SYM-OP-IS 2025
52nd Symposium on Operational Research
Palić, 7 - 10.9.2025.

UNIVERSITY OF BELGRADE
FACULTY OF ORGANIZATIONAL SCIENCES

Original article **https://doi.org/10.5281/zenodo.17533648**

MORAL HAZARD IN THE 2008 FINANCIAL CRISIS

ĐORĐE MIRKOVIĆ[1], OGNJEN NIKOLIĆ[2], MARIJA KUZMANOVIĆ[3]

[1]University of Belgrade, Faculty of Organizational Sciences, Belgrade, djordjemirkovic001@gmail.com, 0009-0007-2232-8428
[2]University of Belgrade, Faculty of Organizational Sciences, Belgrade, ognjen.nikolic@fon.bg.ac.rs, 0000-0003-0756-4290
3University of Belgrade, Faculty of Organizational Sciences, Belgrade, marija.kuzmanovic@fon.bg.ac.rs, 0000-0001-5857-6932

Abstract: *Moral hazard refers to a situation where an actor takes excessive risks without bearing the consequences. It is particularly harmful in principal-agent relationships, where the agent exposes the principal to greater risk. Such patterns were evident in the financial system during the emergence and peak of the 2008 crisis. The aim of this paper is to model these interactions and assess the extent to which moral hazard contributed to the crisis, with emphasis on securitization, banks that are "too big to fail", and conflicts of interest of credit rating agencies. The methodology involves three dynamic Bayesian game models: the relationship between lenders and borrowers, between investment banks and the state, and among banks, rating agencies, and investors. The conclusion is that, although moral hazard played a significant role, it was not the sole cause of the crisis. Combined with weak regulation and the complexity of the financial system, it highlights the need for deeper examination to prevent similar issues in the future.*

Keywords:*, moral hazard, 2008 financial crisis, game theory, banking, loans.*

1. INTRODUCTION

In mid-2007, the economy of the United States and other major world economies stood on the brink of the worst financial crisis since the Great Depression of the 1930s. As in that earlier period, this crisis led to the collapse of major financial institutions, a deep global recession, and drastic measures by governments around the world to mitigate the economic consequences of the financial system's collapse (Rose & Marquis, 2011).

The key causes of this crisis included the process of mortgage loan securitization, the deregulation of the financial market, the creation of extremely complex financial derivatives, and the belief that the real estate market would never decline. However, among the most important causes, moral hazard stands out in particular. Moral hazard is a situation in which actors take greater risks because they do not bear the consequences of their decisions. This problem is the result of information asymmetry, a scenario in which one participant in the game possesses hidden information, creating room for suboptimal and potentially harmful outcomes. A common example of moral hazard can be seen in the health insurance market, where insured individuals are more prone to riskier behavior that increases the costs of the healthcare system. Moral hazard manifested itself on multiple levels during the 2008 financial crisis, producing outcomes harmful to society (Murray et al., 2017). During the financial crisis, moral hazard appeared on several levels: lenders securitized mortgage loans, packaging them into securities and selling them to investment banks. Lenders no longer bore the risk of mortgage default and thus approved loans to risky borrowers. Investment banks believed that the state would bail them out in the event of collapse, which encouraged excessive risk-taking. The bankruptcy of Lehman Brothers, for example, triggered a domino effect. Credit rating agencies, due to their dependence on banks, assigned excessively high ratings to risky products, further reinforcing risky behavior by banks.

The aim of this paper is to determine to what extent moral hazard contributed to the financial crisis. This will be done by modeling the relationships between actors during the crisis using game theory, with a focus on three dynamic Bayesian games: the lender–borrower model, examining how lenders extended credit to risky clients, the investment bank–state model, explaining why banks were prone to excessive risk, and the investment bank–credit rating agency–investor model, analyzing how conflicts of interest in rating agencies encouraged risk. The next section will briefly explain the basic concepts of game theory that will serve as the theoretical foundation for the rest of the paper.

2. MORAL HAZARD ANALYSIS

The first step in analyzing moral hazard is to identify the actors and their interactions within the financial system. This paper will use Ferguson's model (**Figure 1**) of player interactions in the financial system, which he calls the securitization food chain. Ferguson describes this model as "an industrial supply chain for generating mortgage loans and selling them to investment banks. The investment banks then package these mortgages into structured investments that they sell to various investors, including pension funds, hedge funds, and other institutional investors. This supply chain integrates virtually every segment of the financial system" (Ferguson, 2012).

