure in a financial settings is still very limited.
5.8. Effect of level of reward on performance

Ariely et al. (2005) conducted various experiments on the effect of reward on performance. One experiment involved a sample of 87 residents of a rural Indian town playing games individually. Participants were divided into three groups, each of which offered compensation for excellent performance, but the amounts between the groups varied – small amount (4 Indian rupees), moderate amount (40 Indian rupees), and very large amount (400 Indian rupees). Participants were paid based on how well they performed in each game. By reaching “very good” performance in all the games, participants in the large reward group could earn as much as “half of the mean yearly consumer expenditure in the village” (Ariely et al., 2005). The results demonstrated that relatively high monetary incentives can lead to decreased performance (Ariely et al., 2005).

Another experiment conducted by Ariely et al., (2005) involved MIT students who had to perform two different tasks, one involving adding two numbers (a cognitive task) and the other involving typing (a physical task). The two tasks were first given to the subjects without any incentives. Then half of the students were offered high reward (up to $300) and the other half low reward (up to $30) to perform both tasks again. Finally, subjects were given the opposite incentive of the one they were first offered and asked to perform the task again (Ariely et al., 2005). The results of the study once again supported the hypothesis that relatively high monetary incentives lead to decreased performance. It also demonstrated a negative relationship between incentives and performance even when subjects perform tasks that they are familiar with. However, results also show that not all tasks are influenced to the same extent. Tasks that involve only an “effort” job seem to be performed better with increased incentives, contrary to tasks with cognitive elements, which are performed worse after a certain level of reward is passed (Ariely et al., 2005). The tasks that managers have to perform in their daily activities on the job are complex, involve cognitive elements, and require judgment – they are, therefore, the kind of tasks susceptible to high rewards’ negative effects on performance.

5.9. Convex-shaped incentive pay function and risk-taking

The incentive pay system in the American financial industry is an example of a system with convex performance-based compensation (shown in Fig.16) – the higher the returns, the higher the inventive pay. Convex compensation implies a greater rate of increase of incentive
pay at high returns compared to moderate returns, while the increase is not so pronounced in the case of moderate returns versus low return. This makes investment an asymmetric bet – by getting the returns she generates for the company from moderate to high, a manager stands to get a much higher increase in incentive pay than by getting them from moderate to low. Such an asymmetry gives an incentive for taking on more risk – if it results in a gain, it brings significantly more compensation to the manager, if it results in a loss, the decrease in compensation is nowhere nearly as significant (LeRoy, 2010). In addition, due to the asymmetry, managers are better off when years of high revenues and alternate with years of low revenues rather than when an average of moderate revenues is sustained over a longer period of time – in essence, managers benefit from taking large risks (LeRoy, 2010). Although such risks do generate losses, high income gained in high-revenue years is normally enough to compensate for the low-revenue years (LeRoy, 2010).

In addition, convex compensation may be related to agency problems, since stockholders get the opposite returns on risk – stock prices do not skyrocket following a high-return year as much as they can tumble down following a loss year (LeRoy, 2010).

Connecting convex compensation to mortgage bonds, it seems that fund and portfolio managers would have had an incentive keep trading with them, so they can receive the incentive pay linked to the high returns in the short-run. The investment performance in the long turn would not be of much importance, since it had already paid off nicely to its traders (LeRoy, 2010). Since there is an incentive for traders to take large risks, the demand for risky assets increases and sends a signal to the market, which in turn that provides more high-risk, high-return assets (LeRoy, 2010). LeRoy (2010) also points to credit default swaps, which during the crisis were used for speculation on risks and not as instruments for transferring
risk to the market participants that are more able to bear it. He cites Rajan (2005) who, a few years before the crisis hit, noted that in the financial industry, there was a constant creation of new risks instead of a healthy allocation of the existing one.

5.10. Executive compensation and performance

Suntheim (2010) studies the link between CEO compensation and CEO risk-taking. He recognizes that there are many factors that contributed to the financial crisis, but also points out that the high level of risk-taking is obvious in hindsight. The author cites the work of Kashyap et al. (2008), who attribute the high-risk investment decisions of bankers to faulted risk assessments and management incentives (Suntheim, 2010). Suntheim (2010) also refers to previous research on the effect of executive compensation on risk-taking – a study by Coles et al. (2006), who analyze US firms, and another one by DeYoung et al. (2009) who look at US banks. Both studies conclude that executive compensation affects risk-taking. Suntheim (2010) collects data on the compensation of top officers from 18 countries and 74 different banks between 1997 and 2008. Using statistical analysis, he demonstrates that banks that compensated executives mostly with options and short-term bonuses had a worse performance than the banks that had compensated CEOs with stocks (Suntheim, 2010). To the extent to which this worse performance is attributable to more risk-taking converted to a loss, there is also a link between CEO compensation and risk-taking.

6. Behavioral perspective – intertemporal choice

Intertemporal choice is defined as a choice “between outcomes that occur at different points in time” (Kalenscher and Pennartz, 2008). The main characteristic that distinguishes intertemporal choices from other types of choices is that the former include delayed outcomes that need anticipation and a proper discounting for the evaluation of their present value (Berns et al, 2007).

6.1. Discounted utility function

In neo-classical economics, intertemporal choice studies are based on discounted utility theory. The theory was suggested in 1937 by Paul Samuelson and was soon adopted as a normative framework for intertemporal decisions. The discounted utility model, which is based on various axioms, is regarded as “the equivalent to expected utility in the domain of
time” (Kalenscher and Pennartz, 2008). The models display various similarities, such as the use of a weighted sum of utilities for the evaluation of choice options: the expected utility model uses probabilities as weights, while the discounted utility model uses discount factors as weights (Kalenscher and Pennartz, 2008). If an individual is to choose between two identical rewards at different points in time, the model predicts that she will use a temporal discounting process to discount the future outcomes and will select the one that is closer to the present. (Kalenscher and Pennartz, 2008).

Kalenscher and Pennartz (2008) list the following axioms behind discounted utility theory:

1) **Monotonicity of time preference**, meaning that the same outcome is preferred earlier in time rather than later:

2) **Completeness of time preference**, implying that an individual can defined her preferences and can choose among two outcomes at different points in time:

3) **Intertemporal transitivity**, meaning that choices are made consistently:

4) **Continuity of time preference**, or the assumption of continuous time (Lancaster, 1963)

5) **Intertemporal independence**, implying that “the utility of a reward should be independent of whether a reward was already experienced in the past, or will be experienced at another time” (Kalenscher and Pennartz, 2008)

6) **Stationarity** – if a subject is indifferent between two options that are going to occur at different times, then, when the two options are delayed by the same time interval, a subject should still be indifferent between them (Kalenscher and Pennartz, 2008):

Stationarity is satisfied only when the discount rate used for the discounting of future outcomes is constant, which is another assumption behind the discounted utility model. Constant discounting means that “a given time delay has the same relative impact on preferences and values, regardless of when it occurs” (Kalenscher and Pennartz, 2008).

Therefore, according to neo-classical economic theory, the discount function used to discount future outcomes is exponential, since it has constant discount rates. In addition, only one discount function is enough to describe intertemporal decision-making. The exponential discount function means that “the expected utility of a future outcome can be expressed as an exponential decay function of the same outcome realized today” (Kalenscher and Pennartz, 2008). Moreover, agents are expected to maximize utility and optimize the cost-benefit function (Kalenscher and Pennartz, 2008). Similarly to the deviations from the normative
model of SEU, observed behavior shows deviations also from the discounted utility model that formalized intertemporal decision-making (Kalenscher and Pennartz, 2008).

6.2. Deviations from the discounted utility function

6.2.1. The common difference effect

One of the most commonly observed anomalies of the discounted utility model is the violation of the stationarity axiom. Kalenscher and Pennartz (2008) cite the research of Green et al. (2004) who investigated how individuals decide when they have to choose among monetary rewards at different points in time. The research showed that individuals prefer to receive a smaller reward earlier rather than a larger reward later, since waiting requires some effort. However, Green et al. (1994) ascertain that there seems to be a preference reversal in cases when both rewards are moved further in time with the same time interval, which means that individuals will in that case prefer the larger reward to the smaller – a phenomenon referred to as the common difference effect (Kalenscher and Pennartz, 2008). Another well-documented intertemporal choice behavior presented by Kalenscher and Pennartz (2008) is the immediacy effect, which is an extreme example of preference discontinuity in cases where immediate rewards are available along with delayed ones (Kalenscher and Pennartz, 2008). The described phenomena occur because people are prone to diminishing impatience, resulting in a bias towards the present.

6.2.2. Present-bias or diminishing impatience

O’Donoghue and Rabin (1999) studied the impact of present-biased preferences on behavior. They present two sets of distinctions: 1) choices involve either immediate costs (the costs are immediate and benefits delayed) or immediate rewards (the costs are delayed and benefits immediate), and 2) individuals are either sophisticated (i.e., foresee self-control problems) or naïve (i.e. do not foresee self-control problems). Based on these four categories, the researchers discuss two behavioral phenomena that work in conjunction to affect intertemporal choice. The present-bias effect implies that people procrastinate when there are immediate costs involved while they preproperate in the presence of immediate rewards. Present-bias affects only naïve individuals, because sophisticated individuals, being aware of potential self-control problems, will attempt to avoid them by performing the action earlier, regardless of whether costs or rewards occur immediately. This tendency of sophisticated individuals to perform the action earlier is referred to as the sophistication effect and acts to
counteract, though not entirely cancel, the immediacy effect. While it is true that the sophistication effect applies to both immediate costs and immediate rewards, the extent to which it does so is different. In the case of immediate costs, the sophistication effect does not eliminate procrastination – rather, sophisticated individuals show a smaller tendency to procrastinate. With immediate rewards, preproperation is amplified by the sophistication effect (O’Donoghue and Rabin, 1999).

