

**Charles University in Prague**

Faculty of Social Sciences

Institute of Economic Studies

**DIPLOMA THESIS**

2010

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Financial Crisis as a Result of Risk Management Failure

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Academic Year: 2009/2010

### Prohlášení

Prohlašuji, že jsem diplomovou práci vypracoval samostatně a použil pouze uvedené prameny a literaturu.

### Declaration

Hereby I declare that I compiled this master thesis independently, using only the listed literature and resources.

Prague, 21 May 2010

Štěpán Minařík

## **Acknowledgments**

I would like to thank my thesis advisor Milan Rippel for supervising my work and for the comments and suggestions that he provided to me.

A special word of thanks belongs to my family and friends for their patience throughout the process of writing.

## Bibliographic evidence card

Minařík, Štěpán, Financial Crisis as a Result of Risk Management Failure: Charles University in Prague, Faculty of Social Sciences, Institute of Economic Studies, 2010, pages 79, Supervisor: PhDr. Milan Rippel

### **Abstract**

In this thesis, we examined time period from year 1993 to 2008 concerning real estate market in USA and coherent risk management decisions and tools used by US government and private mortgage institutions. After qualitative analysis of information resources (financial data, official documents and statements, economic researches and comments), we tested hypothesis of underestimation of real estate price bubble in years 2000 to 2007 by mortgage agencies and US stock market. The tool we used was linear regression (ordinary least squares method) to examine pricing of mortgage-backed securities by mortgage agencies and pricing of mortgage bank Fannie Mae stocks by investors.

### **Abstrakt**

V této diplomové práci jsme zkoumali období v letech 1993 až 2008 z pohledu realitního trhu v USA a souvisejících rozhodnutí a nástrojů řízení rizik používaných vládou USA a soukromými hypotéčnými institucemi. Po provedení kvalitativní analýzy informačních zdrojů (finanční data, oficiální dokumenty a prohlášení, ekonomické výzkumy a komentáře), jsme otestovali hypotézu podcenění realitní bubliny v letech 2000 až 2007 hypotéčnými agenturami a akciovým trhem USA. K této analýze jsme použili jako nástroj lineární regresi (metodu nejmenších čtverců), abychom prozkoumali oceňování cenných papírů kritých hypotékami hypotéčnými agenturami a oceňování akcií hypotéční banky Fannie Mae soukromými investory na akciovém trhu.

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## Introduction

In my master thesis, I would like to focus on financial crisis and its backgrounds, because it is a current topic, which influences every one of us. My aim is to find, what the fundamental causes of financial crisis are and where all involved institutions went wrong in risk management. The main risks I would like to consider are: “Credit risk, Operational risk and Market risk”. I would like to assess the question whether the roots of the crisis are a result of behavior of governments and banks in 21st century, or they stretch more to the past.

I will try to discuss historical facts, events and crisis development with market data (MBS price, real estate price index, unemployment, GDP and other economic and financial ratios). For this purpose I will use statistical and econometrical methods (especially linear regression) to find assess relationship between particular market data and MBS prices.

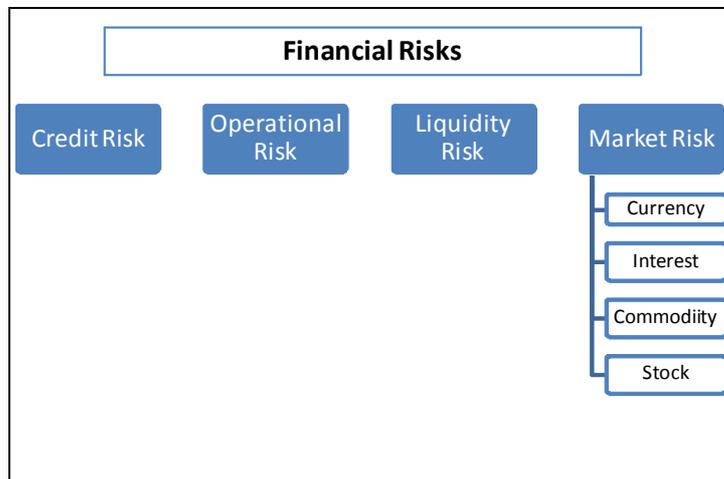
In the first part, I will explain basic background of ideas and practices of risk management in companies with special focus on banks. I will cover four types of risk management that are the most relevant for financial institutions and current economic crisis (credit risk, market risk, liquidity risk and operational risk).

