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A Game Theoretical Analysis of Financial Crisis

Fraydoon Rahnamay Roodposhtil
Department of Business Administration, Islamic Azad University Central Tehran Branch, Tehran. Iran.
rahnama@iau.ir

Mostafa Goudarzi
Department of Business Administration. Islamic Azad University Central Tehran Branch, Tehran. Iran.
m.goudarzi@iauctb.ac.ir

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Abstract

This paper proposes a game-theoretical framework to clarify some element causes of financial crisis and explain some actions which central banks and governments have applied them to restrain the crisis. This paper first explains causes of crisis in framework a game between banks and people who get mortgage from them. The game theoretical analyze explains why people relinquish their house and don't repay their loan and also explain why the banks confiscate the house as soon as the lender don't repay one installment. Next game has been discussed between two countries to explain why governments prefer to guarantee the deposits. Furthermore, we have analyzed injecting liquidity into the market in two ways to explain why some countries pump liquidity into the market and some Other doesn't do it and also in where two states have been resulted as equilibrium, we have calculated probability of each state using mixed strategies framework.

Finally, we have provided a comprehensive discussion to analyze all examined events and that how these events prompt involved government to restrain the crisis and also that how they retrain the crisis.

Keywords

financial Crisis, game theory, Nash equilibrium, payoff, mixed Strategy.

1. Introduction

The global financial Crisis Of 2007 and 2008 is a complex and multifaceted process. Its underlying causes shall be attributed to the prevalent excess liquidity or, using the Federal Reserve Chairman Ben Bernanke's term, to the savings glut' in global financial markets, as well as to the un-orderly proliferation of subprime mortgages in the United States, coupled with inadequate liability and risk management practices of financial institutions. Its systemic complexity and far-reaching spillover effects into a wide-range of credit areas, global financial markets, commodity markets and real economy -make this crisis seemingly more different and more multifarious than the previous financial crisis episodes. (Dick & Nanto, 2008)

Proliferation of this crisis can be explained in terms of changeable allocations of the global savings that have become increasingly illiquid. As these allocations move across various asset types, they generate disorderly asset-price bubbles (Furceri & Mourougane, 2009).

Accordingly, this crisis has gone through five distinctive stages. First, it began with the housing bubble in the U.S. that was increasingly inflated by subprime and near prime (so called Alt-A) mortgage lending. Second, it spread into other types of assets and affected not only mortgage companies and specialized investment banks, but also universal banks. Third, it induced the global liquidity crisis accompanied by a massive pullout of liabilities from the most severely exposed banks, i.e. Northern Rock, Bear Stearns and, later, Lehman Brothers, triggering anxiety about possible credit contagion from counterparty risk on the global scale. Fourth, the collapse Of structured investment products, mainly obligations collateralized debt (CDOs), shifted the global liquidity allocations into commodity futures market causing bubble effects in this area as well. Fifth, it reached a zenith in September 2008 with massive shifts of funds into risk-free securities, as Lehman Brothers filed for bankruptcy protection and US investment banking system faced its ultimate demise. (Jickling, 2008)

But when a financial crisis occurs in the exchange market and stock market, what kind of reaction and attitude should be expected from the government?

This issue has caused many debates. One school argues that the government should leave the market alone, and allow the "invisible hand" to automatically adjust the markets accordingly, in other words, intervention government (Furceri unnecessary Mourougane,2009). The alternative argument is that the government should intervene in the markets because they were only destroyed as a result of international speculation and they had subsequently failed to adjust themselves. (Roshan, 2008)

2. Theoretical Framework and Literature Review

The earliest example of a formal game-theoretic analysis is the study of a duopoly by Antoine Cournot in 1838. The mathematician Emile Borel suggested a formal theory of games in 1921, which was furthered by the mathematician John von Neumann in 1928 in a "theory of parlor games." Game theory was established as a field in its own right after the 1944 publication of the monumental volume "Theory of Games and Economic Behavior" by Von Neumann and the economist Oskar Morgenstern, This book provided much of the basic terminology and problem setup that is still in use today. (Brams, 2003)