Halevy (2008) presents a study about diminishing impatience from an alternative perspective. He regards the present as the only point in time that can be certain, while the future is always uncertain. He introduces the concept of uncertain lifetime, and with it the concept of future that can stop at any time with a positive probability. The inclusion of uncertain lifetime into a model implies that because of the risk of death there is a stopping probability, or alternatively, it is possible to include the risk of not receiving the reward in the future. Diminishing impatience is the result of evaluating future consumption with the use of a non-expected utility function. Since preferences’ excessive sensitivity to certainty is a characteristic of the present, preferences will be biased to the present (Halevy, 2008). Impatience diminishes as all rewards are moved further away into the future – this is why a choice between a smaller reward now and a larger reward in the future points to the smaller reward, but a choice between a smaller reward in the future and a larger reward even further away in the future points to the larger reward.

Another way to look at intertemporal choice is the implicit risk approach, where delayed consequences are associated with a subjective implicit risk, but with the introduction of an explicit risk to immediate or delayed consequences (when the present becomes risky), diminishing impatience becomes less important. This means that impatience may not diminish at all when current decisions involve risk (Halevy, 2008).

**Uncertainty of the future and non-expected utility**

Halevy (2008) presents a model linking uncertainty of the future and non-expected utility, which is needed for the construction of a utility function of preferences over consumption paths. The model has two components - certainty effect, or the overweighting of certain outcomes compared to very likely but not completely certain outcomes, and myopic decision-making, or the tendency of individuals to disregard what their preferences will be in the
future when making a decision in the present. Time consistency is violated when myopia and the certainty effect combine. Halevy’s (2008) model has implications for procrastination. The author discusses the example of an individual who has to complete a task by a certain deadline. At the beginning, with a lot of time at her disposal, the individual desires to finish before the deadline, in order to avoid the stress of last-minute work. However, as time passes and the deadline gets closer, procrastination comes into play, bringing about the risk of last-minute completion and the consequences associated with it (stress, sub-optimal performance, unexpected events that prevent completion, etc). In other words, short time horizon contributes to risk-seeking behavior. Halevey (2008) related this to the reflection effect introduced by Kahneman and Tversky (1979) and discussed earlier, where people become risk-seeking in the vicinity of certainty when negative payoffs are involved (Halevy, 2008).

6.2.3. Hyperbolic discounting

The constant discounting assumption, which implies that “a given delay should have the same relative impact on utility regardless of when it occurs” (Kalenscher and Pennartz, 2008), is also often violated. Kalenscher and Pennartz (2008) cite various research - Ainsle (1975), Rachlin et al. (1991), Green and Myerson (1996), and Frederick et al. (2002) - that indicates exponential discounting, a constant discounting function used in the discounted utility model, contradicts observed preference reversals. In addition, Kalenscher and Pennartz (2008) cite research showing that “rewards delivered with short delays are more steeply discounted than rewards with longer delays” (Kalenscher and Pennartz, 2008). This suggests that discount rates are not constant over time but seem to decline with time, a phenomenon known as hyperbolic discounting (Kalenscher and Pennartz, 2008). A hyperbolic function was demonstrated to be a better mathematical approximation to empirical data in the numerous studies that Kalenscher and Pennartz cite. Future gains are also discounted hyperbolically or quasi-hyperbolically. The quasi-hyperbolic function was introduced by Laisbon (1997), as cited by Kalenscher and Pennartz (2008), and consists of a standard exponential function plus an immediacy effect (Kalenscher and Pennartz, 2008). The various models of time discounting are discussed in more detail in Section 8.2.4.
6.2.4. Violation of utility maximization

Another anomaly in intertemporal choice is related to the violation of the assumption of utility maximization. Following the rate maximization hypothesis, “preferences and preference shifts should depend exclusively on the ratio of reward amount (or monetary value) and the duration between the rewards” (Kalenscher and Pennartz, 2008). However, Kalenscher and Pennartz (2008) suggest that there are many instances of decision-making in which individuals decide merely based on the amount of time they have to wait before receiving the reward. They provide experimental evidence about animals choosing smaller rewards immediately rather than larger rewards that are delayed behind a certain threshold. This is contrary to the rate maximization hypothesis under which the larger rewards should be preferred, and it points to a simplification mechanism which is used to minimize the waiting time at the expense of maximizing outcome (Kalenscher and Pennartz, 2008).

6.2.5. Framing

In addition to being related to risk-taking, framing is also related to intertemporal choice, since there is empirical evidence showing that it affects the discount rate. Kalenscher and Pennartz (2008) present the work of Loewenstein (1988) on the effect of framing on intertemporal choice. Subjects in Loewenstein’s experiment were willing to pay additional $54 for goods delivered immediately instead of in a year when the situation was framed as if the goods are expected to be delivered in a year, while they demanded an compensation of $126 for the delayed delivery when the situation was framed as if the same goods were supposed to be received immediately. This finding is in contrast to discounted utility theory, which assumes a single discount function and therefore also only one discount rate (Kalenscher and Pennartz, 2008). Furthermore, Frederick et al. (2002) refer to the experiments of Benzion et al. (1989) and Shelley (1993) who found the same effect for gains and losses – their subjects required higher amounts of compensation when they were asked to pay early compared to what they were willing to pay for the possibility of being granted a delayed payment option (Frederick et al., 2002).

6.2.6. The sign effect

Gains and losses are treated asymmetrically during intertemporal decision-making, implying a different discount rate for each category. Usually, gains are discounted more than losses (a
phenomenon referred to as “sign effect”), meaning that the two have separate discount functions - another challenge to the discounted utility assumptions. In addition, according to the discounted utility model, losses should be delayed if their weight decreases in the future. However, experiments with human subjects have shown preferences to incur immediate losses over delayed ones (Kalenscher and Pennartz, 2008). Frederick et al. (2002) cite the study of Thaler (1981) who looked at how much individuals were willing to pay for the option of having a traffic ticket delayed by different amounts of time – 3 months, 1 year or 3 years – instead of paying it right away. The study gave discount rates that were lower compared to similar questions that involved monetary gains (Frederick et al., 2002). For example, subjects were on average willing to pay one extra dollar for the possibility of paying the fine of $15 in three months, and two more dollars when the amount of the fine was $100. The required amounts for gains were much higher. To delay the receipt of a $15 reward for three months, subjects asked to receive $30 at the end of the waiting period (Thaler, 1981).

6.2.7. The magnitude effect

Research on intertemporal choices has also shown the presence of a “magnitude effect”, meaning that “large positive outcomes are discounted at a lower rate than small outcomes” (Kalenscher and Pennartz, 2008). The research by Thaler (1981) cited above had implications for the magnitude effect as well. Thaler (1981) explains his findings with the effort that the waiting for rewards requires. The subjects he tested were, “on average, indifferent between $15 immediately and $60 in a year, $250 immediately and $350 in a year, and $3000 immediately and $4000 in a year” (Frederick et al., 2002). The discount rates Thaler (1981) calculated were respectively 139%, 34% and 29% (Thaler, 1981; Frederick et al., 2002), thus suggesting the presence of a magnitude effect – the smaller the amount, the steeper the discounting. The magnitude effect has also been observed in research by Holcomb and Nelson (1989) for payoffs of small amounts ($5 to $17), and Horowitz (1988) for a payoff of $50, as cited by Loewenstein and Thaler (1989).

Explaining the magnitude effect

Loewenstein and Thaler (1989) describe two behavioral phenomena that are likely to explain the magnitude effect. First, it has been shown that besides relative differences also absolute differences in monetary amounts affect the perception of individuals – in this context the
authors cite the study by Loewenstein and Prelec (1989). For example, individuals perceive the difference between $100 now and $150 in a year differently than the difference between $10 now and $15 in a year. The latter difference is seen as much smaller and therefore an people are prepared to wait for the $50 but it is unlikely that they will wait for the $5 (Loewenstein and Thaler, 1989).

Second, Loewenstein and Thaler (1989) cite the study by Shefrin and Thaler (1988) as they claim that the magnitude effect can be explained with the introduction of mental accounting. The authors propose the example of windfalls – unexpected monetary gains – of different sizes. A small one is saved in a mental account for immediate consumption, while the larger one is stored in the mental account designated to savings. If waiting for the small windfall, perceived as “forgone consumption”, is preferred over waiting for the large windfall, perceived as “foregone interest”, a magnitude effect occurs (Loewenstein and Thaler, 1989).

6.2.8. Improving sequences

Since economic agents show sensitivities to change, there seems to be a preference for sequences that improve over time. Increasing sequences bring positive changes (gains) while decreasing sequences carry negative changes (losses) (Camerer and Loewenstein, 2004). Important research about this anomaly has been performed by Loewenstein and Prelec (1993) who discovered that individuals prefer to choose the least desirable option first and leave the best option for last, when they are faced with decisions about how to distribute events of different pleasantness over time. Other research also shows that subjects prefer an increasing salary profile, although the total amount of money they receive is smaller compared to an alternative declining or flat profile (Frederick et al., 2002; Camerer and Loewenstein, 2004). A possible explanation of such preferences is that this kind of behavior eliminates dread and leaves the individual in the anticipation of pleasantness (Camerer and Loewenstein, 2004). Violations of independence of choice have also been observed. Loewenstein and Prelec (1993) asked subjects to choose different options in time. The consumption a subject executes in one period should be independent of the consumption in previous and next periods, but their data showed this was not the case.
6.2.9. Impulsivity and self-control

Glimcher et al. (2007) explored the impulsivity of people, lead by the idea that people are affected by inner conflicts while they value the benefits and costs from choosing immediate against delayed gratification. They found an important aspect of intertemporal choice - people choose gains that are available “as soon as possible”, irrespective of when the “as soon as possible” in reality is, either in a minute or in a month. It should be noted that neurobiological evidence from the same study could implicate the personality trait of impulsivity in such behavior (Glimcher et al., 2007).

