# Principal Agent Problems in the Financial Crisis of 2007-2009

**BMI Master Thesis**

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**Preface**

This paper is one of the last compulsory elements of the program Business Mathematics and Informatics at the VU University Amsterdam. The objective of this subject is to demonstrate the student's ability to describe a problem in a clear manner for the benefit of an expert manager. This is accomplished by doing a literature research and to apply this research to a practical situation.
I have always had a strong interest in strategic thinking. One of the ways that this is modeled in the scientific theory is through game theory. From the broad range of subjects that are available in game theory I decided to focus on information asymmetry and, more specifically, on the principal-agent relationship as this theory is very widely applicable and has a strong explanatory power. In this way I was able to combine my interest in strategic thinking and the financial sector and able to give a clear explanation for the events that happened within the financial crisis of 2007 - 2009.
Finally, I would like to thank my supervisor Rob van der Mei for his comments and suggestions.

Amsterdam,
November 2009,
Jasper Holke Klein

**Summary**
This paper analyses the origin of the financial crisis from a game theoretic perspective. We use the principal-agent theory as a basis for our analysis. Principal-agent theory is broadly applicable in situations where multiple parties strive to maximize their utility and which have asymmetric information.
The financial crisis started after the bust of the US housing bubble, which originated as a result of irresponsible profit maximization by parties in the mortgage lending chain. Those parties couldn't be held accountable for their actions as they were able hide information from their counterparties and government. After the bust of the housing bubble, the losses of the sub-prime mortgages greatly affected the financial system. No one could determine the financial stability of their counterparties anymore, which let to a complete stop on credit lending between the financial institutions. Many institutions had a high leverage and a high funding with short term debt, which got them into liquidity troubles and even bankruptcies.

We found the following principal-agent relationships present in the financial crisis:
1. Mortgage borrower and lender (two-sided problem)
2. Mortgage lender and investment bank
3. Investment bank managers and stockholders
4. Investment bank and government
5. Investment bank, rating agencies and investors
6. Investment bank and financial institutions
7. Financial institutions and creditors
8. Financial institutions and customers / investors

**Recommendations**
Most of the principal-agent problems in the financial crisis require government regulations to be solved. The solutions aim at protecting the financial illiterate, making all parties accountable for their actions and providing transparency in the financial markets.

The following actions should be taken by the US government to solve the principal-agent problems:
- Standardize mortgage contracts and borrower information and add a suitability requirement on mortgages to protect the financial illiterate mortgage borrowers.
- Remove non-recourse mortgages, which will make borrowers accountable for the quality of their houses, removes default opportunities and forces them to pay more attention to the financial aspect of the mortgage.
- Require mortgage lenders to hold on to a part of each mortgage, which makes it unprofitable for them to provide irresponsible mortgages.
- Regulate the leverage ratio and economic capital of investment banks. This makes the investment banks less vulnerable to asset losses and credit crunches.
- Push for more standardization of the derivatives market, which makes it easier to regulate, comprehend and asses the risk of derivatives.
- Require securitizers to hold on to a fraction of each security, to make them accountable for the real risk of the securities.
- Set up a gateway between rating agencies and their customers, which protects their independency and which aligns their incentives with those of the investors.

The following actions should be taken by financial institutions:

- Put more focus on and power to risk management, to prevent a focus on risky short term strategies
- Don’t invest in assets you don’t understand and don’t take the word of your agent for granted, research his claims (about risk).
- Think carefully about information and the incentives of the party that is providing them.
- Optimize the payment schemes by emphasizing stock bonuses and multi year performances, so that long-term strategies are pursued by the management.

**Contents**

# 1 Introduction

In this paper an analysis will given of the financial crisis that started in 2007 and is still lasting in 2009. There will be a brief explanation about the financial crisis and the causes and major effects will be shown. Principal-agent problems at the root of the financial crisis will be revealed and analyzed and it will be determined how these principal-agent problems could be solved and averted in the future.

The organization of this paper is as follows. First game theory [11][13] will be introduced in chapter two. It will be shown how game theory models strategic interaction and tries to find the optimal strategy for each participant. After that, a brief history of game theory will be given, a summary of the forms of representing the strategic interaction and the extensive possibilities of game theory. From the broad applicability of game theory we narrow down to the principal-agent relationship in chapter three. Principal-agent problems exist because there is information asymmetry between the principal and the agent that are both striving to maximize their utilities. First it will be shown how agents can act opportunistically before entering the contract, by hiding their characteristics, and the measures the principal can take to counter this. Then we will show the problem of acting opportunistically after the contract is settled, in which the agent hides his actions, and we show possible countermeasures of the principal. In the fourth chapter we will show our research of the existence of principal-agent problems in the financial crisis, their effect on the crisis and we try to determine ways they could have been averted. The conclusion of this research will be given in chapter five.

# 2 Game theory

## 2.1 Introduction to game theory

Game theory is the concept of modeling strategic thinking and interaction between players [6]. It is basically a multi-person decision theory, which developed the language, tools and methods to analyze the decision making process in strategic interaction. It can be categorized as a branch of applied mathematics applicable to most social sciences. Game theory is mainly used in economics, business and law, but also has applications in political sciences, biology, philosophy and sociology. Due to the nature of the concept of strategic thinking and interaction everyone (unknowingly) practices game theory on a daily basis. The most obvious example is in playing sports, where a team needs to develop a strategy to win that match based on his and his opponent's strengths and weaknesses. Less obvious are the choices parents make to raise their children and how they make sure their children stay safe and healthy. A parent might promise his child a nice gift when he reaches adulthood if he stays away from cigarettes and drugs, or instead punish him when he gets home late. Here the parents need to develop a strategy that makes the child as happy as possible while still meeting their targets. They have to think about their child's response and strategy that he will play, will he hide his mistakes or comes forward with the promise to improve in the future. As a last example consider buying a second-hand car. How do you asses the quality of this car and how do you approach the bidding process? Will the seller even offer the car if it's in good shape and how can you lower the risk of buying a low quality car (lemon)?

With this wide applicability and intuitive concept, game theory provides a very accessible way to approach decision making. Next to the practical use, game theory has two other sides. It can be used descriptively to explain and predict how humans will behave, but experiments showed that there is a mismatch between prediction and practice. This is where the second side takes effect. It is argued that game theory instead should be used prescriptively and should show how rational people should behave.

## 2.2 Brief history of game theory

The history of game theory [12] goes back as far as Sun Tzu's *"The art of war"* (around 500 BC) which describes strategic decision making related to your adversary in war, and in the Talmud (0-500 AD), which gives a description for division corresponding with the modern theory of cooperative games. In 1713 James Waldegrave invented the first minimax mixed strategy. General game theoretic analysis started with Cournot, who provides a version of the Nash equilibrium as a solution to a duopoly in "*Researches into the Mathematical Principles of the Theory of Wealth"* in 1838.

The first contribution to the field of evolutionary biology came from Charles Darwin. In his "*The Descent of Man, and Selection in Relation to Sex"* he provided the first game theoretic argument on natural selection. He argued that in a population gender ratio's will be automatically be equalized. If the ratio is in imbalance the dominated gender has a higher chance to find a mate and therefore a higher chance to pass his genes. This will affect the next generation, which will be a little more effective to produce the dominated gender. Eventually the ratio will equalize again and the advantage fades away.

John von Neumann (1903 - 1957) is commonly accepted as the inventor of modern game theory. He was one of the most important mathematicians of the 20th century and contributed to many fields including quantum mechanics, nuclear physics, computer science and game theory. He provided the first proof to the minimax theorem and published in 1944, together with Oskar Morgenstern, the most famous work in game theory entitled *"Theory of Games and Economic Behavior"*. In this work they build a mathematical theory of economic and social organization based on a theory of games and strategy, they introduce cooperative games and utility theory and provide solutions for two-player zero-sum games.

From this point, the interest in game theory grew and many contributions were made from prominent mathematicians and economists who later became recognized as game-theorists. Game theory became known as the foundation for the understanding of complex economic issues.

The importance of game theory got emphasized in 1994 when Harsanyi, Nash and Schelten were awarded with the 1994 Nobel price in economics, for their analysis of equilibria in non-cooperative game theory. In 2005 Thomas Schelling and Robert Aumann were awarded the same price for their research on the understanding of conflict and cooperation through game-theory. Finally, in 2007 Myerson, Hurwicz and Maskin were awarded for having laid the foundations of mechanism design theory.

## 2.3 Key concepts of games

**General concept**
Game theory models strategic interactions in the form of *games*. These games consist of *players* that have usually a limited amount of *actions* they can take. All actions taken by a player are called his *strategy* and all his possible strategies together form his *strategy space*. Each combination of strategies between the players leads to a certain *utility* for the players involved. If we suppose that all players of the game are *rational* then we can say that every player will always try to maximize his own utility. The utility each player attributes to an outcome depends on his own preferences towards the risk and reward. This means that all risk 'preferences' should be accounted for in the utility. To clarify this concept, we use the following example. Consider two possible strategies A and B with monetary rewards A(10) and B(20) corresponding with the strategies. If the player selects A, he gets 10 for sure, but if he selects B there is a 45% chance the player receives nothing. If the player is risk neutral he will select B over A, because B has an expected outcome of 11, but if the player is risk averse he might select A instead to get the certainty of 10. If we use utility to model the payoffs, A and B will be transformed to utilities and these risk preferences will cease to exist and the expected outcomes can be easily ranked in order of preference.
Not only risk preferences and monetary reward play a part in the utility, but also the goal of each player. Will he pursue maximum individual monetary payoff, will he prefer group utility maximization, reputation and credibility or is he more worried about the long term effects of his choices. A good example of differences in utility is energy saving. Some people will focus on their short term payoff, instead of buying a more efficient light bulb or washing machine, while other people focus on their utility over a few years or even think about the energy consumption related to possible future generations.