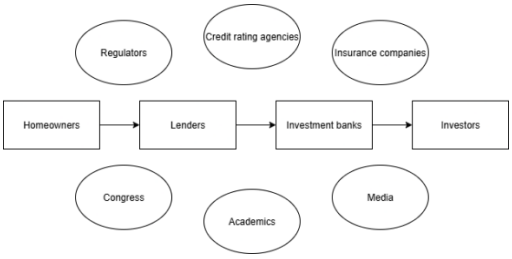

Figure 1: Ferguson securitization food chain (Ferguson, 2012)

Since the aim of this paper is to identify moral hazard, the interactions described above will be used to construct games through which the impact of moral hazard will be analyzed. The proposed models are as follows: the borrower–lender interaction model, the state–investment bank interaction model; and the investment bank–credit rating agency–investor interaction model.

The reason these interactions are not presented within a single model lies in the complexity of such a model. Moreover, while the payouts of one actor's decisions are influenced by the actions of all others, the players in these models exert the greatest influence on each other. Now, the players and their relationships with the actors in the real system will be briefly explained, and then the individual models will be presented.

Homeowners are individuals or families who take out mortgage loans from lenders. Although in practice there are different types of lenders, in this paper they are viewed as a homogeneous unit whose only role is to grant loans. Investment banks buy these loans, package them into securities and sell them to investors, while credit agencies assess the risk of these securities. In the model, the state can bail out the bank to prevent its bankruptcy, and investors (pension funds, individuals, banks) generally choose low-risk instruments

3. STATE AND INVESTMENT BANK INTERACTION MODEL

The model in **Figure 2** shows the interaction between banks (player B) and the state (player D) through a staged dynamic Bayesian game lasting an unlimited number of periods, and **Table 1** symbols used in the model. At the beginning of the game, "nature" determines the type of state with probability p: whether the state prefers to save the bank (Type 1 – Save) or not (Type 2 – Let Fail). Then the bank chooses the risky strategy (R), which increases the chances of higher profit but also of failure, or safe (S), which reduces risk. It is important to note that the probability of bank failure also depends on the risk of other banks due to their interconnectedness. After the bank chooses a strategy, "nature" decides whether the bank fails or not. If the bank survives, the game continues to the next period T+1, and the game information is updated. If the bank fails, the state decides whether to save it (strategy S) or let it fail (strategy P).

The game ends in the event of a crisis, regardless of the state's decision, because the bank either disappears or is under significant state control. The reason for introducing the "nature" player is that this is a signaling game in which the state wants to signal that it will not always save banks to discourage them from excessively risky behavior. Through this game, banks form beliefs about whether they will be saved, which is based on the long-term reputation of the state. Bank owners aim for higher profits through dividends but must ensure the bank's survival, because in the event of failure without state intervention they lose their invested capital. When deciding on a bailout, the state weighs the economic consequences, bailout costs, political costs, and impact on its reputation. Frequent bailouts encourage banks to take greater risk, which is a key aspect of this dynamic interaction.

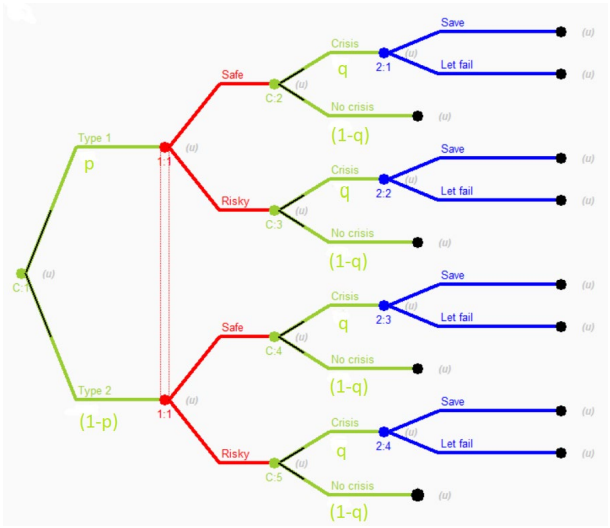

Figure 2: Bank-state interaction model

Table 1: Symbols for Bank-state interaction model

R	Risky strategy
S	Safe strategy
p	Probability State is type 1
q	Probability of crisis
A	Bank payout if fail
B	Bank payout if it doesn't fail
U	Total Bank payout
V	Total State payout
A1	Bank payout if it's saved
A2	Bank payout if State let's it fail
B(R)	B if Bank played R
B(S)	B if Bank played S