Self-control, the mechanism people utilize to control impulsivity, is a phenomenon exhibited in daily life. Deadlines are a good example of the need for self-control - people commit to perform a certain action and therefore need to abide by deadlines (Laisbon, 1997). Laisbon (1997) cites the work of Strotz (1956) in intertemporal choice, which was the beginning of the modeling of the theory of commitment. Strotz (1956) introduced the possibility of non-exponential discounting, which implies that individuals will prefer to restrain their own future choices. Nevertheless, intrapersonal commitment is not well-studied in economics, since people who choose commitment have dynamically inconsistent preferences which are a complex behavioral phenomena mostly avoided by traditional economists.

6.2.10. Myopic loss aversion

Individuals who display myopic loss aversion are more sensitive to losses than to gains and they need frequent assessments of their positions (Thaler et al., 1997). Thaler et al. (1997) cite the work of Benartzi and Thaler (1995), who present two behavioral principles that could explain the equity premium puzzle discussed in Section 4.2.8 - loss aversion and mental accounting, the latter of which is discussed in Section 5.3. With their explanation they were the first to introduce the term “myopic loss aversion” (Thaler et al., 1997). Mental accounting is involved in the framing of decisions, which affects how an individual evaluates choices and it is also closely linked to the framing of past outcomes. Narrowly framed decisions lead to short-termism, while narrow framing of past outcomes leads to frequent evaluation of gains and losses, thus producing a myopic decision-maker (Thaler et al., 1997).
The frequency of portfolio evaluation has important influences on decision-makers facing intertemporal choices. Myopic investors perceive the utility from owning stocks as lower compared to a non-myopic investor, which will lead them gradually to choose less risky investments. Therefore, the assumption behind myopic loss aversion is that the willingness to accept risks increases as the frequency of investments’ evaluation decreases. In addition, investors are more willing to accept risks if losses can be eliminated by a rise in payments. Dependent on the level of their myopia, investors choose more or less risky investments (Thaler et al., 1997).

6.3. Short-term performance and accountability

Incentive pay based on short-term performance metrics with no controls for risk, and with no accountability should the investment decisions prove to be favorable in the short-run, but unfavorable in the long-run, can amplify the effect of several inter-related behavioral phenomena – overconfidence, self-attribution, hindsight effect, illusion of control, and optimism.

Overconfidence, or the tendency of people to exaggerate their own predictive skills while underestimating the role of outside circumstances and pure chance, contributes to risk-taking through underestimation of outcome variability. Overconfidence results in optimism, which leads individuals to overestimate gains while underestimating costs. It is further reinforced by the self-attribution effect - the tendency to internalize success and externalize failure - and the hindsight effect – the selective recall of confirming information which leads to an overestimation of one’s ability to predict the correct outcomes (Rizzi, 2008). Industry and product experts, who are prone to illusions of knowledge and control, are especially susceptible to overconfidence. Experts tend to confuse knowledge with familiarity, with the most striking example being the former Federal Chairman in the United States who “missed the collapse of the housing and structured credit boom” (Rizzi, 2008). Being rewarded for short-term investment success with no regard to the long-run performance of investments can amplify the self-attribution effect and the hindsight effect – managers are rewarded for their success, while failure is the company’s failure, not theirs, and when faced with a risky investment choice, they may selectively recall the last time they took a similar action and were successful in it, as confirmed by the reward they received. Lead by optimism, managers can also overestimate the gains (their short-term performance-based pay) and underestimate the costs (a major loss to the company in the long-run).
The illusion of control refers to people’s belief in their ability to influence or escape the consequences of risk. Notable example is the belief that one can hedge risk, although the likelihood of one individual being better or faster than the market (provided the individual has no information that is not available to the market) is quite low (Rizzi, 2008). Incentive pay for short-term performance indeed entails no negative consequences for excessive risk-taking, potentially giving managers the illusion that they have successfully escaped it, if not on professional, at least on a personal level – their reward cannot be taken back no matter what happens in the long-run.

7. Neuroeconomic perspective – reward processing in the brain

A decision occurs when “an organism, confronted by several discrete options, evaluates the merits of each and selects one to pursue” (Corrado et al., 2009). Due to its central role in daily life, decision-making has been the subject of research of economists, psychologists, and neuroscientists alike. There are several types of decision-making, the most well-understood of which is sensory-based decision-making, “where subjects are asked to judge an objective quality of an external stimulus” (Corrado et al., 2009). Of more interest to neuroeconomics, however, is the value-based decision-making, which is also the least understood form of decision-making. (Corrado et al., 2009). Value-based decision-making involves choices that are mandated not by the immediate sensory characteristics of the options, but by the “subjective experience and preferences of the individual” (Corrado et al., 2009). Value-based decisions do not have one unambiguously correct option. According to this definition, financial decisions are value-based decisions.

To analyze the options available under value-based decision-making, the brain utilizes decision variables – “quantities internal to the subject’s decision process that summarize properties of the available behavioral options relevant to guiding choice” (Corrado et al., 2009). Decision variables are the link between option evaluation and action selection, as presented in the oversimplified, feed-forward model of decision-making in the brain presented in Fig.17. Decision variables are one area where behaviorists and neuroscientists differ – the most extreme behaviorists dismiss decision variables as fictitious, while neuroeconomists make the study of internal decision variables a central goal, guided by the belief that decisions are mediated by scientifically accessible processes in the brain (Corrado et al., 2009). The present study is concerned with the role of incentives in the option
evaluation stage of the decision-making process, as well as by their effect on the decision variables.

![Image](94x615 to 424x685)

**Source:** Corrado et al., 2009

**Fig. 17. Decision-making in the brain**

Decision variables are affected by any property of a behavioral option that influences its attractiveness, including reward magnitude, reward quality, risk, uncertainty, and delay (Corrado et al., 2009). From a neuroscientific perspective, this is how incentive size, structure, and timing are linked to the decision whether to accept a risky investment or not – incentives change the attractiveness of the options to invest or not, thus influencing the decision-variables, and consequently the decision-making process.

Incentives, including money, change the way people think and behave (Rowe et al., 2008). The prospect of a reward, including money reward, influences processes such as attention, decision-making, and the sets of mental rules that determine reactions to events. The representation of rewards in the brain is different from the representation of cognitive or behavioral rules – reward processing is closely associated with the orbital and medial frontal cortex, the anterior cingulate, and the ventral striatum, while cognitive rules are associated with the lateral prefrontal cortex. In other words, introducing an incentive into the decision-making process changes the way the decision is processed in the brain, further emphasizing the importance of incentive presence and structure. This section of the current study investigates how the prospect of a gain or a loss is processed in the brain and how its processing can be influenced by changing the form or size of the potential gain. It is important to note that fMRI studies have shown that there is no significant anatomical segregation of prospect and outcome responses – i.e., the brain treats the prospect of a reward similarly to an actual reward (Trepel et al., 2005).

### 7.1. Processing of gains and losses in the brain

Trepel et al. (2005) discuss the neural representation of prospect theory and provide a summary representation of the brain systems involved in its major aspects (Fig.17). Of
interest to the current study is the value function component. Trepel et al. (2005) point out a distinction between decision utility and experienced utility – the first refers to the weight of an outcome in a decision, and the second – to the hedonic quality of an outcome. Prospect theory is mainly concerned with decision utility, and so is the current study. However, the two types of utility are related and both important to decision-making, because decision utility might be derived from predictions of the experienced utility of different options.

<table>
<thead>
<tr>
<th>Component</th>
<th>Prospect theory feature</th>
<th>Brain area</th>
<th>Neurotransmitter systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value function</td>
<td>* Representations of value*</td>
<td>- Anticipated gains: Ventral striatum, ACC</td>
<td>DA (incentive)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Anticipated losses: Amygdala</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Experienced gains: Dorsal/ventral striatum, VMPFC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Experienced losses: ACC, Amygdala, Dorsal striatum</td>
<td>DA (disincentive)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Loss Aversion: Amygdala</td>
<td>NA</td>
</tr>
<tr>
<td>Weighting function</td>
<td>* Diminishing sensitivity*</td>
<td>- Overweight low $p$: Ventral striatum ( \text{(hope?)} )</td>
<td>DA ( \text{(hope?)} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Underweight high $p$: Amygdala ( \text{(fear?)} )</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>* Suboptimality: 5-HT ( \text{impulsivity} )</td>
<td></td>
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<tr>
<td>Representation</td>
<td>* Framing*</td>
<td>DLPFC, ACC</td>
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<td></td>
<td>* Editing*</td>
<td>DLPFC, VLPFC, (inhibition)</td>
<td>DA, 5-HT</td>
</tr>
</tbody>
</table>

Abbreviations: Dopamine (DA), Serotonin (5-HT), Noradrenaline (NA), Dorsolateral prefrontal cortex (DLPFC), Anterior cingulate cortex (ACC), Ventromedial prefrontal cortex (VMPFC).

Source: Trepel et al., 2009

Fig.17. Neural representation of prospect theory.

While decision utility is related to anticipated rewards, and experienced utility – to experienced rewards, the two types of rewards are processed in related, albeit it not 100% identical, parts of the brain – the striatum for both anticipated and experienced gains and the amygdala for both anticipated and experienced losses.