In the following chapter, I will do a qualitative analysis of historical events that led to subprime crisis and global financial crisis. This analysis includes comments from specialists, financial results of companies and reactions of government and their outcomes. As a result, I want to find out what the break points of risk management decision-making that influenced the situation were. In this part, I will pose some statements, which I want to prove in the last part (OLS modeling).

In last part, I will examine investment behavior of mortgage agencies (Fannie Mae and Ginnie Mae). I used software SPSS 17.0 to run linear regression on monthly and quarterly data consisting Mortgage Backed Securities on one side and many economic and financial factor on other side. These results should show what factors mortgage agencies use to evaluate mortgage packages. Second model examines behavior of the market, evaluating stocks of Fannie Mae (the biggest mortgage company). In this model,

I will use the same method and explanatory variables as in first one. The results should explain whether banks and private investors have used proper instruments and approaches to value their assets.

# 1. Risk management



Picture 1 - Financial risks scheme

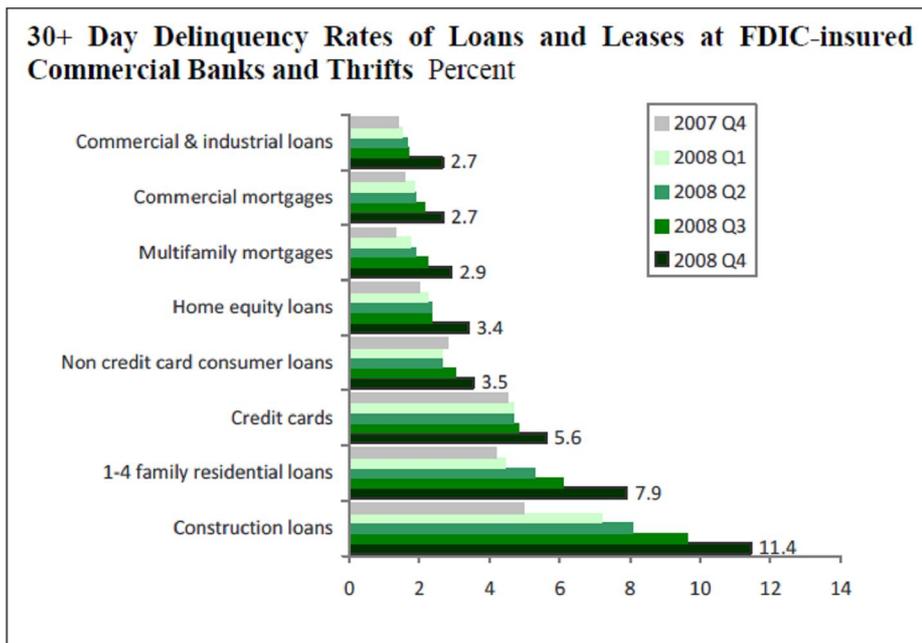
In the first theoretical chapter of my master thesis, I will describe background of solving risk management operations of various kinds. According to the definition, risk management is the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events (D.W.Hubbard, 2009).

Risk management is divided into many parts depending on the object of protection and tools used to diversify. In coherence with current financial crisis the most discussed are for sure credit risk, operational risk, market risk and liquidity risk. I have chosen to describe these kinds of risks and to inquire their effect on financial crisis not only because of its relevance to the problem but because as a financial risks they are easier to quantify than non-financial risks such as Legal risk, Political risk, etc. To describe failures in non-financial risks is not a subject of this thesis.