In 1950, John Nash demonstrated that finite games have always have an equilibrium point, at which all players choose actions which are best for them given their opponents' choices. This central concept of noncooperative game theory has been a focal point of analysis since then. In the 1950s and 1960s, game theory was broadened theoretically and applied to problems of war and politics. Since the 1970s, it has driven a revolution in economic theory. Additionally, it has found applications in sociology and psychology, and established links with evolution and biology. Game theory received special attention in 1994 with the awarding of the Nobel Prize in economics to Nash, John Harsanyi, and Reinhard Selten. (Abdoli, 2008)

At the end of the 1990s, a high- profile application of game theory has been the design of auctions. (Carlsson & Damme, 1993) Prominent game theorists have been involved in the design of auctions for allocating rights to the use of bands of the electromagnetic spectrum to the mobile telecommunications industry. Most of these auctions were designed with the goal of allocating these resources more efficiently than traditional governmental practices, and additionally raised billions of dollars in the United States and Europe.

Game theory is the formal study of conflict and cooperation. Game theoretic concepts apply whenever the actions of several agents are interdependent. These agents may be individuals, groups, firms, or any combination of these. The concepts of game theory provide a language to formulate structure, analyze, and understand strategic scenarios.(Gibbons, (Turocy, 2001)

In this paper at first game lender and borrower Of mortgage have been considered as players and in other player countries which are assumed interdependent have been considered as players of the game. Game' theory has provided a methodology that has lead to insights into many previously unexplained phenomena by allowing asymmetric information and strategic interaction to be incorporated into the analysis (Monderer & Samet, 1989).

This first generation of game theoretic models revolutionized finance but much remains to be explained. Applying Game theoretic methods in finance keep developing and are encompassing many relevant financial areas. Financial crises also have not been excluded from this developing as Lioudmila Savtchenko (2003) has used game theory to explain how financial crisis contagions. (Savtchenko, 2003)

3. Analyzing Recent Events Based

on Theoretical Framework This paper aims to analyze some main recent events and theirs causes by game theoretic framework. Due to the fact that these events and their cause are so complex that all aspect of them is not possible to be considered so we consider main aspect of each events. In other words, before anything we simplify the circumstances so that the mail aspect and causes remains and directs our examination to observed result. [n following section we have analyzed three games so as the first game has been examined as a main cause of current financial crisis and . others explain central banks and government's response to the crisis.

3.1 Lender and borrower game

The first phase of the crisis started when a moderate correction of house prices in the United States triggered a modest increase in mortgage debt delinquencies and a few failures Of financial institutions holding MBS or related instruments in 2007. High uncertainty on balance sheet risks coming from holding unknown amounts of toxic and complex derivatives based on subprime mortgages and from the distributions of losses led to a reaction in money-market liquidity and inter-bank lending premiums in US and European financial markets. Banks announced large wHte-d0W1us both directly and indirectly linked to the subprime mortgage market, both in the United States and elsewhere.

Therefore we examine decision of borrower and lender of mortgage as first game. Each of them has two strategies. First we assume mortgage has been given to lender and she can't repay it because of fixed and high interest rate of mortgage against downward income. In case of lending money and securing it by the collateral of an asset usually there is no concern for lender since if borrower defaults, asset can be repossessed. But this rule is robust when at least there is a creeping inflation in house price and when the increased supply Of house decreases its price there is still concern for banks. Because the borrower has an incentive to not repay excess money for the house which now has less price. So it is probably that the borrower abandons house and defaults. Also the bank prefers borrower repay the loan because the price of house is less than principle and interest of loan. So the bank may give more opportunity to lender to repay the outstood installments. Therefore, at a simple situation there is a game with two player, bank and borrower.

We explain this game as a static and perfect game. Each of players has two strategies.

We examine the situation in that the borrower don't afford repay installment by her income and she has not repaid least one installment of her debt till now In other hand it is assumed that the bank has a lien against the pledged asset. so the bank may do nothing (N) and give more opportunity to borrower confiscate (C). Likewise the borrower

may sell other assets of hers and repay the loan (R) (due to decreased income the repayment is not affordable for 116) or defaults (D).

The best state for borrower is When she defaults (D) and the bank give more opportunity or same do noting (N) and also worst state is when she provides money and attempts to repay loan (R) but the bank attempt to confiscate (C). We assume borrower's utility of best state to worst is a to d and lenders utility of best state to worst is w to z so providing that a>b>c>d and w>x>y>z.