The ventral striatum, including the nucleus accumbens, is the integration point for signals from the prefrontal cortex, amygdala, and hippocampus (Trepel et al., 2005). Knutson and
Peterson (2005) review a large body of evidence that implicates the striatum in the representation of the magnitude of the anticipated reward. In addition, using fMRI, researchers have found a monotonic increase in striatum activity during exposure to risk-free, gain-only stimuli, as well as increased activity in the nucleus accumbens during anticipation of large rewards (Trepel et al., 2005). Knutson and Petersen (2005) have also observed activation in the ventral striatum during anticipation of gains, but not during anticipation of losses – see Fig. 18. It should be noted, however, that there is also very influential research by Tom et al. (2007) whose findings are in contradiction to the findings of Knutson and Petersen. Gelskov et al. (2010) find results similar to Tom et al.’s (2009). These findings will be discussed in Section 7.2.1.

![Fig.18](source: Knutson and Petersen, 2005)

Fig. 18. Monetary gain anticipation activates the ventral striatum

Elliot et al. (2003) conducted an fMRI study to more specifically identify three kinds of regions: 1) regions responding to reward vs. no reward, 2) regions responding linearly to increasing reward, and 3) regions responding non-linearly to increasing reward. As shown on Fig. 19, the striatum, the midbrain, and the amygdala are activated in response to all-or-nothing conditions. Responding linearly to increasing reward is the pre-motor cortex, and responding non-linearly were the anterior medial frontal cortex and the lateral orbitofrontal cortex. It is interesting to note that the linear relationship between pre-motor response in the pre-motor cortex and increasing reward was paralleled by a linear decrease in reaction time – i.e., the larger the reward, the less time participants take to answer. Elliot et al. (2003) suggest that pre-motor responses may increase motor preparedness to respond to reward-eliciting stimuli. This suggestion is in line with other research which suggests that the pre-motor cortex, along with other regions of the dorsal and lateral prefrontal regions, is involved in using information about expected rewards to mediate goal-directed behavior (Elliot et al. 2003). What this means in a financial industry setting is that both the presence of a bonus, as well as its size, may affect decision-making on a neurological level.
7.1.1. Two-stage model of decision-making under uncertainty

So far we have discussed the brain areas implicated in decision-making. Weller et al. (2007) go a step further by suggesting a mechanism for decision-making, rather than just identifying the brain areas implicated in the process. They suggest a two-stage model of decision-making under uncertainty, which indicates two separate neurological mechanisms that guide decision-making, each generating emotion. The first process occurs as a response of a stimulus in the environment (risk), which induces an immediate response and generates an automatic judgment. The amygdala-generated response triggers a second, more complex process that focuses on the outcomes associated with the decision. This process is mediated by the VMPC, a brain structure believed to link working memory and emotional systems, and leads to a second emotional response to the environmental stimulus (risk) which is generated by the thoughts about the prospective outcome. It is this second process that affects individuals’ adaptive ability to make decisions regarding risk, and it is also this second process that can be influenced by incentives. Since the emotional response comes as a result of the thoughts about the prospective outcome, the thought of a large monetary reward may lead to a more positive emotional response, which in turn affects the decision whether to take the risk or not. Kuhnen and Knutson (2005) also suggest that the positive feelings of arousal associated with an anticipated gain may promote risk-taking, while the negative feelings of arousal associated with an anticipated loss may promote risk-aversion. Furthermore, Weller et al. (2007) suggest that the temporal proximity between choice and outcome increases emotional responses – thus the prospect of a large reward in the short-term generates an even stronger positive response than the prospect of a large reward in the long-term.

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6 It should be noted that although the researchers say the observed activation is in the amygdala, the activated area is too far back to be the amygdala – it is more likely to be the hippocampus (Ramsøy, 2011).
7.1.2. Processing of rewards and losses by two separate systems

Another important suggestion of Weller et al. (2007), in line with Trepel et al.’s (2005) view, prospect theory, and neuroimaging data, is that decision-making under risk may take place in partially separate neural systems for dealing with gains and losses. This suggestion is also supported by the work of Peterson (2007), who states that “two major brain structures are fundamental to almost all human behavior – reward approach and loss avoidance”. The two structures can be activated or deactivated independently, meaning that when people are faced with financial decision-making, one or both systems can be used in the process. Perceiving a potential reward in the environment activates the brain’s reward approach structure, which coordinates the search for, the evaluation of, and the motivated pursuit of rewards.

Information within the reward structure is transmitted mainly through the neurotransmitter dopamine, a hormone associated with pleasure and recently found to play a part in reward valuation and pursuit. In fact, the reward structure of the brain lies along one of the five major pathways for dopamine transmission in the brain – the mesolimbic pathway, which, as shown on Fig. 20 “extends from the ventral tegmental area (VTA) at the base of the brain, through the nucleus accumbens (NAcc) in the limbic system, to the grey matter in the frontal lobe (MPFC) (Peterson, 2007). The brain’s loss aversion system is less defined than the reward approach system. Its activity is mediated by the neurotransmitter serotonin and involves several brain regions, the main ones being the amygdala and the anterior insula.

![Fig. 20. The reward structure of the brain](source: Peterson, 2007)

*Processing of gains*

Based on brain imaging studies, Kuhnen and Knutson (2005) also support the idea of different neural systems involved in the processing of affect generated by the anticipation of gains and losses, with the nucleus accumbens showing proportionate activation during anticipation of gains. The brain region implicated in the anticipation of losses is not as clearly defined, but the anterior insula is the most likely candidate for a number of reasons, including activation during risk-taking tasks involving non-monetary rewards. Kuhnen and Knutson
(2005) demonstrate that activation in nucleus accumbens precedes risk-taking choices, as well as risk-taking mistakes, and activation in the anterior insula precedes riskless choices, as well as risk-aversion mistakes. Their findings suggest that anticipated gains and anticipated losses activate different parts of the brain, leading to different financial decisions, and that excessive activation of either part may lead to investing mistakes. A large monetary reward may induce excessive gain anticipation, thus leading to excessive activation of the nucleus accumbens and a subsequent risk-taking mistake. In addition, Kuhnen and Knutson (2005) have found evidence that activation of the one structure or the other is enough to induce a change in risk preferences. Therefore, only giving gain cues (size of a bonus) and/or obscuring loss cues (the likelihood of default on a mortgage bond) can turn risk-avoiders into risk-takers.

**Choking under pressure**

The fact that high rewards may have a detrimental effect on decision-making is also demonstrated by the “choking under pressure” phenomenon discussed in Section 5.7., where less-than-optimal performance is observed in response to high reward contingencies. Payment in the form of a percentage of high-value investment portfolio should the portfolio increase in value is a typical example of a high reward contingency, which makes this phenomenon relevant to remuneration plans in the financial industry. There are three broad explanations for the high-reward paradox, each suggesting different underlying brain activity.

The first group of theories are distraction theories, which attribute the deterioration in performance to attentional competition; the second are explicit-monitoring theories, which attribute it to inhibition by conscious processes, and the third are overmotivation theories, which attribute it to excessive drive and arousal (Mobbs et al, 2009). Overmotivation theories point to excessive activity in the brain reward pathways leading to an “instinctive” mechanism interfering with the more cognitive process of decision-making, which involves attention and working memory. It is known that attention becomes narrower when people are aroused, and that such narrow attention reduces people’s ability to see all the details and to plan ahead. The fMRI study conducted by Mobbs et al. (2009) is the first of its kind and shows activity in the ventral mid-brain to be strongly correlated with performance decrements caused by high, relative to low, rewards. Why exactly incentive-based motivation causes
performance deterioration remains to be answered, but based on the anatomical location of
the brain activity, Mobbs et al. suggest that it has a dopaminergic basis.

7.1.2. Size of reward and brain activity

The significance of the size of the reward, as opposed to just the presence of one, has been
discussed in other work as well. Cooper and Knutson (2008) use fMRI to demonstrate that
the nucleus accumbens is activated not only in response to the valence of the incentive
anticipation, but also in response to its salience. This finding is related to the view of Weller
et al. (2007), whereby the anticipation of a larger reward generates a stronger positive
emotional response, thus influencing the second step in the decision-making process. The
work of O’Doherty et al., as cited by Elliott et al. (2008) also finds a positive correlation
between brain activity and size of abstract rewards. What is even more interesting, Elliott et
al. (2003) cite research that shows that winning money, as well as other abstract rewards, is
associated with activation in the same brain regions that respond to primary reinforces such
as food. In addition, these brain regions are the same as the ones identified in a large body of
research on reward-processing in animals. These findings are important, because they suggest
that 1) at a neurological level, response to monetary incentives may have a primitive,
involuntary component, and 2) both the existence and the size of the monetary incentive for
risk-taking are factors that affect the decision-making process.

7.1.3. The role of dopamine in reward processing

The size of the reward is related to the concept of incentive salience (the “desirability” of the
incentive), a topic closely associated with the role of dopamine in reward-processing. That
dopamine plays an role in reward processing is well-established, but the debate continues
over its precise causal contribution (Berridge, 2007). Existing theories can be divided into
three categories: 1) dopamine mostly mediates the hedonic impact of reward (liking), 2)
dopamine mostly mediates the learned predictions of future rewards (learning), and 3)
dopamine mostly motivates the pursuit of rewards by attributing incentive salience to reward-
related stimuli (wanting) (Berridge, 2007). It should be noted that rewards are often
simultaneously “liked” and “wanted”, so separating the two in research setting is often
difficult.
7.1.4. Dopamine, liking, and wanting

The first group of theories – “liking”, presumably reflecting experience utility (Trepel et al., 2005) – is based on the fact that many pleasant rewards, from food to social and cognitive rewards, activate dopamine systems. However, dopamine does not appear to be necessary to cause normal “liking” reactions when a distinction between ‘liking’ and “wanting” is made, and more dopamine does not mean more pleasure (Berridge, 2007). The second group of theories that consider the role of dopamine in learning is based on dopamine systems’ coding of prediction error rules. The prevalent notion is that dopamine neurotransmission is especially important in reinforcement during reward learning. However, it is not clear “whether dopamine activation causes the rest of the brain to learn, or… whether learning by other brain systems causes dopamine activation (Berridge, 2007). Research has shown cases of learning without dopamine in animals, and other studies have demonstrated that increase dopamine neurotransmission does not lead to better or faster learning. Thus, dopamine appears to be neither necessary nor sufficient for learning. The reason why dopamine neurons’ firing obeys prediction error equations may be that they reflect learning occurring somewhere else in the brain, but do not themselves cause any new learning (Berridge, 2007). However, the learned dopamine neurons firing may in turn cause incentive motivation, or “wanting”, presumably reflecting decision utility (Trepel et al., 2005), the focus of the third cluster of theories.