## 1.1. Credit risk management

Credit risk is uncertainty of situation when counterparty fails to meet its obligations to the subject that became a creditor to the counterparty. Banks usually use very sophisticated fundamental tools to analyze probability of default of the counterparty

and thus set conditions of the contract (interest rate, volume of the credit, etc.). As we can see from Picture 2, delinquency of all counterparts to commercial banks in U.S.A has significantly risen since 2007 and that caused a lot of trouble not only to the banks but also to the insurance companies that insured mortgages (e.g. AIG) and other financial institutions.



Picture 2 (30+ Day delinquency rate, [www.mba.com](http://www.mba.com))

To optimize credit risk banks use specialized departments and technological tools. Necessary components of effective credit risk management could be divided into 5 groups:

**1. Robust technology and business processes:**

Helps companies to efficiently identify measure, manage and valuate risk that counterparty presents.

## **2. Vision, strategy, policy:**

General principles that apply to all credit risk situations. As well as specific principles that are applicable to some countries and types of counterparties or transactions.

## **3. Exposers:**

Competence of banks to reveal forecast and avoid counterparty's exposure across the whole company

## **4. Robust analytics:**

Efficient and accurate credit risk analytics combined with quality timeline of delivery bring detailed information that can be used to balance risk and reward.

## **5. Others:**

There are more essential ingredients in efficient credit risk management such as: transparency, defined credit decision process, stress testing, timeliness and accuracy of risk calculations as well as efficient credit risk reporting. These risk characteristics are equally important than the ones from first four points.

All five categories above are very important and no bank or any other company can manage its credit risk if it fails significantly in any of them.

Banks faced multiple various problems in past few years but obviously one of the biggest sources was lax credit standards for borrowers and counterparties. Because of the liberalization of lending sector and higher competition on the market, banks were under pressure to acquire as many borrowers as possible to achieve profit goals required by their shareholders.

This reason accompanied with inflexible credit policy that did not comply with changes in whole economy and eventual risky counterparts still received loans. Two



## 1.2. Market risk management

Market risk according to definition is a risk of unpredictable change of value of investment, trading portfolio. I have not used expression decrease of value on purpose, because even increase of value can cause significant losses, for example case of futures or options. The most important market risks are connected with value of:

- Equity
- Currency
- Interest rate
- Commodity

Production, sale companies, or retail banks have many useful tools to hedge themselves against market risk (but with significant expenditures). In case of investment banks situation is different because these bank speculate on change of prices.

### 1.2.1. Value at risk

Market risk can be measured by many various practices. Traditionally subjects use Value at Risk convention, which is a well-established short-term risk management tool. Value at risk has roots in the early 1990s during the financial crisis of Orange County, Baring, Metallgesellschaft, Diawa etc. Because of huge losses of billions of dollars, companies and governments started to use widely VAR as an easy to understand method to manage their financial risks.

VAR is simple to explain. Formally VAR measures the worst expected loss over a given horizon under normal market conditions at a given confidence level. As an example we can say that daily VAR value of portfolio of the bank is 35 million dollars on 99% confidence level, if the managers do not feel comfortable with this amount of risk they can decide to trim the risk (Jorion, 2001, p.22-23).

Basic mathematics of VAR stands on following idea that given some confidence level  $\alpha \in (0, 1)$  the VaR of the portfolio at the confidence level  $\alpha$  is given by the smallest number  $l$  such that the probability that the loss  $L$  exceeds  $l$  is not larger than  $(1 - \alpha)$ .

- Probability distribution (Dědek, 2009):  
Rates of return on a portfolio  $R = \Delta W / W_0$  can be summarized by a random variable  $\tilde{R}$  whose future outcomes are subject to a given probability distribution.
- Density function:  $f(x) \doteq P(x - \delta < \tilde{R} < x + \delta)$
- Distribution function:  $F(X) = P(\tilde{R} \leq X) = \int_{-\infty}^X f(x) dx$
- Mean (expected value):  $\mu = \int_{-\infty}^{+\infty} x f(x) dx$  (*first moment – location*)
- Variance  
(volatility):  $\sigma^2 = \int_{-\infty}^{+\infty} (x - \mu)^2 f(x) dx$  (*second moment – dispersion*)
- Target horizon: Period of time over which value is measured.
- Confidence level: Percentage how far value can be protected against loss (according to Basel II confidence level has to be 99%)

VAR method is used not only by banks or by other financial institutions; it is a tool that is used across all industries. As an example, we can show any international corporation that has to manage its inflows and outflows in various currencies and thus is very sensitive to market changes. “Cash flow at risk analysis” can be used to know the probability is critical shortfall of funds for a company.