**Belief**
Next to a clear utility, people need to form a belief about the strategy played by the other players. This belief can be formed on factors inside the model, available information, strategies and monetary payoff and utility structure of the opponent. But also factors from outside can influence these believes, for example the reputation of the adversary, his history and current situation, characteristics, risk preferences and his believes about you.

**Induction**
A common tactic used to try to get information about the other players strategy is called backward induction, which means to reason forward and induce backwards. The basic idea is to look at the payoff structure from your opponent and reason which of his strategies would lead to a maximization of his payoff. This technique will later be shown in chapter 2.4.1, where the extensive form representation is discussed.

**Nash equilibria**
Another way to analyze the possible strategies and payoffs is to look for Nash equilibria. When each individual player in a game cannot improve his strategy taking in account that his opponents won't change their strategy, then the game is in a Nash equilibrium. Examples of the Nash equilibrium will be given with the normal from analysis in chapter 2.4.2.

**Uncertainty**
The most limiting factor in strategic decision making is uncertainty. In practice, this causes a mismatch between rationalized beliefs and observed outcomes. This uncertainty can be based on the two factors, Nature's choice and information asymmetry between the players. Nature's choice is more or less the uncertainty that is created by the factors that cannot be taken into account in the model or those that are random in nature. Playing heads and tails or rolling a dice is random, while a project can fail due to chance even if everyone pushes himself to the limit.

**Information asymmetry**
Information asymmetry causes uncertainty due to difference in information between the players involved. A player can hide his true nature, he can conceal his efforts and utilities or he could even lie. Therefore it can be difficult to disclose the true competence and effort level of an employee or the safety of granting a loan or health insurance.
But as it will be shown in the next chapter's, uncertainty (or the lack of) can also be favorable and create opportunities for higher payoffs. This opens a whole new array of possible strategies applied in order get the maximum result.

## 2.4 Forms of representation

In order to model and analyze the games effectively three forms of representation have been developed for game theoretic situations: (1) the extensive form, (2) the normal form and (3) the functional form.
The basic notation for all forms is the same. Players are numbered $i \in \{1, 2, \dots, N\}$, where N is the total numbers of players participating in the game. Each player has a strategy set $S_i$ of which $s_i$ is a single strategy. A possible outcome is denoted by $s = (s_1, s_2, \dots, S_N)$ which has a utility for player i of $u_i(s) = u_i(s_1, s_2, \dots, S_N)$. The set of all possible outcomes is denoted as S.

### 2.4.1 Extensive form

The extensive form representation graphs games as decision trees. It can show the order of the movements of the different players and visualize the availability of information for the different players. Uncertainty in the game can be modeled by adding a nature's choice node, which is basically a random number generator. It can also represent an infinite action space, for example in defining a price for any product, which can be any real number.
An example of a game represented in the extensive form is shown at the left side in Figure 2.1. Each node in the picture represents a decision for the player involved, except when it is an end-node, in which case the game ends and the players get the payoffs (utility) listed next to it. The payoffs correspond to the player ranks, so the first number is the payoff for player 1 and the second number is the payoff for player 2. Each solid line starting from a node represents a possible action (strategy) for the player associated with that node. Player 1 starts this game and he has two choices, up or down. After player 1 made his choice it is player 2 his turn. Player 2 also has the two choices up and down and the actions are marked with an apostrophe to distinguish them from the actions of player 1. There is imperfect information for player 2, because he cannot distinguish which action player 1 has taken. This is represented in the extensive form as a dashed line between the nodes of player 2. If there was no imperfect information, player 2 could distinguish his place and choose a strategy and get the payoff of his choice. In this case we should name his strategies differently in order to indicate the separation. This situation is shown at the right side in Figure 2.1.

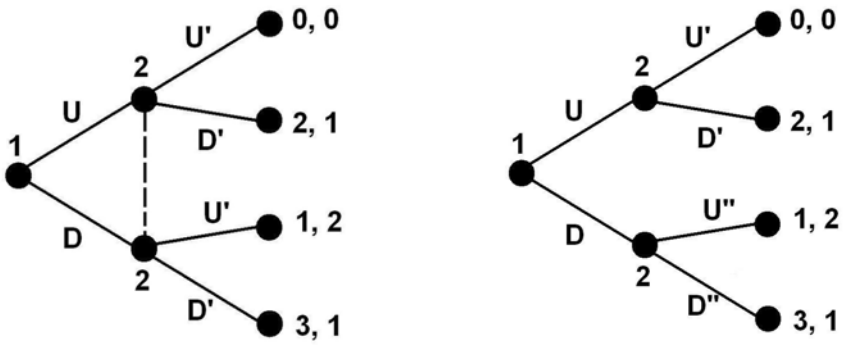


**Figure 2.1: Extensive form game tree with imperfect information and perfect information**

If both players are rational then we can apply backward induction in order to find the optimal strategy for both players. We start with the game with perfect information. We distinguish two cases for the second player: the upper and the lower case. In the upper case he will always play D' and in the lower case always U", because these will yield the highest payoff for him. So in this case player 1 will choose Up, because his possibilities are limited to only two outcomes, a payoff of 2 if he chooses Up and a payoff of 1 if he chooses Down. The final outcome of this game will be (U,D') with payoffs (2,1).
In the game with imperfect information we have to focus on the payoff structure of player 1 and apply forward induction for player 2. We can see that for player one, the payoffs of choosing down Down are always higher than the payoffs for choosing Up, regardless what strategy player 2 chooses to pursue. For player 1 we can say that his strategy of choosing Up is dominated by choosing the Down strategy. Player 2 can deduct this information and will eliminate the upper case and therefore he is left with the two choices U' for a payoff of 2 and D' for a payoff of 1. Now he will choose U' and the outcome of the game will be (D,U') with the corresponding payoffs of (1,2).

The most remarkable thing is that the uncertainty in player 1's movement causes a decrease in payoff for him. If he could manage to remove this imperfect information and reveal his action to player 2, he could double his payoffs! This means that hiding your actions can be disadvantageous for your situation; sometimes it might be better to communicate your action to your opponent to yield a better result. In contrary, if player 2 could block this communication his result will double instead.

### 2.4.2 Normal form

Normal form games are represented as a matrix and therefore it is more limited than the extensive form representation. Representing the game in the normal form requires the players to have no knowledge of the previous actions of their adversaries and the games will model all actions as simultaneous movement. The information represented in a normal form game is limited to showing the players, strategy spaces and payoff functions. Table 2.1 shows the previous game with imperfect information from Figure 2.1, but instead converted to the normal form. Players 1's actions are shown vertically and player 2's choices are shown horizontally. The payoffs associated with the different strategies are shown on the intersections. If both players choose down, player 1 gets a payoff of 3 and player 2 yields a payoff of 1.

Table 2.2 shows us the conversion of the game with perfect information. It looks a bit more completed because we need to show each of player 2 decisions, even if the state is impossible to reach. To be able to model this completely player 2 now needs to define two actions, one for the up-state and one for the down-state. In this representation the information that player one moves first is lost and we cannot transform this normal form back to a unique extensive form.

| 1 \ 2 | U' | D' |
|---|---|---|
| U | 0,0 | 2,1 |
| D | **1,2** | 3,1 |

**Table 2.1: Normal form with imperfect information**

| 1 \ 2 | U'U" | U'D" | D'U" | D'D" |
|---|---|---|---|---|
| U | 0,0 | 0,0 | **2,1** | 2,1 |
| D | **1,2** | 3,1 | 1,2 | 3,1 |

**Table 2.2: Normal form with perfect information**

An outcome $s \in S$ is a Nash equilibrium if for all i: $u_i(s_i,s_{-i}) \geq u_i(s'_i,s_{-i})$, where $s'_i \in S_i$ and $s_{-i}$ is the strategy profile for all players except i

When looking for equilibriums to analyze games, the easiest way is to use the normal form representation and examine each possible combination of strategies. For each combination look at the gains for each individual player to deviate from this strategy, while keeping his adversaries strategy fixed. If there is no positive gain the players should have no incentive to deviate and the game will be in a Nash equilibrium. In our normal form games the Nash

equilibrium is shown in bold. If we look at the first game we see that there is one equilibrium (D,U'). For example (D,D') cannot be an equilibrium because player two will deviate to the U' strategy, which will double his payoff. The second game with perfect information has two Nash equilibriums of which one (D',U'') has been rationalized in the previous chapter**.** A Nash equilibrium doesn't have to be the optimal solution. All players might be able to do better if they coordinated on a different Nash equilibrium or even if they are able to coordinate on the joint maximum payoff strategy and split the gains.

### 2.4.3 Characteristic function form

The characteristic function form is used to model cooperative games [4]. A cooperative game consists of two elements, a set of players $N = \{1, 2, \dots, n\}$ and a characteristic function $v(S)$ that states the value of the coalition S, where S is a subset of N. $v(N)$ specifies the overall value created by the coalition of all n players.

The marginal contribution of player i is defined as $MC_i = v(N) - v(N\setminus\{i\})$, where $N\setminus\{i\}$ is the subset of N consisting of all players except player i. The division of the value is given by the allocation which is noted as $(x_1, x_2, \dots, x_n)$

The final allocation has to satisfy the following three conditions:
(i) Individual rationality: $x_i \geq v(\{i\})$ for all i
(ii) Efficiency: $\sum^{n}_{i=1} x_i = v(N)$
(iii) Marginal Contribution Principle: $x_i \leq MC_i$ for all i.

If condition (i) is violated the player can just step out of the coalition to earn more. If condition (ii) is violated there is still a residual value to gain and the solution is not optimal yet. If condition (iii) is violated the coalition can remove player i to get a higher gain.

We will clarify this modeling of cooperative games with the following example.
Consider 3 players, $N = \{1,2,3\}$, where player 1 is a seller and player 2 and 3 are buyers. Player 1 has one item to sell which is produced at a cost of €4. Player 2 is willing to pay €9 and player 3 will pay €11 at maximum.