Incentive salience

The motivational value of incentives has many forms, but incentive salience is the one most closely associated with dopamine and the motivational impact of reward stimuli (Berridge, 2007). Incentive salience is defined as “a conditioned motivation response of a brain, usually triggered by and assigned to a reward-related stimulus” (Berridge, 2007). Determining the value of the incentive salience is based on both pre-existing reward-related associations and current neurobiological states. Incentive salience is the mechanism that translates the mere prediction of hedonic rewards into motivation; it makes a specific associated stimulus or action into an object of desire and “can tag a specific behavior as the rewarded response the individual is motivated to perform” (Berridge, 2007). In a financial industry setting, dopamine can tag risk-taking as the specific behavior the individual is motivated to perform, because in the past this behavior has lead to a financial reward in the form of a monetary
incentive. It should be noted that while dopamine mediates only the dynamic attribution of incentive salience to reward-related stimuli (the “wanting”, or the decision utility), it is the presence of all three (“liking”, “learning”, and “wanting”) that produces the full phenomenon that constitutes “reward”. Berridge (2007) states that the “wanting” hypothesis is supported by more evidence than either of the other two, and that it is able to explain most of the evidence that gave rise to the other two.

7.1.5. Dopamine and learning

In contrast to Berridge, Carrión and Pöppel (2007) follow the “learning” hypothesis for the contribution of dopamine in reward processing. The authors define learning as “a change in responsiveness to a particular stimulus” and state that the brain estimates and keeps in memory the value of potential actions based on the amount of the reward each action has yielded before. The animal uses this value to predict the likely reward or punishment for each action and choose the most beneficial one. The actual reward gained from an action is then compared to the prediction, and the difference constitutes a “reward-prediction error”. As the supporters of the “learning” group of hypotheses hold, dopamine is linked to the brain’s encoding of reward-prediction errors, which would mean that dopamine plays a role in shaping future behavior – essentially the same outcome as the one claimed by the “wanting” hypothesis, but arrived at through a different mechanism. Moreover, Carrión and Pöppel (2007) cite evidence that when the reward is greater than expected, the firing of certain dopamine neurons increases, leading to an increased motivation towards the reward – or increased “wanting”, to put it in Berridge’s (2007) terms. Thus, although the supporters of the “wanting” and “learning” theories disagree on the exact mechanisms through which dopamine shapes future behavior, they do have points in common. Therefore, the current work draws on research from both lines of thought.

7.1.6. Dopamine and risk-taking

The function of dopamine also points to a link between anticipated reward and risk-taking. Trepel et al. (2005) identify it as a primary substrate for the representation of decision utility. An fMRI study by Goetz and James (2008) found that brain activity related to expected reward occurs immediately, while risk activation is delayed. Higher levels of dopamine, in turn, lead to reward-related brain activity that occurs before the risk-related one. This would
mean that the anticipation of a large reward (the larger the reward, the stronger the activation) may lead to higher levels of dopamine, which in turn may lead portfolio managers/investors to concentrate on the reward, not on the risk. Carrión and Pöppel (2007) link dopamine to experienced rewards and learning as well, stating that when people win a bet, they seem to experience a dopamine “high”, which helps them remember to choose the same course of action next time they are presented with similar situation. If a monetary award is then added to the reward of simply winning and additional dopamine is administered to participants, they seem to notice only the winning symbols, and not the losing ones. In a financial industry setting, an additional bonus added to the simple reward of a “winning” investment can serve as a similar unexpected reward leading to a dopamine surge under which losing cues are not noticed. This concentration on gain cues relates to the work Kuhnen and Knutson’s (2005) discussed in Section 7.1.2, which demonstrates that overstimulation of the brain’s reward approach system may lead to risk-taking errors.

7.1.7. Processing of losses in the brain

There is less consensus among researchers on the topic of loss avoidance in the brain. The amygdala is among the most commonly implicated structures because of the vast body of literature that links it to the processing of fear and threat (Khan et al., 2002). The work of Kahn et al. (2002) has linked the amygdala specifically to the processing of monetary loss. Similarly to the reward approach structure, the amygdala can be activated by the prospect of a negative outcome (Kahn et al., 2002; Trepel et al., 2005), which makes the role of the amygdala relevant to the investment decision-making process. Neuroimaging studies have shown that the amygdala is active during the anticipation of losses (Trepel et. al, 2005). However, researchers still disagree on the amygdala’s exact function in loss aversion.

It is important to note that the evaluation of a potential negative outcome and the response to its occurrence are not processed exclusively in the amygdala – other brain structures implicated in these processes are the prefrontal cortex, anterior singulate, parietal cortex, hippocampus, and ventral striatum (Kahn et al., 2002).

7.1.8. The role of serotonin in loss processing

Negative outcomes of decision-making are encoded mainly by serotonin, “the most mysterious of the main vertebrate neuromodulators” (Daw et al., 2002). Compared to dopamine, serotonin is much more widespread in the brain and plays a role in a variety of
phenomena, including impulsivity, attention, mood, and aggression. Research data on serotonin’s role in these and other phenomena is contradictory, making it difficult for researchers to arrive at a relatively uniform understanding of how it works, similar to the one regarding dopamine. One important aspect of serotonin is its apparent opponent reaction to dopamine (Daw et al., 2002), which is in line with the theory that the brain uses two different and opposing systems to code for appetitive and aversive events. Thus, by understanding the role of dopamine, researchers can constrain aspects of the role of serotonin, implicating it in mediating avoidance behavior elicited by aversive incentive stimuli. A good deal of evidence points to the fact dopamine is involved in activating behaviors that serotonin inhibits and vice versa. It has also been suggested that executing approach or withdrawal (i.e., whether approach or avoidance behavior occurs in response to a stimulus) depends on the balance between dopamine and serotonin release in the ventral striatum (Daw et al., 2002). Linking this to the role of monetary rewards, if a monetary reward leads to a large enough dopamine release in the brain to change this balance, then in theory, it should have the power to change the behavior from avoidance to approach. It should be noted, however, that there seems to be much less evidence of the inhibitory action of the dopamine system on the serotonin one than vice versa (Daw et al., 2002).

7.1.9. The amygdala and loss processing

The amygdala is a very primitive part of the brain associated with the response to stimuli caused by dangerous, potentially life-threatening situations; its reactions are very quick and very strong, “generating action well before the slower, cognitive regions of the brain, can engage [in the assessment of the stimuli]” (Goetz and James, 2008). According to Levine and Pizarro (2006), fear is evoked when “goal failure is threatened, but has not yet occurred”. Since financial loss threatens the goal of increasing one’s wealth, it is a fear-inducing stimulus that would produce a response by the amygdala. A person thinking about a non-experienced, hypothetical loss may consider himself to have a high risk tolerance. However, this cognitive evaluation does not include the regions of the brain that would be activated if a loss actually occurs or if it is anticipated. When a loss is occurred or anticipated, it elicits a response in the amygdala that is difficult to unlearn; therefore, once a loss occurs, it may make individuals much more risk-averse than they self-report to be. It would then take a series of positive experiences (gains) to override the amygdala’s response to financial risk stimuli. This means that in a prolonged bull market, generational replacement can lead to a
situation where the majority of managers have not experienced a significant loss (although they know that it is possible in theory) and are thus deprived of the amygdala’s mechanism of lowering risk tolerance. The result is a generation of high-risk prone managers and investors.

The implication of the amygdala in the coding for loss has been challenged by Tom et al. (2007) who conducted an fMRI study and saw no increased activity in the amygdala as the size of the loss increased. The study, however, involved decision-making situations where the outcome was not immediately known – i.e., the participants knew there could be a loss, but were not told if they chose the loss option after they made a decision. Based on this, Tom et al. (2007) suggest that the activation in the amygdala seen in other fMRI studies where the outcome is immediately known may be a reaction to a negative prediction error, not to a negative value. They conclude that although the amygdala may be implicated in some instances of loss processing, it does not appear to be a necessary component of risk aversion.

### 7.2. Processing of rewards and losses by one system

So far we have discussed the processing of gains and losses in separate parts of the brain. However, Tom et al. (2007) suggest that gains and losses are processed in the same areas of the brain. Their fMRI study demonstrates that areas of the brain that code for gains show decreased activity with an increasing size of a loss, suggesting joint sensitivity to both gains and losses in a set of regions in the brain. Tom et al.’s (2007) study also demonstrates that as size of the loss increased, brain activity in the joint regions decreased at a faster rate than it increased with an increase in the size of the gain. This difference in the rate of change in brain activity for gains and losses provides a neuroscientific explanation for the findings of prospect theory – on a behavioral level, the potential gain needs to be at least about twice the size of the potential loss for people to agree to take the gamble.