Any two-player game in strategic form can be described by a table like table l, with rows representing the strategies of the bank and columns those of borrower. Each strategy combination defines a payoff pair, like (w,b) for (N,R), which is given in the respective table entry. Each cell of the table shows the payoff to the bank at the (lower) left, and the payoff to player 2 (the borrower) at the (right) top.

Table I shows utility of every state (strategy combination) for each player.

Note that in this strategic form, there is no order between player I and 2 since they act simultaneously (that is, without knowing the other's action).

Table 1

		The borrower	
		R	**D**
The Bank	**N**	**b** **w**	**a** **z**
	C	**d** **x**	**c** **y**

Such this game in game theoretic literature is called prisoner's Dilemma game. In the prisoner's Dilemma game, "default" is a strategy that dominates "repay" for borrower and for the bank "confiscate" is dominant. Strategy C of the bank dominates N since if the borrower chooses R, then bank's payoff is x when choosing C and w when choosing N (note: w>x) if the borrower chooses D, then the bank receives y for C as opposed to z for N. Hence, C is indeed always better and dominates N. In the same way, strategy D dominates R for borrower. The underlined payoff denotes dominant strategy per each strategy of opponent. It is clear that in state (C, D) both players reach to dominant strategy.

No rational player will choose a dominated strategy since the player will always be better off when changing to the strategy that dominates it. The unique outcome in this game, as recommended to utility-maximizing players, is therefore (C, D) with payoffs (y, c). Somewhat paradoxically, this is less than the payoff (w. b) that would be achieved when the players chose (N. R).

This game has a Nash equilibrium in (C. D) which each player earns second worst payoff (c for borrower and y for lender). The central concept Of Nash equilibrium is much more general. A Nash equilibrium recommends a strategy to each player that the player cannot improve upon unilaterally, that is, given that the players follow the Other recommendation. Since the other it is players arc also rational, reasonable for each player to expect his opponents to follow the recommendation as well. This payoff occurs when players decide and act at same time without any knowledge about opponent's decision. Whereas if two players negotiate, they will select IN. R) and finally their utility will rise in this state. In Other words if there is a chance for two player negotiate and furthermore they trust to each other, they can rise their utility but this case requires a key element which this Current crisis has crunched it. It is "Credit". The two player don't select (N , R) due to lack of credit. In other words, they don't trust to each other. For instance if the bank gives more opportunity to the borrower it is probably the borrower doesn't repay. It put off the

confiscating one period later while the price of house is decreasing and it causes more losses for bank. Due to this cause, the bank prefers to confiscate the house as soon as the borrower defaults. Since two players are rational with common knowledge. the borrower is aware Of bank's thinking and prefer to not attempt to provide money for repay installments. Note we assume the borrower has at least one outstood installment so the bank can apply its lien against house.

' If they negotiate before game they can earn best utility but if each of them acts against contract other rival will loss. This distrust direct both players to worst utility in which the borrower doesn't attempt to repay loan as soon as she doesn't afford one installment and alike the bank prefer to confiscate the house. Afterwards. the bank sells the house to refund the loan earlier. Thereby the excess supply Of house decreases its price that it prompts the borrower to not attempt to provide money and alike it prompts the bank to confiscate as soon as possible. This vicious circle continues to make a credit crunch.

3.2 Game of Guaranteeing Deposits

Succeeding the banks confiscated the pledged house, they put them sale but it couldn't refund the entire loan due to the plunged house price. Thereby, all security in US and other countries which were backed by US mortgage earn losses for their owners as Bear Stearns reported significant losses on its investment in US mortgage bond. By the end of June, however, problems cropped up again. The US investment bank Bear Steams reported significant losses on its investments in US mortgage bonds, and two of the bank's hedge funds were in serious trouble. Rumors abounded, and 'subprime' was a word that was much in the minds of market players. In June/July 2007 there were wider than usual market movements. but they were put down to a 'thin and illiquid summer market'. A small German bank (IKB) was the first to report heavy losses on subprime Joans, but others soon did the same. In Au-gust 2007 more banks reported losses. BNP Paribas and German Sachsen LB, among others, reported heavy losses, and the suspicion of banks' exposure to US credit nourished. Confidence in the banks suffered, and funding conditions tightened. The central banks felt impelled to pump liquidity into the markets or guarantee deposit Of their bank to return confidence to the market. Here we assume each country prefers to guarantee the deposits in its Own country rather than inject liquidity into the market We examine these two actions as two different games.