The characteristic functions are now defined as:
$v(\{1\}) = v(\{2\}) = v(\{3\}) = €0$
$v(\{1,2\}) = €9 - €4 = €5$
$v(\{1,3\}) = €11 - €4 = €7$
$v(\{2,3\}) = €0$
$v(\{1,2,3\}) = €11 - €4 = €7$ (player 1 will sell the unit to the highest bidder, which is player 3)

The marginal contributions are:
$MC_1 = v(\{1,2,3\}) - v(\{2,3\}) = €7$
$MC_2 = v(\{1,2,3\}) - v(\{1,3\}) = €0$
$MC_3 = v(\{1,2,3\}) - v(\{1,2\}) = €2$

We can now derive the final allocation using the three conditions previously mentioned. Player 2 will gain €0 from the cooperation, as his marginal contribution is €0. Player 3 will gain between €0 and €2 after which we can derive the allocation of player 1 to be between €5

and €7. The €2 will be split amongst player 1 and player 3, but we cannot derive the actual split with this model.

## 2.5 Characteristics of games

The games in which the players are involved can have many different types of characteristics. Most of these characteristics can be combined or extended which results in a very large number of different games possible.

**Relationship between players**

A game can be cooperative, non-cooperative or hybrid if it contains aspects of both characteristics. Cooperative means that a group of players, a coalition, can form binding commitments, for example by using legal contracts. In non-cooperative games, cooperation can occur, but only if this cooperation is self-enforcing.

**Communication rate**

For cooperative games it is usually required that the players have the possibility to communicate in order to make agreements about the pursued strategies. If this communication is possible in non-cooperative games it gives way to a whole area of influential possibilities. Pleads, threats, bluff and brinkmanship are examples of the actions the players can undertake prior to choosing a strategy. Of these possibilities brinkmanship is the most dangerous. It involves the threat of escalating the game to the worst possible outcome in order to force the opponent to act in your advantage. It is very much present in international politics, where the Cuban missile crisis of 1962 is one of the prime examples.

**Order of movement**

There are two types of possibilities in the order of movements in games. The players can act simultaneously and thus they won't have knowledge of the other player's action, until they can observe the endgame result. The same effect happens when players make a decision at different points in time, but are not able to observe the decision made by the adversary earlier. Games can also be sequential, where players take turns in performing an action and are able to observe a part of the action taken by the previous players.

**Order of time**

Games can be played once, but they can also be repeated for a prolonged time period. In the first case players have to focus on their one-time gain, but if the game is repeated more strategies become possible and reputation has to be considered. In a repeated game series players can try to cooperate to optimize their long term utility. Players can try to play strategies that are not equilibrium strategies but if both commit to the right strategy the payoff will be higher. In this case players can be tempted to make a one-time deviation of this strategy in order to improve their one-time gain, but this will harm their reputation will the other players. As a punishment the next time the game is played they will also deviate from this long time optimal strategy and all players will be worse of in the long run. This is usually called a grim trigger; the cooperation strategy is played repeatedly until one player deviates. After that the short run suboptimal equilibrium is played constantly.

**Limitations of possibilities**

Game theory distinguishes discrete and continues games. The games analyzed are usually classified as discrete, with a limited amount of players, movements and outcomes. Some examples of discrete games are chess, bidding in auctions or competing in markets. In

continues games the choices, events and possibilities are practically infinite, which makes modeling of these cases much harder. Cops and robbers, playing hockey and fighting a war are some of games that fall in this category.

**Distribution of payoffs**
Here we distinguish two possible types of games, zero sum and non-zero sum. In a zero sum game the payoffs of all the players always equal 0 for each particular set of strategies. One player's winnings are always someone else's loss, for example in a game of betting or in poker. For non-zero sum games gains and losses between the players don't need to be correlated.

**Information rate**
The information rate is the most important factor in games, as it creates uncertainty. In a game of perfect information all players have complete knowledge of all actions taken in the past by themselves and all other players and this information is constantly updated. A game will have imperfect information if a player cannot perceive some actions taken by the others players and thus will not know his exact place in the game at this moment. Not all information is available or can be verified to truth. This is also called information asymmetry between the players and will be the main focus of this literature research.

## 2.6 Information asymmetry

In strategic decision making information is the most valuable resource, it is commonly said that information equals power. The higher the quantity and the quality of the information that is available to you, the better your possibilities are to make strategic decisions. Good information extraction, reliable communications and solid interpretations are vital to improve the value of your information. But even with high effort and good skills it can still be impossible to reach perfect information. As these measures can be very costly and time consuming in most cases there will be an information asymmetry between the parties involved. Either one of the parties will have more or better public information, and all parties will have private information that is not accessible by the other. This creates a high information uncertainty between the parties and can result in a distortion in the balance of power.

Due to the broad aspects of information asymmetry, it involves area's that are not suitable to be modeled and analyzed by game theory or area's where this process just has started. Areas in which reducing information asymmetry is crucial are:

- international politics, regulations and conflicts
- insurance business
- money lending
- job market
- mergers & acquisitions
- joint ventures, cartels, partnership or other cooperative efforts between corporations
- financial markets
- auctions and bargains

# 3 Principal-agent problems

A principal-agent relationship originates when a principal contracts an agent. The principal hires this agent to perform a service for him or to act on his behalf. For example a tourist can hire a taxi driver to bring him to the hotel or a project manager needs to contract employees to participate in the project. However there are three factors that disturb this relationship. There is a conflict in goals as agents are autonomous and will strife to maximize their own utility. The second problem is information asymmetry between the principal and agent, which is a potential advantage for the agent. This information asymmetry can be divided in three parts: the agent currently has more information than the principal, the agent will have more information than the principal in the future or he can hide his actions.
The last factor is uncertainty in the outcome. The outcome might not only depend on the agent's efforts, even if the agent puts in maximal effort the outcome can still be negative. When the principal cannot ensure that the agent acts in compliance with his interests and when it's impossible or too expensive to monitor the efforts of the agent the principal-agent problem arises. The principal-agent problem is illustrated in Figure 3.1.

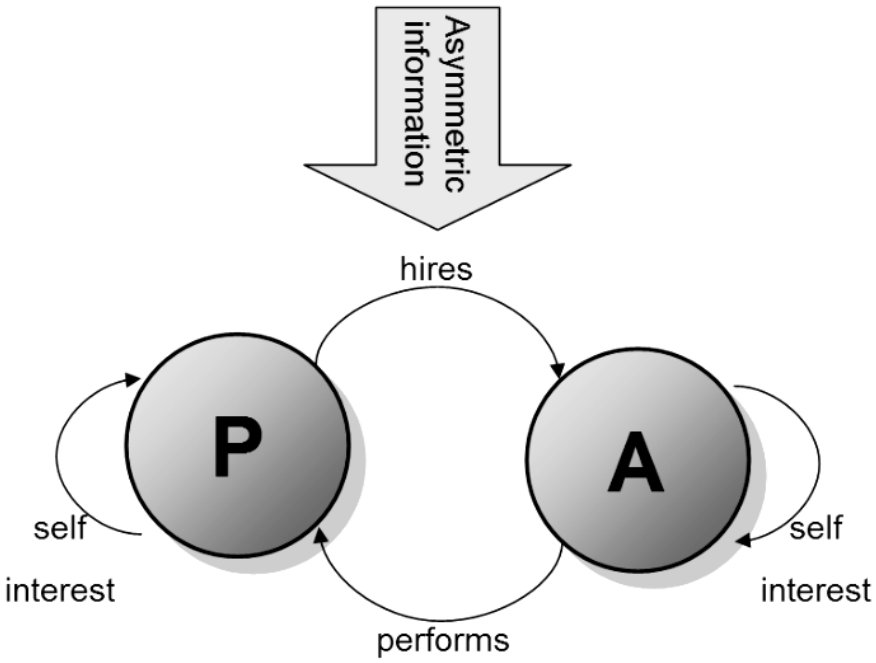


**Figure 3.1: Principal-agent problem**

We will clarify the problems in the principal-agent relationship with a few examples. Consider again the tourist (principal) that hires a taxi driver (agent). The goal of the tourist is to get to the hotel as cheaply as possible, while the goal of the taxi driver is to get the tourist to the hotel and to maximize his profits. The taxi driver knows the city very well, while the tourist has never been there before. In this situation the taxi driver can decide to commit moral hazard and drive a few extra blocks before arriving at the hotel, which will give him some extra profit or if he is paid for his time, he can choose to take the route with the highest traffic. If the tourist cannot take measure to prevent this, the taxi driver can take advantage of him. The second example is one with a much bigger impact on society and is one of the causes that let Enron go bankrupt [3]. We can find the principal-agent problem in the relationship between shareholders and the management of listed companies. Shareholders, the principal, provide

the company with liquidity and for this they would prefer a steady return on their investment in the form of dividends or higher equity. However their interest might not be aligned with managers as they are interested in maximizing their own profits in the form of bonuses. These bonuses often correspond to the profit the company makes in the short run, but for the managers there is no downside. In order to maximize their bonuses, they might take huge risks that will lead to huge short term profits, but a grim outlook for the long run. After collecting the bonuses, the managers can move on to a different company where they can ask for a higher salary, because of their 'brilliant' performance in the past. Eventually when the situation goes wrong the company will have a huge loss or can even go bankrupt and the shareholders will lose much of their investment.

**Strengths and weaknesses**

Principal-agent theory has three main strengths [9]. The theory is broadly applicable and can be used to analyze a majority of the topics in information asymmetry. The theory can be applied within markets and organizations, but also in politics and energy saving. The second main strength is the strong explanatory power provided by principal-agent theory. It analyzes rational individuals in a principal-agent relationship and provides logical realistic predictions, which are empirically testable. The third strong point is the focus on solutions. Principal-agent theory not only analyzes the relationship, it also provides solutions to improve the efficiency of this relationship.