#### 7.2.1. The amygdala and prospect theory

Litt et al. (2008) provide a different explanation to prospect theory than the one offered by Trepel et al. (2005). It assigns a key role to the amygdala. Unlike Tom et al., Litt et al. (2008) support the view that positive and negative events are encoded in separate, albeit interacting, brain areas. However, similarly to Tom et al., Litt et al (2008) suggest that there is one main brain structure that processes both positive and negative events, but receives inputs from
different parts of the brain depending on the valence of the stimuli. This brain structure is the amygdala. Litt et al. (2008) cite research that challenges the amygdala’s traditional association with aversive stimuli, and suggests that it is activated based not on valence, but rather on the degree to which stimuli are salient or arousing. The amygdala receives inputs from midbrain dopamine in relation to positive prediction error, and from serotonergic neurons in the dorsal raphe nucleus in relation to negative prediction error. The asymmetric response to loss could be a result of the amygdala’s different sensitivity to inputs from midbrain and dorsal raphe, which would explain prospect theory’s display of loss aversion. Such an asymmetric response could be a result of the negative stimuli’s higher saliency compared to positive stimuli – negative stimuli signal behavior that needs to be changed based on negative feedback, while positive stimuli indicate behavior that needs to be maintained or reinforced. From an evolutionary standpoint, changing behavior to avoid danger is more urgent than reinforcing behavior to obtain reward. Another possible explanation is that negative stimuli produce a stronger emotional response, because they need to induce a change to an existing behavior, which is harder than reinforcing an existing behavior.

Although the role of the amygdala is important to the processing of losses in the brain and to loss aversion in general, recent research by Gelskov et al. (2010) has found a linear increase in activity in the posterior and anterior left insula in response to increasing potential gains, and a decreasing activation in the bilateral anterior insula, as well as in the ventral striatum in response to increasing potential losses. The results implicate the anterior insula in the evaluation of the magnitude of potential losses, leading the researchers to suggest that the amygdala may play a different role in the decision-making process.

8. Neuroeconomics perspective – intertemporal choice

Intertemporal choice is defined as “the trade-off among outcomes occurring at different points in time” (Xu et al., 2009). Most individuals are willing to sacrifice value to obtain a reward sooner, and that is valid for both primary rewards, such as food, and secondary rewards, such as money (Carter et al.2010), which makes intertemporal choice a valid issue in decision-making for investment. The time an individual has to wait for a potentially beneficial outcome is regarded as a cost and thus discounted against the benefits of the outcome (Wittmann and Paulus, 2009). In an investment setting, this means that the time an
The investor has to wait to receive the expected higher profit is regarded as a cost and is weighted against the profitability of the investment. Put in economic terms, the expected utility of the choice whether to invest in a particular security or not is viewed as a function of the magnitude of the profit, the probability that it will be received, and the magnitude of the delay before the profit is received. Since human decision-making, especially in economic terms, can involve the anticipation of outcomes that lie years in the future, the human brain constantly generates predictions about the future (Wittmann and Paulus, 2009). Therefore, the way the brain perceives time and discounts delayed monetary rewards is an important factor to consider when talking about the structure and timing of incentive pay.

8.1. Neural mechanism of intertemporal choice

In the existing literature, there are two perspectives on the neural mechanism of intertemporal choice. One considers delay as one of the many aspects that play a role when individuals evaluate different options, with the value representation having no special qualities because of the delay i.e., the brain process a delayed option the same way as an immediate one, but takes the delay into consideration and discounts accordingly to arrive at a choice. The other perspective suggests that intertemporal choice is the result, at least in part, of a different valuation system in the brain – i.e., the brain processes a delayed option differently than it processes an immediate one. The current evidence from neuroimaging studies supports a blend of the two perspectives, where the initial aspects of intertemporal choice are processed differently from other forms of choice, but later the value signal is represented together with the values of other choices in a common rewards system, i.e., the brain assigns values to delayed and immediate options using different mechanisms, but then combines these values in a common reward system in order to compare them (Carter et al., 2010).

8.2. Dimensions of intertemporal choice

8.2.1. Anticipation

Intertemporal choice consists of several dimensions – time discounting, anticipation, self-control, and representation (Berns et al., 2007). Anticipation refers to an individual’s tendency to experience pain or pleasure while imagining a future event. Anticipation is left out of economic models of intertemporal choice, because in economics, purely mental events cannot be a source of utility. However, research has shown that anticipation of an outcome
can lead to physiological arousal, and, more importantly, that it can confirm utility or disutility in itself, thus entering the decision-making process. fMRI data has demonstrated that anticipation of aversive stimuli and anticipation of positive stimuli activate different parts of the brain, with anticipatory activity in the ventral striatum and the orbitofrontal cortex registered in relation to the prospect of receiving a financial windfall (Berns et al., 2007). Similarly, fMRI data shows that activity in brain areas associated with pain increases with the anticipation of delayed painful stimuli, and the extent of this anticipatory activity correlates with the extent to which an individual chooses to expedite the aversive event. Such behavior is in direct contradiction to economic models of decision-making, which predict that an individual will postpone aversive events as long as possible because of their disutility (Berns et al., 2007). In a financial-industry setting, the pure anticipation of a large monetary reward (bonus) at the end of the year can affect the decision whether to make a risky investment or not.

8.2.2. Self-control

The second dimension of intertemporal choice – self control – is the tension an individual experiences when she attempts to select a long-term outcome over a gratifying short-term one. Any decision to wait for a long-term outcome consists of two components – first, making the initial choice to wait for a long-term outcome, and then sticking to that choice as time goes by and different short-term temptations arise. Economic models in general overlook the second component, assuming that once a decision is made, the individual will stick to it. However, most people experience preference reversal, which has been incorporated in models of intertemporal choice that draw not only on economics, but also on psychology and neuroscience. In a financial industry setting, an individual who has initially decided to stick to long-term, lower-risk investments may experience preference reversal if offered a monetary incentive for investing in short-term, riskier assets.

8.2.3. Representation (framing)

Representation, or the way the brain interprets (frames) a set of choices, is the least studied dimension of intertemporal choice, although chronologically, it appears first in the time line of decision-making and can affect all subsequent steps (Berns et al., 2007). Economic models of intertemporal choice assume that the way an option is represented is an objective matter. In
In fact, the same situation can be mentally represented in many different ways. People use different heuristics to make a decision, and which heuristics exactly come into play depends on how the individual sees the situation. Heuristics are “simple rules of choice that dictate what to do in certain situations” which are used by the brain to simplify the complex process of decision-making (Berns et al., 2007). Thus, the way options are represented affects the way people interpret the situation, and consequently has an impact on the intertemporal trade-offs people make. In relation to monetary awards specifically, research has shown that showing individuals reproductively salient stimuli changes the way they evaluate time-dated monetary rewards, potentially through either creating a sense of urgency, or through generating affective arousal, which increases the relative strengths of the affect-based immediate-rewards system. In the financial industry, representing a high-risk investment in terms of the percentage bonus it will bring to the individual can lead to a different decision than representing a high-risk investment in terms of the loss to the company the individual may be held accountable for.

8.2.4. Delay discounting

Delay discounting, the most well-studied dimension of intertemporal choice, is a complex decision, and it activates brain areas associated with a wide range of processes, including two distinct networks – the network associated with value (ventral striatum, medial prefrontal cortex, orbitofrontal cortex) or subjective value (posterior cingulate cortex, or PCC) and a core network associated with prospective processes like planning for the future (inferior prefrontal cortex, medial prefrontal cortex, temporal-parietal cortex) (Carter et al., 2010). On Fig.21, value network activation is shown in red, and core network activation is shown in blue. However, similarly to the processing of gain and loss options, discounting for positive vs. negative outcomes is processed asymmetrically in the brain, thus providing a neural basis for the steeper discounting of future gains compared to future losses (Xu et al., 2009).
8.3. Discounting future gains

Neuroimaging studies have demonstrated that the brain recruits several systems when choosing between immediate and delayed rewards. While significant activation is observed in the dorsolateral prefrontal cortex (DLPFC), lateral orbitofrontal cortex (LOFC), posterior parietal cortex (PPC), as well as in motor and visual regions for all rewards regardless of delay, when comparing options that include an immediate reward to options of delayed rewards only, certain brain regions are more activated than others – the medial orbitofrontal cortex (MOFC), medial prefrontal cortex (MPFC), posterior cingulate cortex (PCC), and ventral striatum (Xu et al., 2009). This distinction is shown on Fig.22.

Since the urge for immediate gratification (reward) is impulsive, an individual has to employ goal-directed behavior in order to suppress the impulse and achieve positive outcomes that are delayed in the future (Wittmann and Paulus, 2009). However, this becomes increasingly difficult as the anticipated time to receiving the reward increases, because the subjective value of the positive reinforcer is discounted as a function of the delay. Therefore, intertemporal choice is not only a matter of now vs. later, it is also a matter of now vs. how much later.
8.3.1. Duration of delay

The striatum has been implicated precisely in the processing of the duration of delay— not only is it activated in response to delayed rewards, but it is also activated differently based on the duration of the delay. Preferences for rewards that come sooner become even stronger when the rewards can be received within a timeframe that the subject perceives as short – time discounting, therefore, does not involve an objective, measurable, universally applicable discount factor, but is rather a result of perception (Wittmann and Paulus, 2009). Objective duration is perceived logarithmically, not linearly - the discounting function is steeper at shorter time intervals, and becomes flatter as reward delay increases – i.e., the rate of discounting is higher for rewards available not immediately, but still in the short run (Wittmann and Paulus, 2009). Consequently, the underlying neural processes accounting for the perception of time become an important factor in understanding delayed rewards discounting. Still, research into these mechanisms is relatively limited (Wittmann and Paulus, 2009).

Wittmann (1999) suggests that reward options with delays ranging from seconds to minutes to years to decades are likely to be processed by different neural mechanisms. Wittmann and Paulus (2009) have conducted neuroimaging research on the discounting of monetary rewards that shows that rewards with delay beyond a year are processed differently than rewards with delay up to a year (Fig.23). The research has also shown that the striatum can influence whether an individual chooses a delayed reward that will be received within one year versus one that will be received after one year. What is special about the year is that this time unit is a basis for both psychological and physiological rhythms in both humans and other mammals. Evolutionary speaking, human behavior has been ordered in an annual cycle, initially because it had to match animal cycles and seasonal change in order for hunting and farming to be successful. Even in the present developed world, “social, political, and economic planning is packed into one-year time frames” (Wittmann and Paulus, 2009).