In guaranteeing game, each player earn best payoff when she guarantee (G) all deposits in her own country and in other hand Other player doesn't do such action (U). Because in result Of this situation depositors prefer to withdraw their money from unguaranteed banks and put them into the guaranteed banks. So this situation is worst state for that country which has not guaranteed deposits. Second best state is when both countries don't guarantee their deposits because they take no risk and no benefit. Likewise second worst state is when both players guarantee all deposits in their own territory because neither of them can absorb liquidity from other player's territory while they take a risk.

Therefore, according to game theoretical base of these interactions table 2 shows players' payoff in each state considering two-player game. We consider player I's utilities of best state to worst as a to d and player 2' utilities of best state to worst as w to z so providing that a>b>c>d and w>x>y>z.

Table 2

		Player 1	
		G	**U**
Player 2	**G**	**c** **y**	**d** **w**
	U	**a** **z**	**b** **x**

The reported result is similar to previous game. The game has Nash equilibrium in state (G, G) which indicate the best action for each player is guaranteeing deposits. So given that both players act at the same time without awareness of opponent's decision, they earn second worst payoff c) whereas if they negotiate, they can cam second best payoff(x. b).

If this game is done in dynamic situation in which one of them plays first and other player plays after that the result will be the same providing that they don't negotiate.

The result of this game in static and dynamic state indicates the guaranteeing deposits couldn't absorb liquidity from other country because this action will prompt other country to follow suit and finally all involved country will be in risk.

3-3 Game or Injecting Liquidity

In this game we assume that every government is concern about the impact of crisis on their economy and injecting liquidity into the market is the only solution to restrain the financial crisis. Also it is assumed that either player pumps liquidity into the market, both countries will gain its benefits equally. Given these assumptions, the best state for each player (country) is when it does nothing (N) and its opponent injects liquidity into the market (I).But if neither of them inject liquidity the crisis may disturb their economy severely so this state is worst state for either player.

The second worst state of each player is when it injects liquidity but its opponent does nothing. And second best state is when both of them provide money for the market.

Table 3 shows payoff of each state. We consider a as a best payoff. b second best. c second worst and d as a worst payoff of player 1 and also w,x,z and z for best to worst payoff of and player so that a>b>c>d and w>x>y>z.

Table 3

		Player 1	
		I	**N**
Player 2	**I**	**b** **x**	**a** **y**
	N	**c** **w**	**d** **z**

As table 3 shows, there are two equilibria in this game (N. l) and (I, N) So there is a mixed strategy for *each layer. In other words the best for each player is that she applies two strategies With a probability to maximize her utility.

Solving game shows to maximize utility of both players, player 1 must 'Select Strategy I or N with a probability p and I-p respectively and player 2 must select strategy I or N with probability q and 1-q respectively providing that

$$P=(y-z) / (-w+x-y+z)$$

And since this game is symmetric

$$q= (c-d) / (-a+b-c+d)$$

For example. [f we consider numbers I to 4 in place Of d to a and to ,the game will result that either player selects Strategy I With probability 0.5 and selects N with same probability.

Therefore probability Of either player's strategy depends on utility Of each state for other player. This result demonstrates this fact Why some country is trying to inject liquidity into the market and some others doesn't do it.

If we consider the best state for each player is when both of them inject money instead of one player it and other do nothing, the game is discussed differently. In this case table of payoff will be as following.

Table 4

		Player 1	
		I	**N**
Player 2	**I**	**a** **w**	**b** **y**
	N	**c** **x**	**d** **z**

Here the state (I, I) is Nash equilibrium in which both countries liquidity into the market undoubtedly. This game is firm when community's expectation is important for both countries and they prefer to apply most effort to restrain the crisis rather than expect Others to solve their problem.

4. Conclusion and Discussion

Although modeling real events in simple way and with robust assumptions may illustrate something far from reality but it can vivid some main aspect of events so that the complex events became more understandable.