Regardless of these strong points the theory is also being criticized. The critics focus mainly on the completeness of the theory and the accuracy of modelling real-world situations. The theory is deemed incomplete due to the large amount of unresolved agency problems in different areas of economy. Much of the literature in principal-agent theory involves highly complex mathematical models which lack applicability and contact with reality. Principal-agent theory is limited due to restrictive and faulty assumptions. It assumes that all people are opportunistic and that the theory doesn't take complex human behaviour, interaction and preferences into account.

**Models**

Two major principal-agent models have been the main target of studies [5][10], problems of adverse selection and problems with moral hazard. In models of adverse selection one party acts opportunistically before entering the contract, while in models of moral hazard the party acts opportunistically after signing the contract.

## 3.1 Adverse selection

Adverse selection occurs when one of the parties, usually the agent, has better relevant information prior to the contract. This hidden information will be used opportunistically to optimize the utility gained from entering the contract. This basic model is represented as a diagram in Figure 3.2.

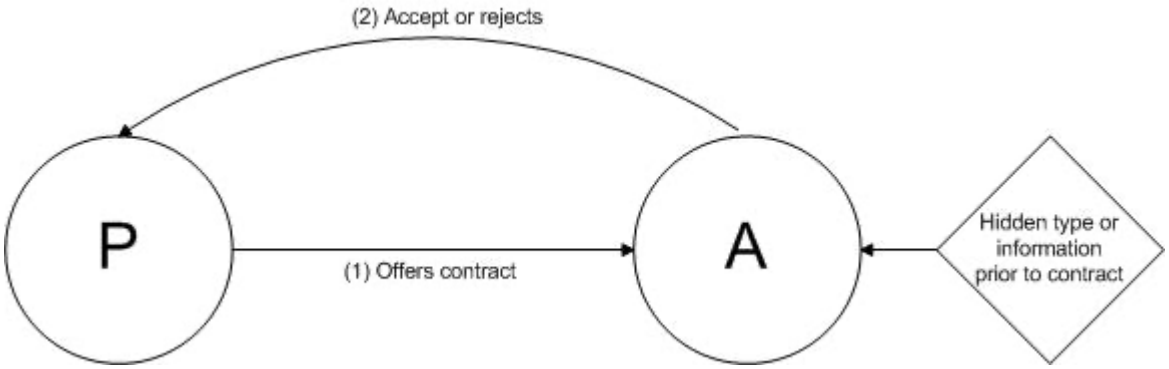


**Figure 3.2: Model of adverse selection**

Adverse selection is one of the main considerations in the insurance business. People with a higher risk profile are usually more interested in insurances than those with a low risk profile. This means that there is a positive correlation between the demand for insurances and the risk of loss. The insurance company is unable to price this correlation, because of the hidden information of the agent or because of regulations that prohibits discriminating between customers. Next to this the high risk agents would like to pool with the low risk agents in order to get a more favorable contract, while instead the low risk agents like to stay separated.

We will show the problem of adverse selection with the following simplified example. The principal in this case is a car insurance company, which offers insurances to car drivers (agents). The world is split equally in two types of drivers, those with a high risk of having an accident and those with a low accident risk. High risk drivers have an 80% chance of getting involved in an incident, while low risk drivers have a 20% chance of incidents. A car incident will cost the insurer (on average) €10.000. The drivers themselves know to which type they belong, but the insurance company cannot distinguish this information.
For the insurance company the expected costs of accidents is given by (50% * 20% + 50% * 80%) * €10.000 = €5.000. The problem of adverse selection becomes clear when we look at the insurance contract that they can offer. If the insurance company is not aware of adverse selection it might offer a contract for €6.000. This situation is shown in Figure 3.3. In this case they deduct that there will be a profit of €1.000 as the expected cost is only €5.000. But if we examine the expected costs of the two types of customers we can deduct that the company will make a loss at this contract price. If a high risk driver doesn't buy insurance his costs will be 80% * €10.000 = €8.000, but with insurance his cost will only be €6.000. Low risk drivers will incur a cost of 20% * €10.000 = €2.000 if they don't buy an insurance, but €6.000 if they buy one. Only high risk drivers will be buying the insurance, which will put the company at a loss of €2.000 per customer. The problem of this adverse selection, in which only high risk drivers will buy a contract, has to be solved in order for the insurance company to be profitable.

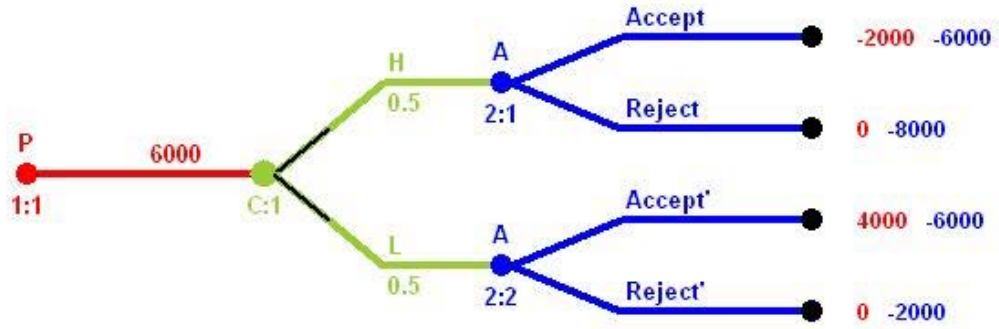


**Figure 3.3: Game tree of adverse selection of the example in car insurance**

## 3.2 Solutions to adverse selection

To counter adverse selection we need to associate the unobservable types of the agents with their observable actions. We can do this in two different ways, namely signaling and screening. In signaling the type of the agent is revealed pre-contract and in screening the type is revealed post-contract.

**Signaling**
One of the ways to solve the problem of adverse selection is to implement signaling in the principal-agent relationship. In this situation the agent is required to send a costly signal to the principal before he will offer the contract. This signal will reveal some of the hidden information of the agent, which can be beneficial to both parties. The model of adverse selection with signaling is given Figure 3.4.

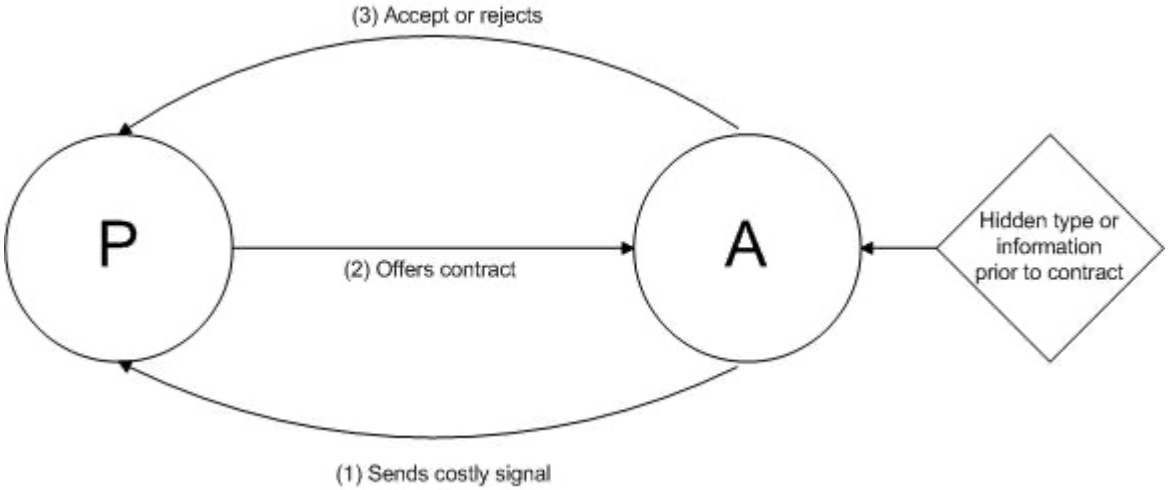


**Figure 3.4: Model of adverse selection with signaling**

In case of the car insurance company the costly signal could be a proof of not being involved in any accidents for a certain amount of time. This will increase the likelihood that the agent is a low risk driver, in which case the principal can offer him a favorable contract. The situation with a signaling requirement of three years accident-free driving is shown in Figure 3.5. In this case the principal has a 98,5% certainty that the agent is a low risk driver and can tailor the contract based on a low risk drivers. If the requirement is set to four years this certainty is very close to 100% and we could remove the upper branch. For the agents that cannot comply with this 3 year requirement the principal will treat them as a high risk driver and offer a contract accordingly. Note that 49% of the low risk drivers will also be in this group and will reject the contract, thus the principal will lose the opportunity to serve these drivers.

We can find a second example of signaling in the job market. Employers put educational requirements on their vacancies, to make sure they hire people with the right skill level. Agents with a high educational background will only apply for jobs that require a high educational level, as the wage will be higher than jobs that require a low educational level. For low skilled agents it is difficult and more costly to finish the required education and thus the company has a high chance to contract a highly skilled agent for the job.

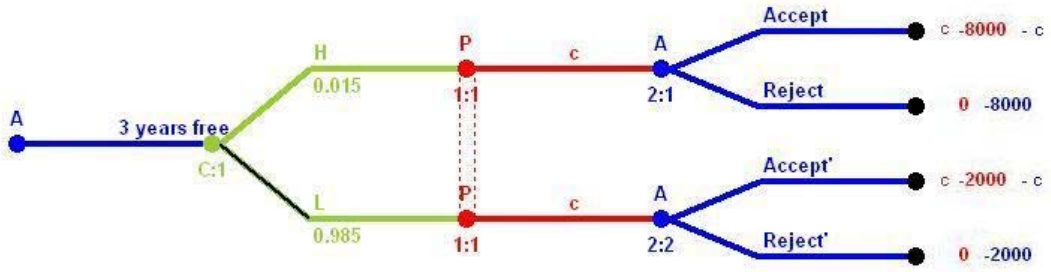


**Figure 3.5: Signaling of three years of accident-free driving**

## Screening

Screening is similar to the standard adverse selection model, but instead the principal knows that adverse selection will take place. This knowledge allows him to expand the different types of contracts he can offer so that the agent will reveal his type by choosing one of the contracts. The principal needs to design the contracts in a smart way, such that each contract targets a specific type of agent and maximizes the profit of the principal. This is the reason that many companies offer slight variations of the same product. A health insurance company can offer five types of insurances, each with a higher premium but also higher coverage. Internet provides act the same, they provide a low bandwidth package for a low price but packages with a higher bandwidth for higher prices.
Another way would be to just target one type of agent and design the contract in such a way that it's only accepted by that specific type of agent.