In addition, a meta-analysis of past studies on temporal discounting of monetary rewards shows that a plateau of low discount rates is reached after one year, and remains virtually unchanged for the period between one and ten years, suggesting that “subjects perceive the one-year unit as a discrete entity” (Wittmann and Paulus, 2009). Rewards to be received
shortly past the discrete entity of one year may seem much further way than rewards to be received shortly prior to the end of the discrete entity of one year.

This finding is especially relevant to the financial industry, because performance bonuses related to investment decisions are set in an annual framework – i.e., the reward for a risky investment usually comes at the end of the year the investment was made, which means that the maximum delay period is one year, and becomes progressively shorter as time passes. Thus, bonuses will be time-discounted via a different neural mechanism than other forms of compensation given with a delay of more than a year, potentially leading to a different decision. The decision whether to invest in a risky asset or not is therefore influenced not only by the relatively short delay of the reward for it, but also by the specific timeframe. A temporally proximate reward (within the timeframe of a year) is more likely to be chosen than a temporally more distant reward (outside the timeframe of a year) (Wittmann and Paulus, 2009).

8.4. Discounting future losses

Most intertemporal choice studies have focused on the time discounting of gains (Xu et al., 2009). While similar discounting functions can be used to describe discounting of both gains and losses, behavioral research shows that people discount gains more steeply than losses, suggesting different underlying neural mechanisms. Xu et al. (2009) conducted one of the few fMRI studies focused on time discounting of losses and found that similarly to immediate and delayed monetary gains, immediate and delayed monetary losses activate different regions of the brain. Brain areas that show activation during delay discounting for rewards – DLPFC, LOFC, PPC, and motor and visual regions – also show activation for delay discounting for losses. In addition, decision-related activation in responses to losses is observed in other brain regions, including the bilateral thalamus and dorsal striatum. When comparing the activation by options containing an immediate loss and options containing delayed losses only, the anterior cingulate cortex (ACC), insula, superior frontal gyrus (SFG), MPFC, and PCC show a significantly greater activation. This distinction is shown on Fig.24.
The insula is associated with the processing of negative emotions and is particularly involved in evaluating and representing negative emotional states – two functions that align well with its implication in the discounting of delayed losses, because excessive sensitivity to losses is motivated by negative emotions. Activation of the thalamus during loss-associated time discounting is also in line with its well-known associations with both primary as well as secondary aversive reinforces, among which losing money. Activation of these brain areas shows that emotions, and in particular negative emotions people experience while waiting for an aversive event (anticipation), play a role in intertemporal choice, with delayed losses having a greater emotional impact than delayed gains. The greater activation in the VMPFC during coding for delayed losses compared to coding for delayed gains suggests that the subjective value of a delayed loss is greater compared to the subjective value of an equivalent delayed gain. In other words, the findings of prospect theory – that people are more sensitive to a loss than to a gain of the same amount – remain valid even when time discounting comes into play.

The activation of the striatum during delay discounting for losses is somewhat surprising, given the striatum’s close association with rewards and reward stimuli discussed earlier. There is growing evidence that the striatum has a broader role than reward processing – processing of salient stimuli in general. Its involvement in delayed losses may indicate that people perceive intertemporal losses as much stronger than intertemporal gains, thus making intertemporal losses more salient stimuli. Finally, when comparing time discounting of future
gains to time discounting of future losses, the DLPFC, PPC, ventromedial prefrontal cortex, insula, thalamus, and striatum show greater activation during processing of future losses relative to future gains. This distinction is shown on Fig.25.

![Brain areas showing greater activation in response to future losses than in response to future gains](image)

Source: Xu et al., 2009

Fig.25. Brain areas showing greater activation in response to future losses than in response to future gains

**8.5. Models of time discounting**

While scientists tend to agree on the brain systems involved in time discounting, there have been various views on how exactly those systems discount future rewards. For a long time, the prevalent view was that of neo-classical economics and its discounted utility function, which assumes that people discount future outcomes exponentially, based on how far away in the future they are, similarly to financial markets evaluating gains and losses (Berns et. al, 2007). The appeal of this model lies in its simplicity and universality – it can be easily applied to any situation, because it views intertemporal choices as regular choices that need to be re-weighted because of their delayed consequences. The value of a reward diminishes by an equal amount for each unit of time that the reward is delayed, i.e. a re-weighted reward with a magnitude $x$ occurring at time $t$ in the future is worth $\alpha t$, where the fixed constant $\alpha \leq 1$ is the discount factor. A graph of the discounted utility function is shown on Fig.26.

However, empirical evidence from psychology challenges the discounted utility function, and especially its assumption that people discount the future exponentially. While experiments with animals have shown that “the effectiveness of a reinforcer diminishes the further it is delayed in time”, the bulk of evidence points to the fact that animals discount non-exponentially. The most commonly observed discounting behavior is hyperbolic, meaning that most rewards are discounted using a factor of $1/t$ that is inversely proportional to the delay. A graph of the hyperbolic utility function is shown on Fig.26. This means that the discounter is more impatient when making short-term trade-offs than when making long-run tradeoffs – a choice between now and three weeks from now is different than a choice
between 5 years from now and 10 years from now. Humans have also shown a hyperboloid discount function, although it is unclear whether the similarity between humans and animals is a matter of homology or analogy (Berns et al., 2007). Most people are able to consider costs and benefits that extend for years in the future, while most animals discount a reward to nearly zero if it extends beyond a minute. Humans, like other animals, are capable of rapid time discounting, but unlike other animals, are also capable of taking into account long time horizons when making decisions. This ability is believed to be due to the unusually large prefrontal cortex of humans compared to other species. As a result of this apparent contradiction in time discounting, a new perspective has emerged, suggesting that intertemporal choice in humans is a result of two systems working in parallel – one that is strongly future-oriented and one that is strongly present-oriented (Berns et al., 2007).

Neuroscience’s contribution to the understanding of intertemporal choice is precisely in the field of this dual-system perspective. Neuroimaging studies have shown that prefrontal areas are involved in choices between immediate and delayed rewards, as well as in choices between delayed and even more delayed rewards. However, only in choices between immediate and delayed rewards are the mesolimbic dopamine system and associated areas activated. In addition, the relative activation of either the prefrontal cortex (long-term orientation) or the mesolimbic dopamine system (short-term orientation) is a significant predictor of choice, suggesting that one system does take precedence over the other. Such studies, however, demonstrate correlation, but do not prove causation (Berns et al., 2007).
9. Conclusion

The aim of this study was to find out whether incentive pay in nondepository lender institutions and broker and dealer institutions in the American financial industry is related to increased risk-taking. We approached the question by breaking it down into two sub-questions related to two distinct characteristics of incentive pay in the American financial industry – its amount and structure, and its short-term evaluation horizon.

9.1. Behavioral economics perspective on amount and structure of incentive pay

Looking at the amount and structure of incentive pay from a behavioral perspective, there are various behavioral phenomena related to risk-taking that may be influenced by incentive pay. First of all, the very presence of incentive pay, regardless of amount and structure, may lead managers to frame their investment decisions as personal gains and fail to consider the potential loss to the company, especially since incentive pay is not taken back if the short-term performance on which it is based turns out to have brought excessive risk to the portfolio, putting its long-term stability at risk. Mental accounting and editing rules also contribute to the separation of the personal gain from the company loss. The house money effect comes into play, too – managers invest money that is not theirs, and they have an incentive to get the highest pay-off on it in the shortest time – hence the appeal of high-risk, high-return assets.

The peer comparisons inherent in the structure of incentive pay also contribute to excessive risk-taking. Peer comparisons encourage herding, which, although a risk-averse behavior in principle, paradoxically contributes to risk-taking when the group as a whole is risk-seeking – in this case, not taking risks would be deviating from the herd. On top of the non-monetary incentive to stay with the herd (safety), managers have a monetary one as well – they only need to marginally outperform their peers, which they can do by doing the same thing, only slightly better. Even though managers as individuals may realize they are taking on excessive risk, it pays off to stay with the crowd. Herding at institutional level translates into herding at market level, resulting in more uniform decisions which amplify the credit cycle.

In addition, the effect of peer-performance-based incentive pay in bull markets is amplified, because in bull markets compensation incentives are stronger than unemployment incentives, inducing managers whose funds are performing poorly to take on more risk in an attempt to
outperform their peers and thus maximize compensation. Adding to this effect is the convex-shaped performance-based compensation structure, where the difference between compensation at high and moderate levels of performance is significantly bigger than the difference between moderate and low levels of performance, essentially making investment an asymmetric bet.

Another issue with the structure of incentive pay is that it is based entirely on outcome, completely ignoring the decision process. However, actions and outcomes can be unrelated. Such a structure sends the signal that the decision-making process does not need to be logical, as long as the result is positive, thus encouraging risk-taking and even pure gambling behavior, especially since a win translates into a bonus, and a loss translates into no accountability.

The high amount of incentive pay can indirectly and negatively influence performance by increasing motivation to a sub-optimal level – an effect known as choking under pressure. This phenomenon has not been given much attention by economists, but the few studies that have been performed demonstrate that high levels of pay have a negative effect on performance of complex cognitive tasks.