In this paper we explained some controversial events in current financial crisis using game theoretical framework and in simple way. Although we examined the past event Without forecasting future event but the offered explanation illustrates some main aspect of financial crisis to a base to forecasting future events.

The first game illustrated how the between banks and borrower of mortgage in US direct both of them toward the critical point in which borrower had no willing to repay and banks were in hurry to apply their lien against collateral. Afterwards the vicious circle which aggravated the credit crunch was portrayed. Second and third issues using two-player game explain gov against observed events and portray the governments who guarantee all deposits or pump liquidity into the market how think of their opponents' behavior and how their respond to these thoughts.

Therefore, in general gained results explained Why the mortgage lender confiscate the house. why the abandon the collateral, Why some country prefer to guarantee the deposits and some Other prefer to inject money into the market.

References

1) Abdoli, Gh.; 2008; "Game Theory and Its Application": Jahad Daneshgahi press: University Of Tehran (in Persian).
2) Dick K. Nanto: 2008 "The US. Financial Crisis: The Global Dirnension with Implications for U.S. Policy"; CRS report for congress: Or-&r Code R L 34742.
3) Carlsson, ll. and E. van Damme 1993. Ciarncs and Se lection." Equi librium Econonxtrica 61. 989-1018.
4) Furceri. D and Mourouganc, A.; 2009: "financial crisis: past lessons and policy implications": preliminary version.
5) Glhbons. R.; 1992; Theorv for Applied Economists", Princeton University press. Princeton. New Jersey
6) Jickling Mark: 2008; "Congressional Research Service (CRS) report for congress"; Code RL34412.
7) Monderer. D. and D. Sanrt ;19S9, "Approximating Knowledge with Cornrnon Common Beliefs." Games and Economic Behavior.
8) Pedersen R. E. The Global Financial Crisis"; Jyske Markets.
9) Piazzesi. M, M. Schneider and S. Tuzel (2007). "Housing. Consumption. and Asset Pricing". Journal of Financial Economics 83.
10) Roshan. S.: 2008; "Global Financial Crisis and Effect in Dubai property market": working I.A.U, University paper: .Dubai.UAE
11) Savtchenko. L.; 2003 " Currency Crisis as a Coordinating Device of Heterogeneous Investors"; Graduate School Of Economics. Keio University working paper.
12) Brams S. J. : " Negotiation Games: Applying Game Theory to Bargaining and Arbitration": Rutledge Taylor Francis Group.
13) Turocy L T. 2001: Game Theory": Encyclopedia of Information Systems, Academic Press, appear in 2002.

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تجزیه و تحلیل کاربری تئوری بازی‌ها در بحران مالی

فریدون رهنمای رودپشتی
استاد بازنشسته دانشگاه و موسس و رئیس مرکز پژوهشی مهندسی مالی و سرمایه‌گذاری، تهران، ایران.
Roodposhti.raahnama@gmail.com

مصطفی گودرزی
دانش‌آموخته کارشناسی ارشد رشته مالی دانشگاه آزاد اسلامی واحد تهران مرکزی، تهران، ایران
m.goudarzi@iauctb.ac.ir

چکیده
این مقاله با هدف پیش بینی چارچوب تئوریک نظریه بازیها به تحلیل کاربردی آن جهت شناسایی دلایل وقوع بحران مالی و همچنین نقش بانک مرکزی و دولتها در مدیریت بحران تدوین شده است. در این مقاله چهارچوب کلی یک بازی بین بانکها و مردم که درگیر بحث رهن املاک و مستغلات هستند تدوین و ارائه شده است بطوریکه نقشهای بازی بین بازیگران به ویژه دولت در بحران مالی بطور منظم در این مقاله ارائه شده است.
نتایج پژوهش نشان می‌دهد که بعضی از دولتها و کشورها استراتژی تامین نقد در بازارهای کشور دیگر در تامین اعتبار، نقطه تعادل بازی در بحران مالی را مد نظر قرار دادند. در این مقاله پیشنهادات لازم جهت بازی و مدیریت بحران نیز ارائه شده است.

کلمات کلیدی
بحران مالی، تئوری بازیها، تعادل نش مثلث بازی.