## 3.3 Moral hazard

In moral hazard the principal is unable to observe the agents actions after signing the contract. This causes the agent not to take the full consequences of his actions and thus he can use this hidden information to act opportunistically and maximize his own profit. In most cases the principal will have to carry the (opportunity) costs of this behavior. The model of moral hazard is shown in Figure 3.6.

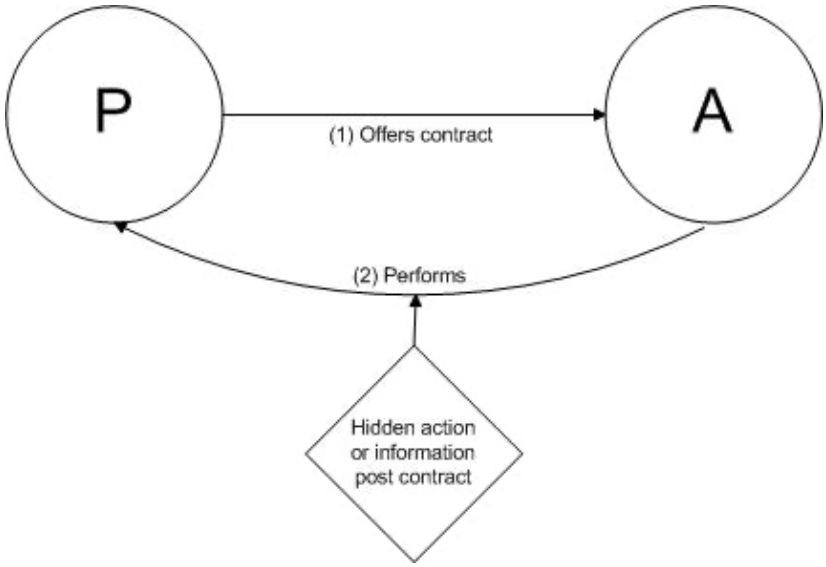


**Figure 3.6: Model of moral hazard**

The two examples at the beginning of this chapter, about the taxi driver and Enron, are a form of moral hazard. Moral hazard is also an important consideration in the insurance business. The fact or having insurance will alter the behavior of the agents. They can become a more risky type, which takes less attention and energy and thus is more 'profitable', as they know that the insurance company will pay out in case of an accident. Secondly, by having an insurance they will try to get the maximum use out of it. They might schedule an extra doctor or dentist visit, where they would hold out if they didn't have insurance. Thirdly if the insurance pays out at replacement level, they can purposely destroy a product and claim the full value of a newer product from the insurance.

Moral hazard is also an important factor in project management. Here a company (principal) hires a project manager (agent) to lead a project for the development of a new product. From signaling they already found out that the manager is experienced enough to undertake this project, but as the project is so complicated it is very costly to monitor. The agent now has the choice to commit a high effort which is costly or a low effort which saves him much valuable energy. As with many project there is a low failure chance if the agent commits a high effort and a larger chance to fail if he commits a low effort. The company needs to find a way to commit the agent to a high effort and thus increasing the chance of a successful project.

## 3.4 Solutions to moral hazard

We have to solve moral hazard by associating the agent's unobservable actions with observable outcomes. We can distinguish two types of solutions, pre-contract solutions and post-contract solutions. Pre-contract solutions take place before hiring the agent; while post-contract go into effect after hiring the agent.

The main post-contract solutions are focused on extraction information about the performance of the agent. This can be done by monitoring and performance evaluation. Constantly monitoring the progress of the agent is very costly and time consuming; instead there are usually certain checkpoints where the progress is evaluated. The agent knows this evaluation will take place and might be able to take action to delude the principal.

The pre-contract solutions can be more effective and are generally less costly. The main solutions are job design and contract design.
Job design is mainly a preventive measure for moral hazard and supporting measure for the other methods. The work should be structured in such a way that it reveals the maximum amount of information to principal at the lowest cost. Next to this the work should be arranged, so that it provides the possibility to use contract design schemes.
There is no single form of contract that can solve all moral hazard problems, but contract design provides a good opportunity to align the agent's incentives with the principal's incentives as much as possible. Contract design usually focuses on maximizing the output or minimizing the costs.

We will show the possibilities of contract design with the following example. A software company (principal) is hiring an outside firm (agent) to develop a new program for them. In this example both are big companies, which are in general risk neutral. If this project is successful the software company will earn €600.000. However there is uncertainty involved in the outcome. If the agent commits a high effort the project has an 80% chance of success, and if they commit a low effort the project has only a 50% success rate. A high effort will cost the agent €150.000, whether a low effort will cost him €100.000. The agent has no outside opportunities, so if he doesn't accept this project he won't have any payoff. The basic game tree of this example is shown in Figure 3.7.

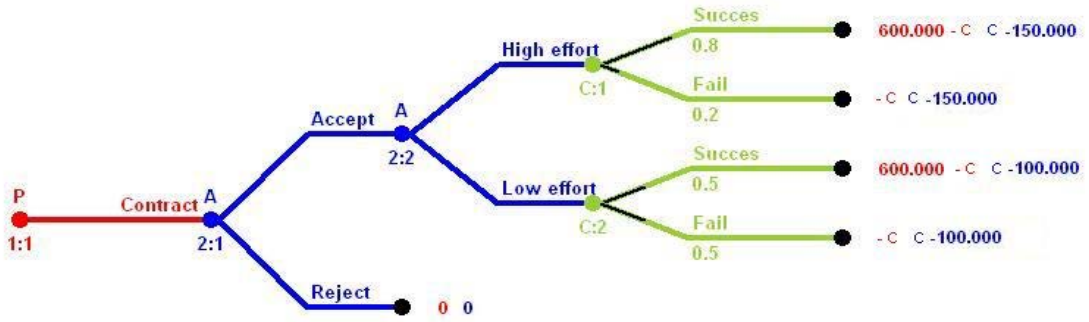


**Figure 3.7: Starting point of the contract design example**

There are four basic schemes the company can use to design contracts. In general a scheme will be successful if it induces participation of the agent (participation constraint) and if it gives the agent the incentive to commit a high effort (incentive constraint).

**Fixed Payment Scheme**
In a fixed payment scheme the agent gets a fixed wage, no matter the outcome of the project. Any offer that the principal makes to the agent will result in a low effort, as the agent wants to maximize his utility. The principal will offer at least €100.000 and the expected return of the project will be maximum 50% * €600.000 - €100.000 = €200.000

**Observable Effort Scheme**
In this scheme the company will offer a contract based on the amount of effort the principal has put in. For a low effort the agent will be offered at least €100.000 and for a high effort at least €150.000. In case of a low effort the expected return will again be €200.000 and if the agent's effort is high the expected return will be 80% * €600.000 - €150.000 = €330.000. However this type of scheme is only possible if monitoring is possible and not to costly and thus it can usually not be implemented.

**Bonus Scheme**
In a bonus scheme the principal will offer a wage and an extra bonus that is based on an observable outcome. In this example the only observable outcome is the success of the project. The agent will put in a high effort if it is more profitable than a low effort. This is shown in the incentive constraint as S + 80% * B - €150.000 ≥ S + 50% * B - €100.000. The agent will put in high effort when the bonus is at least €166.667. We now need to induce the agent to participate by solving S + 80% * €166.667 ≥ €150.000, which results in a minimum salary of €16.667.

When the agent commits a high effort the expected profit will be 80% * €600.000 – 80% * B - S = €330.000 and for a low effort the expected profit will be 50% * €600.000 – 50% * B - S = €200.000. These expected profits are the same as the observable effort scheme and considering the cost of monitoring the principal is better off with a bonus scheme. However when the agent is more risk averse the costs for the principal will increase. Either the bonus has to be higher, or there will be a higher emphasizes on the fixed salary.

If in our example, the chance of success with the agent committing a low effort is increased to 60% instead of 50% the optimal bonus scheme will show a dramatic change. Now the optimal bonus will be €250.000 and the optimal salary will be - €50.000. This is the amount that the agent needs to pay in order to get this project or we could see it as the fine that the agent needs to pay when the project fails.

Instead of choosing the pay a bonus the principal could choose for a penalty scheme. In this case the principal will pay the agent a salary of €166.667 + €16.667 = € 183.333 and charge a fine of €166.667 if the project fails. This reversal will keep the preferences and expected return intact. Most insurance companies in the Netherlands operate like this. Every year the agent pays a fixed amount for the insurance, and if he makes a claim ('the project fails') he will incur a limited penalty, which is called a no-claim charge. This causes awareness with the agent, who will try to avoid this penalty. Market research showed that if the insurance company had chosen instead for a higher fixed amount and a bonus until a certain claim threshold, the agents would act a bit more reckless.

**Franchise Scheme**
In a franchise scheme the principal transfers all risk to the agent, which will make the agent the residual owner of the project. The fee of franchising will be the equal the highest expected profit of the principal. In our example it is the maximum of 50% * €600.000 - €100.000 = €200.000 and 80% * €600.000 - €150.000 = €330.000 and thus the agent will be required to pay €330.000 to become the franchisee of the project.

# 4 Financial crisis of 2007-2009

The financial crisis that started in 2007 has been the biggest economic crisis since the great depression in 1929. The financial crisis had a severe impact on the world economy and led to many bankruptcies of financial institutions and other major corporations. The crisis started with the bust of the housing bubble in America, after which it quickly spread throughout the rest of the world. We will first give a short summary of the financial crisis and then look at the events that caused the housing and debt bubbles to form. Subsequently, we examine how these bubbles influenced the whole financial system [1][8] and why the system was so vulnerable [7]. Finally, we point out several principal-agent problems that were at the base of the crisis and show how they can be solved.