9.2. Neuroeconomics perspective on amount and structure of incentive pay

On a neuroscientific level, incentive pay changes the attractiveness of the options to invest or not, thus influencing the decision-variables, and consequently the decision-making process. Since the representation of rewards in the brain is different than the representation of cognitive rules, introducing an incentive into the decision-making process changes the way the decision is processed. The brain treats the prospect of a reward (an expected bonus) similarly to an actual reward (a received bonus) – the two are processed in similar, albeit not 100% identical, parts of the brain. In addition, neuroimaging studies have shown that the size of the reward affects both brain activation and response time – brain activation increases, and decision time decreases. Relating this to incentive pay, both the presence of a bonus, as well as its size, may affect decision-making on a neurological level.

Since the thought of a prospective outcome activates the affective system of the brain, the thought of a large monetary reward (a percentage bonus of a high return) may lead to a
positive emotional response, which in turn affects the decision whether to take the risk or not. Another possibility is for the positive feeling of arousal to promote risk-taking. It is important to note that there is evidence that the temporal proximity between choice and outcome increases emotional responses - thus the prospect of a large reward in the short-term generates an even stronger positive response than the prospect of a large reward in the long-term.

A large body of research supports the idea that gains and losses are processed in different parts of the brain, with dopamine, a hormone associated with pleasure, implicated in the processing of gains. Anticipated gains and anticipated losses activate different parts of the brain, leading to different financial decisions, and that excessive activation of either part may lead to investing mistakes. A large monetary reward may induce excessive gain anticipation, thus leading to excessive activation of the reward-approach structure of the brain and a subsequent risk-taking error. There is also evidence that activation of the one structure or the other is enough to induce a change in risk preferences. Therefore, only giving gain cues (size of a bonus) and/or obscuring loss cues (the likelihood of default on a mortgage bond) can turn risk-avoiders into risk-takers. Related to the size of reward is also the behavioral phenomenon of choking under pressure, which, on a neurological level is marked by the strong correlation of activity in the ventral mid-brain and performance decrements caused by high, relative to low, rewards.

Related to the role of dopamine in reward processing is the notion of the effect of incentive salience on risk-taking. Dopamine mediates the dynamic attribution of incentive salience to reward-related stimuli, tagging a specific behavior as the rewarded response which the individual is motivated to perform. In a financial industry setting, dopamine can tag risk-taking as the specific behavior (rewarded by a bonus) the individual is motivated to perform, because in the past this behavior has lead to a financial reward in the form of incentive pay. The link between dopamine, experienced rewards, and learning suggests that if an additional bonus is added to the simple reward of a “winning” investment, it can serve as an unexpected reward leading to a dopamine surge under which losing cues are not noticed. Research has also shown that brain activity related to expected reward occurs immediately, while risk activation is delayed. Higher levels of dopamine, in turn, lead to reward-related brain activity that occurs before the risk-related one. This would mean that the anticipation of a large reward (the larger the reward, the stronger the activation) may lead to higher levels of
dopamine, which in turn may lead portfolio managers/investors to concentrate on the reward, not on the risk.

Studies on the interaction between dopamine and serotonin, a hormone implicated in mediating avoidance behavior elicited by aversive incentive stimuli (a potential investment loss), have shown that dopamine is involved in activating behaviors that serotonin inhibits and vice versa. If a monetary reward leads to a large enough dopamine release in the brain to change this balance, then in theory, it should have the power to change the behavior from avoidance to approach. However, that is much less evidence of the inhibitory action of the dopamine system on the serotonin one than vice versa.

There is evidence that winning money, as well as other abstract rewards, leads activation in the same brain regions that respond to primary reinforces such as food – i.e, at a neurological level, response to monetary incentives may have a primitive, involuntary component.

An influential line of research suggests that rewards and losses are processed in the same parts of the brain, but the extent to which it gets activated by gains and losses is different - as size of a loss increases, brain activity in the joint regions decreases at a faster rate than it increases with an increase in the size of a gain. This difference in the rate of change in brain activity for gains and losses provides a neuroscientific explanation for the findings of prospect theory – on a behavioral level, the potential gain needs to be at least about twice the size of the potential loss for people to agree to take the gamble.

The evidence from both behavioral economics and neuroeconomics speaks to the fact that the amount and structure of incentive pay in American nondepository lender institutions and broker and dealer institutions is related to increased risk-taking.

9.3. Behavioral economics perspective on short-term evaluation horizon of incentive pay

The short-term evaluation horizon on which incentive pay is based is problematic not only with regard to the difficulties with evaluating the investment, but also with regard to the way it influences managers’ investment decisions. The choice between a reward (incentive pay) that falls within a timeframe that is perceived as short and a reward (incentive pay) that falls
beyond this time frame is not the same as the choice between two rewards that both fall beyond this timeframe – in the first case, people tend to be more impatient, finding it more difficult to utilize self-control to wait for the reward that falls beyond the timeframe, even if it is larger. The year as a unit of time is perceived as a short timeframe – thus the choice between a reward to be received at the end of one year (bonus based on annual return on investments) and a reward to be received later than one year (a potentially higher bonus based on aggregate return on safer investments) is influenced by impatience, making it more likely for managers to choose the former, even if it is smaller. In contrast, a choice between a reward to be received later than one year (bonus based on the aggregate of several years of return on investment, for example) and a potentially higher reward to be received later than one year (a potentially higher bonus based on the aggregate return on safer investments) will not be influenced by impatience, making it more likely for managers to select the latter, because it is larger. In addition, people have shown preference for improving sequences – they prefer an increasing salary to a flat one even when the aggregate amount of the increasing one is smaller. With incentive pay, people will prefer to see increasing amounts – thus they will aim to increase the pay-offs on their investment within the evaluation timeframe, usually a year. High risk pays off well in the short-run.

Being rewarded for short-term investment success with no regard to the long-run performance of investments can amplify the self-attribution effect and the hindsight effect – managers are rewarded for their success, while failure is the company’s failure, not theirs, and when faced with a risky investment choice, they may selectively recall the last time they took a similar action and were successful in it, as confirmed by the reward they received. Lead by optimism, managers can also overestimate the gains (their short-term performance-based pay) and underestimate the costs (a major loss to the company in the long-run). In addition, if incentive pay for short-term performance entails no negative consequences for excessive risk-taking, it can give managers the illusion that they have successfully escaped risk, if not on professional, at least on a personal level – their reward cannot be taken back no matter what happens in the long-run.

Two behavioral phenomena that speak in favor of large amounts of incentive pay are the magnitude effect and myopic loss aversion. The magnitude effect means that people discount smaller amounts at a higher rate than they discount larger amounts – i.e., managers are more inclined to wait until the end of the year to receive their incentive pay if the amount is large.
Myopic loss aversion suggests that people’s willingness to accept risk increases as the frequency of evaluations decreases – in this sense, having an annual evaluation compared to a less frequent one, would lead to increased risk aversion.

### 9.4 Neuroeconomics perspective on short-term evaluation horizon of incentive pay

Current evidence from neuroimaging studies shows that the brain assigns values to delayed and immediate options using different mechanisms, but then combines these values in a common reward system in order to compare them. Delay discounting, the most well-studied dimension of intertemporal choice, is a complex decision, and it activates brain areas associated with a wide range of processes, including two distinct networks – the network associated with value or subjective value, and a core network associated with prospective processes like planning for the future. Similarly to the processing of gain and loss options, discounting for positive vs. negative outcomes is processed asymmetrically in the brain, thus providing a neural basis for the steeper discounting of future gains compared to future losses. On a neurological level, intertemporal choice is not only a matter of now vs. later, it is also a matter of now vs. how much later. Research shows that the striatum – a brain structure key to time discounting, is activated differently based on the duration of the delay. The striatum can also influence whether an individual chooses a delayed reward that will be received within one year versus one that will be received after one year. In addition, a meta-analysis of past studies on temporal discounting of monetary rewards shows that a plateau of low discount rates is reached after one year, further confirming the unique perception of the year as a time unit. This suggests that annual bonuses are time-discounted via a different neural mechanism than other forms of compensation given with a delay of more than a year, potentially leading to a different decision. The decision whether to invest in a risky asset or not is therefore influenced not only by the relatively short delay of the reward for it, but also by the specific timeframe.

The evidence from both behavioral economics and neuroeconomics speaks to the fact that the short-term evaluation horizon of incentive pay in American nondepository lender institutions and broker and dealer institutions is related to increased risk-taking. Combining the answers to the two research sub-questions, we arrive at the conclusion that incentive pay in American
nondepository lender institutions and broker and dealer institutions is related to increased risk-taking.

9.5. Limitations

The current study has several important limitations. First, most of the experimental studies included in the secondary research did not involve financial industry professionals. Given the different levels of expertise, experience, and education between the subjects of the experiments and financial industry professionals, the findings of the experiments may not be fully applicable to the latter. However, we had to rely on the available experimental studies, because after an extensive search through various academic databases such as Business Source Complete, ScienceDirect, PsychInfo, as well as through the academic search engine Scirius, no experimental research on the effect of incentives on risk-taking involving financial industry professionals was found.

The majority of behavioral studies we base our conclusions on were conducted by Western researchers on Western subjects, and published in English. If we are to follow an interpretivist line of reasoning, which claims research is never value-free, then our study is based on a decidedly Western perspective. To the extent to which Western cultures are more risk tolerant than Eastern ones, our conclusions may have been affected by the exclusion of an Eastern perspective. It should be noted, however, that neuroscientific research is much less susceptible to cultural influences because it is concerned with biological processes common to all people.

Another limitation is posed by the trade-off between breadth and depth. We decided to focus on one aspect of risk-taking to be able to explore the issue in detail at the expense of providing a broader account of the factors involved in decision-making under uncertainty. Relaxing some of the delimitations we set in the beginning may provide direction for future studies. For example, the combined effect of gender and incentive pay on risk-taking is a very relevant topic, given the male-dominated financial industry.
10. References:


*Heads I win, tails you lose.* The Economist. Oct 20, 2009