Moral hazard in this model represents a situation where banks behave risky because they know the state will bail them out. The equilibria leading to this situation are (Risky, Save) and (Risky, Let Fail) because regardless of the state's decision, there will be negative consequences. The question is how high the probability p must be to avoid this equilibrium. The general formula for the bank's total payoff in one stage is:

$$D = q * A + (1 - q) * B \tag{1}$$

The bank's payoff is calculated by multiplying the probability of bank failure by the respective payoffs. $B(R)$ is greater than $B(S)$, but q also increases when playing R. The higher the q, the greater the share of A in the final payoff. It is important to note that B is always greater than A. This is because B represents the bank's payoff in normal operations, while A represents the scenario where the bank fails. Even if the bank is bailed out, the bank owners will not profit from it but will simply avoid losing money. From this, it can be concluded that the bank can play the risky strategy if the value of q is not high enough for A to start reducing the total payoff. The formula for the bank's payoff in case of failure:

$$A = p * A1 + (1 - p) * A2 \tag{2}$$

The bank's payoff in case of failure depends on the type of state and is calculated by multiplying payoffs with the corresponding probabilities. If the state is Type 1, it prefers to save the bank, so the $A1$ is higher. Conversely, if the state is Type 2, it does not prefer to save, which results in a large loss of $A2$, which may be a negative value. The value of $A1$ is lower than any value of B (payoff in case of survival), but $A2$ is a huge loss. Therefore, for the expected value of A to be acceptable, the probability that the state is Type 1 must be very high. The conclusion is that banks' belief that they will be saved leads to a worse equilibrium because it encourages risky behavior. However, the model also considers the probability that the bank will not fail. If that probability is sufficiently low, the bank may play risky even without the state's guarantee of a bailout.

4. INVESTMENT BANK, CREDIT RATING AGENCY AND INVESTOR INTERACTION MODEL

Proposed model of interaction among investors, credit rating agencies, and investment banks as a dynamic Bayesian game is given in **Figure 3**. The game takes place over a period T. During this period, we observe the interaction of three rational players in a game with incomplete information. Within period T, the bank purchases a certain quantity of mortgage loans of variable quality from lenders. Nature assigns an aggregate value to this mortgage package as safe or risky. Based on the chosen strategy, the bank creates securities whose quality is assessed by the credit rating agency. Investors decide whether to invest based on the rating (safe or risky). In each period, the bank receives a new amount of mortgage loans whose risk changes over time.

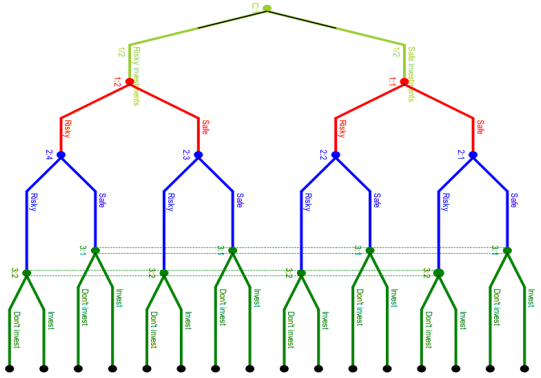

Figure 3: Bank, credit agency, investor interaction model

The game begins with nature determining, based on probability p, the quality of the mortgages forming the basis of the securities the bank offers and sells to investors. In the early stages of the game, mortgages represent safe and stable investments because loans were granted to people capable of repayment. As time passes and the volume of approved loans increases (also influenced by the bank's choice of a risky strategy), loans are given to people who cannot repay them, and thus mortgages become increasingly risky. The proposed model then branches into two subgames, depending on whether nature selected a risky mortgage outcome or a safe mortgage outcome. The model assumes investment bankers have insight into the true risk level of these financial instruments. After nature, the bank chooses a risky (r) or safe (S) strategy. The safe strategy means creating instruments based on safe mortgages, while risky means creating riskier and more complex instruments.

Next is the credit rating agency player, which can either rate the investment as risky, or to rate is as safe. The model assumes credit rating agencies have perfect information regarding the risk of the security. The credit rating agency must rate the instrument according to its true risk. If the bank plays risky, the instrument will be risky and should be rated as such. Conversely, if the bank plays safe, the instrument should be rated as safe. The last step in this game is the investor's choice to invest or not in the security offered by the bank. The only information the investor has about the risk of the financial instrument is the credit rating agency's rating, on which they base their decision.