## 4.1 The financial crisis in a nutshell

In the United States, very risky mortgages were provided, of which the risk was covered up by securitization. This securitization made it possible to spread the mortgages easily throughout the whole financial system. When the United States housing bubble started to bust and house prices started to decline, it became clear that there were large amounts of sub-prime mortgages in the system. This resulted in a decline in confidence in all financial institutions as no one was able to estimate how much each institution was exposed to these sub-prime mortgages. The price of credit started to increase, because the perceived credit risk of the institutions rose. This made if more expensive for financial institutions to reissue their debt. As the awareness of the existence and the magnitude of risky mortgages packages increased the process of buying these stopped almost completely which resulted in the collapse of the sub-prime industry. Many financial institutions had to write off losses on their mortgage portfolios and stock markets started to decline.

The first big investment bank to get hit was Bear Stearns which got taken over by JP Morgan Chase in March 2008. The financial crisis kept increasing in magnitude and in September 2008 the whole financial system was at the risk of collapsing. The housing bubble was completely bust and credit was almost impossible to get. In order to avoid a total collapse of the housing market, the Fed nationalized mortgage giants Fannie Mae and Freddie Mac at September 7$^{th}$, which were public label securitizers that bought and securitized mortgages. This action showed the graveness of the situation of the financial market and panic started all over the world. A week later Lehman Brothers bankrupted and Merrill Lynch got taken over by Bank of America. The US Federal Reserve had to make huge loans to AIG to keep them standing; eventually these loans added up to 170 billion dollars. At September 21$^{st}$ the last two Wall Street investment banks Goldman Sachs and Morgan Stanley reformed to be a bank holding company, which put them under much more strictly government regulations but also makes it easier for them to get credit.

In October 2008, all the stock markets in the world collapsed and kept declining for months. In the whole world, numerous economic stimulus programs were set up that pumped thousands of billions of dollars in the economy in order to keep the financial system standing and the economy running. The fear is now, that after world economy was damaged by the financial system, the economy is going to deal more damage to the financial system. Many jobs and assets have been lost, due to which some of the previously good loans and mortgages will turn bad.

## 4.2 Start of the housing and debt bubbles

### The bond market

As a response to the stock market crash of 2000 (dotcom bubble) the fed kept the interest rate very low. As a result American government bonds got less profitable and it became very easy for American's to get credit loans. As a response to the lower income on the American government bonds, investors diverted more to less safe junk bonds and government bonds of less financially stable countries that yielded a higher interest rate. Over the last five years the bond market seemed very safe as there were no big crashes in this market. Due to the low interest rates the leverage ratio (debt to equity ratio) increased enormously. As long as the interest rates stay low and there are no losses a high leverage can yield huge profits. After a few years the interest rate started to increase again, which caused bond prices to decline, interest payments on (credit card) loans and mortgages to increase and it got more expensive for companies to refinance their debt.

### Ordinary Americans

After the stock market crash of 2000, Americans moved a lot of their investments from the stock market to the seemingly safe real estate market. This has been called the great housing market in which most Americans bought a (new) house. For these houses they took on irresponsible mortgages, which where ARM (adjustable rate mortgage) and possibly sub-prime. Many mortgages had a very low teaser rate for the first few years, after which the rate increased dramatically. After the house price increased the borrowers would refinance the mortgage at the level of the increased housing price and renegotiate their adjustable rate. These mortgages work like a ponzi-scheme and will only work as long as the housing price keeps rising, the interest rate stays low and when the economic situation is stable. When the housing price started to decline and the interest rate started to increase many mortgage owners started to default, in which case the mortgage lender got the real estate object and the borrower had no obligations anymore.

### Mortgage lenders

Mortgage lenders provide mortgages to borrowers; these institutions can be banks but also other unregulated mortgage brokers. As there were no federal regulations for these mortgage brokers they were allowed to provide any possible irresponsible loan. One of the loans that is most illustrative to the origin of the financial crisis is the ninja-loan. In a ninja-loan the borrower has no income, no job or assets, in other words he has nothing. The reason that these brokers were willing to provide these 'financial suicide' loans is that they would hold on the loans for a maximum of 4 days after which they passed them on to other financial institutions (mostly securitizers), which would securitize them. They had virtually no risk on these loans as the first mortgage payment was due in 30 days. This behavior is compared with the hot potato game in which children throw around an object in a circle until the music stops, the one that holds the object at that point will be eliminated.

### Bank regulators

The bank regulators are blamed to have been sleeping for all these years and have failed in their consumer protection role. The unethical and unsustainable sub-prime lending practices were (in hindsight) clearly visible years before the housing bubble bust and especially in the periods closer to the bust, when the lending practices became more and more irresponsible.

## 4.3 Spread of the housing and debt bubbles throughout the financial system

**Private label securitizers**

These securitizers consist of but extend beyond the big Wall-Street investment banks. Basically securitization is the practice of buying mortgages and debts of all kinds of different credit rating, cutting them in small pieces and combining them in MBS's (mortgage backed securities) and afterwards in CMO's and CDO's (collaterized mortgage/debt obligations). The value of the package is perceived higher than the value of the individual components as part of the risk is diversified away. In reality these packages were extremely dangerous and the value was much lower than originally stated. These packages were later being sold again to other financial institutions, who then (unknowingly) owned a package with some good rated loans and some sub-prime loans. This is the same practice as buying a package of three paprikas in the supermarket in which always one of the three is of worse quality.

The private label securitizers are the main culprit of the spreading of the financial crisis throughout the whole financial system and later the world, as they sold their junk packages with sub-prime mortgages in huge quantities. One of the most remarkable aspects of this practice was that the big securitizers also kept a large part of these junk packages. Next to this the enormous quantities of these packages held by single institutions caused them to have a very high concentration risk in the real estate market. This is an indication of being self delusional and very bad risk management practices.

These packages fall in the category of so called OTC (over the counter) derivatives, which are questioned now as they seem to serve no other purpose than to generate profit for these big investment banks. They are so complicated that comparison shopping is impossible and that is very hard to understand the actual risk of these derivatives. Next to this the exact contents of package remain largely hidden, which gives rise to moral hazard on the side of the securitizer.

**Rating agencies**

The rating agencies are supposed to be a safeguard for investors, as they rely on rating agencies to determine the risk of securities. For bearing a higher risk the investor wants to be compensated more than for bearing a low risk, which means that as the risk of a security increases the return has to increase as well in order for investor to buy the security. In rating mortgage backed securities (MBS), the rating agencies highly underestimated the risk of these securities. They were throwing around AAA ratings like confetti, which is the safest rating they can attach. Due to these ratings, many investors believed that the securities were indeed very safe and thus they made very large investments in MBS's. The investors trust these ratings because the rating agencies are supposed to be an independent party. In fact the private label securitizers were able to influence the rating agencies to get high ratings on their securities. The rating agencies get paid by their customers to provide the rating on the products, which puts the customers in a stronger negotiating position. This is the same situation as when the professors would be paid by students for their grades. The interests of the rating agencies and the investors were not aligned and thus they were less reliable as a source for information for the investors.

## 4.4 Vulnerability of the financial system

**Securities firms and investment banks**
A healthy financial system will be able to deal with (big) losses, but the financial system was (and still is) very vulnerable. One of the main reasons is the huge leverage under which the financial institutions operate. A leverage of 30 to 1 was very common just before the crisis started. In this case the institution has a balance sheet with in ratio a debt of 30, stockholders equity of 1 and assets the size of 31. A small loss of only 3.2% on the assets would already totally wipe out stockholders equity, which means that the stock of the company will severely devaluate. In case of a bankruptcy the debt holders will be paid first after which the crumbs are left for the equity holders.

The funding of the assets of the investment banks consisted for the majority on short term borrowing (1 to 3 months) and even on overnight borrowing. This means that most debts are short term and need to be repaid every few months. This puts the banks at a high liquidity risk; because they will have to repay the debt with cash and if an institution cannot pay these short term liabilities it will be insolvent and can even end up in bankruptcy. The cash will come either from issuing new debt or from the selling of assets; the latter is either very costly or impossible if the assets are illiquid. The price that companies have to pay for loans is depending on the current safe interest rate and the credit rating of the company. When the interest rate increases or the credit rating decreases the issuing of new debt will be much more costly. During the financial crisis companies had to write off huge losses on their derivatives and assets. No one was sure anymore which companies could survive and which were in great trouble so the short term credit market completely collapsed, and it became much more expensive and much more difficult, even impossible, to get short term credit. This is called a credit crunch and this event led to serious trouble in the financial market as lots of companies were heading for insolvency.

Next to a high leverage and precarious funding the financial institutions build a huge mountain of derivatives on top of the mortgages and other loans. These derivatives don't show at the balance sheet, but can create large profits and losses. The markets for these derivatives are huge; a recent estimation put the market size of CDS (credit default swaps) at a notional value of 66 trillion dollars. A credit default swap is much like a property insurance, but then instead on a loan. In a normal CDS setting, three parties are involved, a borrower of a loan, the lender which also will be the buyer of the swap and the seller of swap. The seller of the swap will take over the default risk from the lender for periodic payments. In case the borrower of the loan defaults the seller of the swap will have to pay a certain amount to the buyer of the swap. The market of CDS is so inflated because the same loan can be used for an infinite amount of CDS, in fact you don't even need to be the lender of the loan in order to buy the CDS. This creates huge speculation possibilities as now I'm able to bet on the default of my neighbors' loan in infinite quantities. In good market conditions these financial institutions can earn huge profits with these kinds of derivatives, but when the market conditions deter these profits turns quickly into (huge) losses. For these reasons Warren Buffet, calls these OTC derivatives weapons of mass financial destruction, as they have the potential to blow up any company that is careless with them.

As a result of these practices the big five investment banks of Wall Street; Lehman Brothers, Bear Stearns, Merrill Lynch, Goldman Sachs and Morgan Stanley, don't exist anymore in their previous form.

**Securities Exchange Commission**
The SEC is also blamed to have been asleep as they should never have allowed these extreme practices of the investment banks. In hindsight it is clear that these huge leverages, short term funding and huge exposures to unregulated derivatives made the system very unhealthy.

**Retail banks**
The structure of the financial banking system creates a very precarious situation. Banks are able to create money by granting loans. From every deposit that is made banks are required to keep a fractional reserve, for example 10%. They can use the other 90% of the money to grant a loan. In other words the bank can create a loan, while only 10% of the money exists. This loan can then be used to buy goods and it will eventually end up as a deposit in a bank, which then will proceed to loan out 90% of that deposit again. This process can proceed until the limit has been reached. In this way the original deposit will be multiplied by the inverse of the fractional reserve ratio, which in our case is 10%, and thus leads to a ten fold of outstanding deposits (and debt).
In any circumstance a bank will only be able to pay out the fractional reserve as a percentage of its deposits. This means that banks solely operate on trust, because when they are suspected to be financially less healthy all depositors would quickly try to remove their deposits, which will result in a self-fulfilling prophecy in the form of a bank run. The government tries to prevent this by insuring the individual deposits until a certain level, which makes sure that there is no need to start a bank run, as the money cannot be lost.
It gets even more precarious, because over each deposit and loan a certain interest has to be paid. Banks only create the principal of the loans, so where does the money to pay interest come from? In fact the money to pay the interest doesn't exist. All the interest payments need to be made from the original loan pool, but this pool is also needed to pay back the original loans. In order to avoid a large amount of defaults and keep the system stable the money supply has to constantly increase. This continuously increasing of the money supply is the source of inflation

The basis creates a situation in which the money supply and economy have to keep growing to keep the financial system going. Banks are very vulnerable to losses as they only keep a fraction of their debt. The banks survive on trust and when this trust diminishes, sometimes even insurance on the deposits cannot save them from a bank run.

**Management of financial institutions**
In the last decade in financial institutions there has been a strong emphasizes on bonus systems. Originally bonus systems were put in place to reward employees if they put in exceptional effort and when the institution achieved exceptional results. If used well bonus systems can provide a strong advantage for the company, but unfortunately the bonus systems are usually not implemented well. A faulty implementation can lead to an ineffective system were bonuses are given out while the level of effort is normal or even worse it can lead to a hazardous situation for company due to profit maximization of the employees. Managers in financial institutions tried to maximize their bonuses by trying to make huge short term profits, at the expense of a very high medium and long term risk. The results of these actions would only show a few years later when the manager collected his bonuses already and couldn't be held accountable anymore. This is one of the reasons that the financial institutions started to work with a very high leverage and traded in a large amount of risky assets and risky derivatives, which all resulted in huge short term profits.

## 4.5 Principal – Agent Problems in the financial crisis

In the originating of the financial crisis there are principal-agent problems visible in the different layers throughout the mortgage chain. This relationship chain is visualized in Figure 4.1. In the diagram we have the actors mortgage borrower, mortgage lender, investment bank, government, rating agency, financial institution and customer. Between those categories and even within those categories we can find the following principal-agent problems, which are also shown in the diagram with their corresponding numbers.

1. Mortgage borrower and lender (two-sided problem)
2. Mortgage lender and investment bank
3. Investment bank managers and stockholders
4. Investment bank and government
5. Investment bank, rating agencies and investors
6. Investment bank and financial institutions
7. Financial institutions and creditors
8. Financial institutions and customers / investors

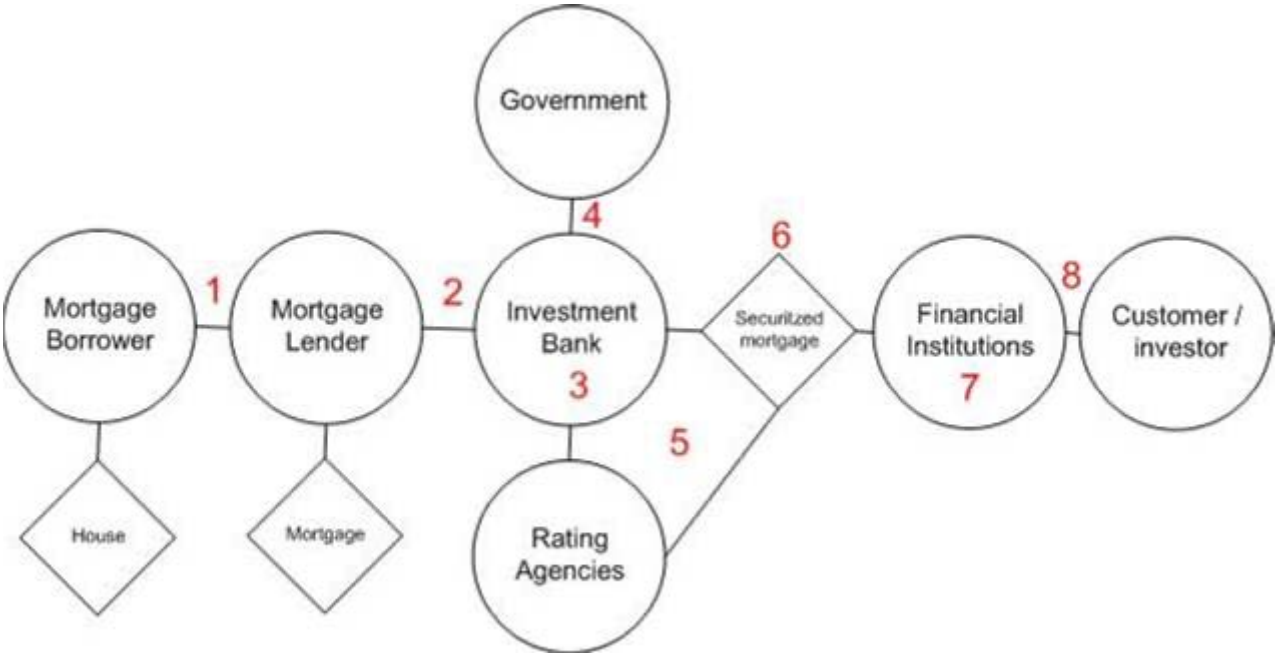


**Figure 4.1: Principal-Agent relationship chain in the financial crisis**

### 1. Mortgage borrower and lender (two-sided)

The borrower receives the mortgage loan from the lender. He is required to pay back this mortgage within a certain time period and with variable or fixed interest rate payments. In this relationship with the mortgage lender, borrowers committed adverse selection and moral hazard. As the conditions for given out mortgages were relaxed the borrowers got in the positions to withhold or falsify information. Information wasn't verified and often there were no signaling requirements as borrowers could easily choose another mortgage lender for the loan. In this way they could hide their financial position and thus get a more favorable mortgage. After getting the mortgage they had an easy way to commit moral hazard. In most of the states in the US mortgages are non-recourse, meaning that the borrower could default on his mortgage in which case he would only lose the house. This means that if the house price falls under the mortgage level he will default on his mortgage to avoid a loss. So if the

housing price increased the borrowers would make a profit and if the housing price would decrease they wouldn't have to bear the loss. This also means that when the housing price hasn't increased maintenance and insurance risks are at the side of the mortgage lender. As a result of this, after defaulting the houses are usually in a very bad shape. There were also more creative practices in which mortgages borrowers would default on their loan after a housing price decline and then proceed to buy their neighbors house or they would buy multiple houses and rent those out.
The mortgage lender didn't have to bear the risk of defaulting of the borrowers as they would resell the mortgages. This puts them in the position to make irresponsible loans like the ninja-loan, as they could just aim to maximize the amount of mortgage loans given out. As many Americans were 'socially pushed' to buy a house and many were financially illiterate it was very easy for the lender to put irresponsible mortgages at them in which they would pay a low rate the first few years after which they had to pay very high rates.

The solutions for these principal-agent problems are not complicated to design. We need to make both parties accountable for their actions. We can make the borrowers accountable by removing the non-recourse on mortgages, which means that after selling the house the mortgage borrowers might still have a residual debt. This encourages them to maintain the house well, think carefully about the financial aspects of the mortgage and it removes profitable defaulting opportunities.
We can make the mortgage lenders accountable for their actions by requiring them to keep a certain amount (possibly 10%) of each mortgage, so they can only resell 90%. This puts them in a situation that they cannot afford to make irresponsible loans anymore. This is not enough yet as they would still be able to profit from irresponsible interest rates if the non-recourse on the mortgages is removed. There need to be a stronger consumer protection from the federal government, this can be in the form of a federal regulator for all mortgage lenders that sets up a suitability standard for mortgages and makes sure that the future mortgage borrowers are well informed of the risk.

**2. Mortgage lender (A) and investment bank (P)**
The mortgage lender was able to make these irresponsible and very risky mortgages as he was able to resell them quickly to investment banks and other securitizers, in which case he wouldn't bear any risk anymore. To sell the mortgages to securitizers the only information the mortgage lender needs are the loan-to-value ratio (size of loan vs. the assessed value of the house) and the FICO score (credit score) of the mortgage borrower. The quality of this information was very doubtful, because it could be manipulated by pushing property assessors to value the house higher and optimizing the FICO score just before mortgage application. Information about income or job stability were not asked and not given out. This caused the investment banks to overestimate the quality of the mortgages.

Again this principal-agent problem can be solved by making the mortgage lender accountable for his actions. If he is required to hold on to a fraction of the original mortgage loan he will not be able to make irresponsible loans and sell them, as he will make a loss on the fraction he needs to hold. Here is also room for a federal regulator to require standardized mortgage contracts and independent verification of the mortgage information, which makes it more difficult for the mortgage lender to hide the characteristics of the mortgage he is reselling.