The bank's payoff depends on three factors: the price of selling a single security, the quantity of securities sold, and non-monetary factors, such as moral beliefs, reputation, and others. The payoff formula is:

$$D = c * Q - \mathrm{B} \tag{3}$$

where D is the bank's profit, c is the price of a single security, Q is the quantity sold, and B are the non-monetary factors.

There are additional factors to consider. First, if the security is riskier, it carries a higher yield and its selling price is higher, but investors are less likely to buy such securities. On the other hand, some non-monetary factors, like moral belief, may lead the bank not to play risky. Second, there is a collective action problem. If competitors sell risky instruments while the bank sells safe ones, there is a risk of losing market share, further reducing payoff. Third, if the majority of issued mortgages are risky, payoff from the safe strategy is lower because the bank must issue fewer securities, reducing total payoff.

Credit rating agencies are funded by investment banks that create the financial products, not by investors. This creates a potential conflict of interest because banks that hire credit rating agencies have an interest in their securities receiving high safety ratings to attract investors. The payoff function also includes non-monetary factors such as moral beliefs, reputation loss, and similar aspects. There is potential for a collective action problem, where if one credit rating agency refuses to rate a bank's securities as safe, that bank may go to another credit rating agency.

Because the investor cannot know whether a security is truly safe or risky, the model assumes the dominant strategy of the investor is to buy if safe, or not buy if risky.

Moral hazard in this model represents a situation where the bank behaves risky. Its risky behavior leads investors to buy securities that have a risk of default. There are two potential reasons for this: first, the bank believes the credit rating agency will always rate its security as safe, second is that the bank believes all other banks play risky and that it would lose too much if it does not also play risky, resulting in a large loss of market share.

The game will be analyzed through two scenarios depending on the credit rating agency's strategy. The first scenario assumes the credit rating agency always plays "Safe," while the second assumes it gives an accurate rating. In reality, there is a possibility, which this model ignores, that the agency intends to give a correct rating but there is some probability of error.

Initially, the assumption is that the credit rating agency will always rate the security issued by the bank as safe. If the bank believes this, by backward induction it can realize that the investor's dominant strategy is to buy the security. Therefore, the bank can play risky and increase its payoff without fear that the investor will not buy. This conclusion relies on two key assumptions. The first is that the profit from sales ($c * Q$) exceeds the loss from non-monetary factors (B). The second is that the profit from selling securities under the risky strategy exceeds the profit from selling securities under the safe strategy. This is because the quantity of securities sold (Q) remains the same while the price per security (c) increases. Without the assumption about the credit rating agency's actions, the bank would balance increased profit per security against a reduction in the number sold. This situation represents moral hazard because the bank increases the risk for investors and the entire financial system without bearing the full risk itself. An additional factor in this scenario is that even if the bank wants to play safe (high value of non-monetary factors), payoff can decrease further due to loss of market share. Assuming non-monetary factors can be neglected, the bank's dominant strategy will be to play risky.

In the second scenario, assuming the credit rating agency will rate the security correctly, the bank's strategy changes and depends on whether it pays off to sell fewer securities at a higher price.

The conclusion is that if a conflict of interest existed in credit rating agencies, it contributed to the financial crisis. Also, if it did not exist, the collective action problem of investment banks likely created undesirable effects.

5. BORROWER AND LENDER INTERACTION MODEL

A proposed model of a dynamic Bayesian game involving a borrower (the actor taking the loan) and a lender (the actor granting the loan) is given in **Figure 4**, with the payout symbols used in the model in **Table 2**. The model incorporates certain elements from the works of Medak (2009) and Luo & Zhang (2010). The game begins with nature's decision on the type of borrower: a safe borrower has a high credit score and a high probability of repayment, while a risky borrower has a low score and a higher risk of default. The lender identifies the borrower's type based on the submitted documentation and decides whether to grant the loan. The interest rate for risky borrowers is higher and often variable, while safe borrowers receive a lower, more stable rate. The borrower always accepts the offered loan, and their strategy is to either repay it or default.

The model introduces two global variables: the rate of property price growth (A) and the interest rate (B). These change during the crisis so that property prices grow for a long period and then suddenly drop, while interest rates rise after the central bank raises the discount rate. Borrower payoffs depend on the situation: if the loan is not granted, the payoff is zero; if it is granted and repaid, the payoff depends on the subjective cost of interest (SK) and the relative property value (VN) according to the formula:

$$C = SK - VN \tag{4}$$

A high SK reduces the payoff, while a high VN increases it, making repayment possible even through selling the property. These values are influenced by the borrower's type, the interest rate (B), and property price movements (A). If the borrower does not repay the loan, their payoff is D, which includes reputational, psychological, and moral loss.

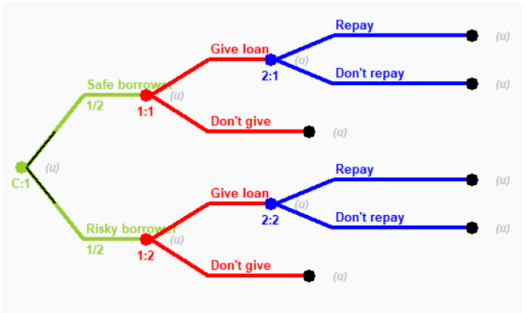

Figure 4: Borrower-lender interaction model

Table 2: Payout symbols for borrower-lender model

Before securitization		
	Repay	Don't repay
Z	B	F
D	C	D
After securitization		
	Repay	Don't repay
Z	G	G
D	C	D

Moral hazard in this situation occurs when the lender grants loans to risky borrowers because they do not bear the risk of their default. In the pre-securitization model, the bank's payoff can be the resale of the

property (F) or interest income (B), depending on the borrower's strategy. Since interest income is a long-term stable return, B is a better outcome compared to F, as resale of the property is a more difficult process that is more likely to result in a smaller payoff. However, assuming that property growth is high enough, the bank may find both outcomes acceptable. Therefore, it can be concluded that the bank's action depends on two factors. First, whether property price growth is high enough so that even if the borrower does not repay the interest, the bank will not lose money ($F \geq B$) and second, whether the borrower will choose to repay or not. If $F \geq B$, then the bank can grant the loan in any case. If $F < B$, then the bank considers the second factor—whether the borrower will repay. As noted, the borrower's strategy depends on the cost of interest payment, which in turn depends on three variables: borrower type, interest rate (B), and property price movements (A). Analysis through scenarios shows that at one point, property price growth, and consequently the profit from resale, was so high that lenders found it profitable to lend even to risky borrowers. There was also the presence of a "strategic default" strategy when property value loss outweighed the benefit of repayment. With securitization, lender payoffs become independent of borrower behavior, as loans are sold to financial institutions. The dominant strategy is to grant loans ($G > 0$), even to risky borrowers, leading to a non–Pareto optimal equilibrium. In conclusion to this model, securitization fostered moral hazard, but rising property prices also played a major role by enabling riskier behavior and short-term gains. Moral hazard also arises among borrowers who choose to default when penalties are low.

6. CONCLUSION

The aim of this paper was to model the interactions of financial market participants relevant during the financial crisis and analyze the occurrence of moral hazard. Using concepts from game theory, particularly Bayesian games and information asymmetry, the study examines the securitization chain, from lenders granting mortgages to borrowers, to investment banks repacking them into securities sold to investors, with credit rating agencies signaling their safety and the state acting as a potential rescuer.

Three models were developed: borrower–lender, investment bank–state, and investment bank–credit rating agency–investor. The borrower–lender model shows that, besides securitization, the housing market boom made lending to risky borrowers a dominant strategy, while some borrowers exhibited moral hazard by choosing not to repay despite having funds. The bank–state model indicates that bailout expectations encouraged risky behavior, especially when the bank's probability of failure was low.

While the paper focuses on the most evident moral hazards, others exist also existed in managerial bonuses, political corruption, academic conflicts of interest, and more. Future research could integrate additional crisis elements, merge and refine the models, and design mechanisms to prevent moral hazard and conflicts of interest in financial market interactions.

LITERATURE

Ferguson, C. H. (2012). *Predator nation: Corporate criminals, political corruption, and the hijacking of America.* Crown Currency.

Luo, Q., & Zhang, S. (2010). The Analysis of Mortgage under the Subprime Crisis Based on the Evolutionary Game. *In 2010 International Conference on E-Business and E-Government*, 4712-4715.

Medak, D. (2009). A Case for Government Enforcement: A Game Theory Analysis. *Undergraduate Economic Review*.

Murray, N., Manrai, A., & Manrai, L. (2017). The financial services industry and society: The role of incentives/punishments, moral hazard, and conflicts of interests in the 2008 financial crisis. *Journal of Economics, Finance and Administrative Science*, 168-190.

Rose, P. S., & Marquis, M. H. (2011). *Financial institutions and markets.* New York: McGraw-Hill.