**3. Investment bank managers (A) and stockholders (P)**
The incentives of the managers in the financial institutions were not aligned with the incentives of the shareholders. The stockholders are interested in optimal strategies to make the company most profitable in the long run, which will maximize their stock value and dividends. But as mentioned in Chapter 4.4 managers maximized their utility in the form of bonuses by trying to make huge short term profits, at the expense of a very high medium and long term risk. After receiving the bonuses the managers are not accountable anymore for their risk seeking behavior. The short term strategies that were employed before the financial crisis resulted in a strong stock value decline during the crisis.

This is a more persistent principal-agent problem, which mostly depends on the quality of the payment scheme for managers. If these schemes are well-designed and bonuses are attached to long-term profits or good risk management then the problem will be much smaller. A possible measure would be change the cash bonus to a stock bonus, which they are required to hold for at least four to five years. This would add more uncertainty for the managers, but their current and future performance can improve the value of this bonus significantly. Now they will focus more on the medium and long term benefit of the company, as that will improve their stock value. Next to this measure, the managers' incentives can be even more aligned if we let the bonus depend on their performance in a certain range of years, for example five years. In this way they are even more inclined to move away from short term strategies. A last addition would be to give risk managers more power within the companies. This way there will be more emphasizes on the control of (extreme) risks which is more beneficial for the long term profitability of the institution.

**4. Investment bank (A) and government (P)**
The government is responsible to set up regulations and regulatory agencies in order to protect the financial system and its users. The US government didn't set strict regulations to protect the US mortgage borrower and to restrict the possibility of irresponsible mortgages and neither does it pose strong requirements on investment banks. Still there is an indirect principal-agent problem between the government and the investment bank; it is indirect as there isn't any contract or deal involved. The large financial institutions are major employers and very important for a stable financial system. Their importance gives them the opportunity to commit moral hazard on the government because they know they are 'to big to fail' or 'to entangled to fail'. They can take huge risks and in the end they won't be held accountable for it, or only to a lesser extent, because they count on the government to bail them out. The consequences can be far reaching and in no one's best interest if the financial institutions would go bankrupt.

As this is currently an indirect principal-agent problem the government should make it direct, by putting regulations on the investment banks. The regulations should focus at the stability of the bank and at a reduction of extreme risks. The leverage ratio is the easiest target of regulation as a reduction of the leverage will reduce the shocks of asset losses on the equity. They can target liquidity requirements by requiring putting an economic capital requirement on investment banks. This would be a certain amount of the assets (maybe 10%) to have a high liquidity, for example cash or short-term credits. This way if the company cannot refinance its debt, it will still be able to be solvent until more assets can be sold or new debts can be taken. To make the financial institutions less risky overall, there should be a push on more standardized securities of which the risk is easier to calculate and which can be compared between the financial institutions. This makes it much harder for an institution to get in the situation where they cannot asses their own risk anymore.

**5. Investment bank (A), rating agencies (P&A) and financial institutions (P)**
This principal-agent problem is two-fold, there is a direct relationship between the securitizer and the rating agency and an indirect relationship between the rating agency and the investor of the rated security. The rating agency should be an independent authority that provides investors with accurate ratings on securities, but instead they allowed themselves to be heavily influenced by the investment banks. Investment banks are in the position to negotiate the ratings of their securities and have the possibility for window shopping between the rating agencies. This requires the rating agencies to be more flexible in their rating process, which resulted in higher ratings on the securities and thus an underestimation of the risk. Their interests were more aligned with the investment bank rather than with the investors, who were unaware of this issue. This is a form of moral hazard from the rating agencies on the investors.

This principal-agent problem is more complicated to solve. The focus should be on the conflict of interest between the rating agencies and the financial institutions that want to buy securities. It is not possible to eliminate this conflict by requiring the investors to pay for the information of ratings rather than the investment bank to pay for the rating process; because once the rating is given out to one investor the information is out in the open. A solution to this problem would be to put a government agency between the securitizer and the rating agencies. The securitizer would have to contact the government agency to start the rating process. The government agency can negotiate standard fees with the rating agencies and will only act as gateway. The advantages of this are that the rating agencies will get securities which cannot be traced to their source company, so they won't be in the position to be influenced by the investment banks. Besides this there will be a standard fee and standard rating process which also cannot be influenced. This will keep the interests of the rating agencies more align with the investors.
If there would also be a government push for more standardized securities, it would be easier for investors to compare the securities of the different securitizers. This opens the opportunity for window shopping and it will be easier for investors to do their own risk assessments of the securities.

**6. Investment bank (A) and financial institutions (P)**
We already know that the investment banks put the rating agencies in a position to commit moral hazard on the financial institutions that buy the securities of the investment bank. Next to this, they committed adverse selection by hiding this information and the true risk of the securities from the financial institutions that would buy their products. These securities were already covering up the real risk of the mortgages and now they seemed to have even a lower risk. The investment banks were also involved in moral hazard as they were not accountable for their actions.

We can solve this principal-agent problem again with solutions we mentioned before. We have to make the investment banks accountable for their risky products, which we can achieve by requiring them to hold a fraction of each security. If these securities are also standardized it will make risk assessment and risk comparison by investors easier.

**7. Financial institutions (A) and creditors (P)**
Many financial institutions relied on short term debt to fund their assets that got provided by creditors, which were mainly other financial institutions. As the (perception of the) gravity of the financial crisis increased it became more and more unclear who was exposed to large amounts of bad mortgages. Due to the information asymmetry between the financial institutions and their creditors, the willingness to extend credit diminished quickly. Eventually it became almost impossible to receive any credit, which caused serious problems for institutions that relied on short term debt, hence the name credit crisis.
The difficulty to gain any credit was a very serious issue of adverse selection. The type of the financial institutions that asked for credit was not visible for the creditors and most of the times it wasn't even visible for themselves, as they had no idea how risky their assets of securitized mortgages were. There was no credible possibility to signal a good type, and bad types wouldn't get any credit at all, because they had a very high chance to default.

This is a very difficult principal-agent problem to solve; as they are no ways for the financial institutions to give out a credible signal of their health. What the government can do instead is to provide large loans for the financial institutions. The government is willing to carry this risk, as it aims to protect the financial system from collapsing. In many cases the government would put extra requirements for performing these bailouts. The requirements included a mandatory amount of loans made to other institutions during a set amount of time, a reduction in risk and leverage and sometimes it targeted the management's payment schemes.
The US government launched the TARP program, which had the original aim to remove the bad mortgage assets from the system by buying them and putting them in a government agency. Instead the TARP was used to buy new emissions of company shares and to provide large loans. If the size of the bad mortgages wouldn't have been so big it would have been possible to restore the trust between financial institutions in this way, but it would be at the expense of the (future) taxpayers as they would have to bear potential losses on the mortgages.

**8. Financial institutions (A) and customers / investors (P)**
This same adverse selection took place in the principal-agent relationship between the financial institution and its customers and investors. It was very difficult for the institutions to prove that they were still in a good shape and the only thing that prevented massive bank runs and a collapse of the financial system was the government guarantee on deposits. Investors weren't so lucky to have this protection and tried en masse to sell their stocks. This caused a huge decline in stock prices for all financial institutions, including the 'healthy' ones as they could not signal their type.

The financial institutions were not able to solve this principal-agent problem either. The governments prevented most bank run by adding (or increasing) the deposit insurance, which guaranteed that the depositors would get their money in case the bank would go bankrupt. They tried to protect the investors by banning short-selling for a certain period of time. Short-selling is a speculation on the decrease in the stock price of a company, which is a practice that can drive the stock price down. Besides this they prevented stock from getting worthless by supporting the financial institutions so they wouldn't go bankrupt.

# 5 Conclusions and recommendations

Principal-agent problems were very present in the financial crisis that started in 2007. They originate from the information asymmetry between the principal and the agent. The problems made it possible for mortgage borrowers, mortgage lenders and investment banks to maximize their profits without being accountable for the risks of the mortgages. Their unaccountable actions lead to the spread of a large amount of sub-prime mortgages throughout the financial system. These mortgages were covered up by complex financial structures and got high ratings which made them look like a very safe investment. After the housing bubble bust, it became clear that the risks of these securities were much higher than expected the credit markets collapsed.
Most of the principal-agent problems in the financial crisis require government regulations to be solved, as players are not willing to give up profitable opportunities. The government solutions should aim at protecting the financial illiterate, making all parties accountable for their actions and providing transparency in the financial markets.

The following actions should be taken by the US government:

- Standardize mortgage contracts and borrower information and add a suitability requirement on mortgages to protect the financial illiterate mortgage borrowers.
- Remove non-recourse mortgages, which will make borrowers accountable for the quality of their houses, removes default opportunities and forces them to pay more attention to the financial aspect of the mortgage.
- Require mortgage lenders to hold on to a part of each mortgage, which makes it unprofitable for them to provide irresponsible mortgages.
- Regulate the leverage ratio and economic capital of investment banks. This makes the investment banks less vulnerable to asset losses and credit crunches.
- Push for more standardization of the derivatives market, which makes it easier to regulate, comprehend and asses the risk of derivatives.
- Require securitizers to hold on to a fraction of each security, to make them accountable for the real risk of the securities.
- Set up a gateway between rating agencies and their customers, which protects their independency and which aligns their incentives with those of the investors.

The following actions should be taken by financial institutions:

- Put more focus on and power to risk management, to prevent a focus on risky short term strategies
- Don’t invest in assets you don’t understand and don’t take the word of your agent for granted, research his claims (about risk).
- Think carefully about information and the incentives of the party that is providing them.
- Optimize the payment schemes by emphasizing stock bonuses and multi year performances, so that long-term strategies are pursued by the management.

These measures could have prevented the financial crisis in its current form, but this is easily said in hindsight. The difficulty is to prevent future crises from happening, which will undoubtedly be in an unexpected area. The best way to protect yourself is to do extensive risk analysis, keep a good margin for error and to always focus on the incentives of your counterparties. When they are not accountable for their actions and you cannot verify their information, don’t trade.

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