On one hand, we can see the players solving their exposure to risk and on the other hand, we have the regulators that set the rules for all financial and non-financial institutions. Even regulators use VAR very often as an effective benchmark to measure risk (more information about governmental regulations can be found in a chapter “Regulation of risk management”).

### 1.2.2. Form 10-K

In the USA, there is even special report Form 10-K that is mandated by SEC (U.S. Securities and Exchange Commission). This report is required from all publicly traded

companies. Annual report presents actual and overall information about company's financial condition (includes audited financial statements). All filings can be found in the SEC's EDGAR database. Any shareholder might request a copy of Form 10-K from the issuer.

### **1.3. Liquidity risk**

Liquidity risk is a threat that subject would not be able to meet its obligations against counterparties. In fact, this risk is caused by limited possibility to sell assets with lower liquidity. As a good example I can show retail bank, where most of its liabilities are very liquid (customers deposits) but most of its assets (loans and mortgages) are not easy to liquidate. Thus, especially institutions with high level of advantage are very sensitive to liquidity risk and to changes in liquidity conditions on the market.

Liquidity risk tends to compound other risks. For example, earlier explained market risk is very close to liquidity risk, because if e.g. interest rates unpredictably and significantly change banks can face some serious cash flow troubles. Credit risk also affects liquidity risk, imagine a factory that buys raw materials and sell goods, if mines sell raw materials on credit and goods retailers go bankrupt, than the factory faces problem with liquidity to meet its obligations against mines. Not only financial risks influence liquidity risk even for example political or legal changes may cause panic on financial markets and closing of positions and thus big problem for banks because of insufficient money base.

Liquidity risk can be measured and managed by many various tools. The most important is VAR modeling (similar as in the market risk chapter). The importance of measuring and managing liquidity risk was heightened especially after Russian default crisis in 1998. One of the biggest complications when measuring liquidity risk is the gap between book and real value of assets that changes very often in time (silent risk) (Berkowitz, 2000).

### **1.3.1. IIF Liquidity risk council**

In 2007 IIF (International Institute of Finance) held a convention of 40 major global firms to define good practice standards of liquidity risk management and intensify dialogue with regulators on actualization of rules. The results were following:

- Firms should have an agreed strategy for the day-to-day management of funding of all kinds of liquidity risks that they may need to manage.
- Such strategies should be approved by the Board of Directors and reviewed by it on a regular basis.
- Senior management should promote the firm-wide coordination of risk management frameworks.
- The report also recommended that firms should have in place:
  - Contingency plans to respond to the potential early warning signals of a crisis.
  - Strategies and tactics in the normal course of business that prevent liquidity concerns from escalating.
  - Possible strategies for dealing with different levels of severity and types of liquidity events that could cause liquidity shortfalls, with the breadth and depth of these strategies incorporating recovery objectives that reflect the role each firm plays in the operation of the financial system.
  - A clear understanding of the role of central bank facilities and the limits on these facilities.

With regard to regulations, the recommendations in the new report reflect approaches that could improve liquidity management for firms and make the system more robust overall. These include issues of supervision concerned with:

- Home-host coordination.
- Harmonization of regulations.

- Principles-based" not "rules-based" liquidity regulations that, for example, focus on qualitative risk management guidance, rather than on prescriptive and quantitative requirements.
- Expansion and harmonization of the range of collateral accepted by central banks and settlement systems.

#### **1.4. Operational risk**

Operational risk has not been a well-defined concept and is not easy to quantify, but most definitions say operational risk is a risk of failure in an operation of a firm, unrelated with external effects (economical rates, demand for goods, change of prices, etc.). The most typical operational failures are e.g. computer bugs, frauds, and errors of decision makers, legal risk, and many more.

Because of difficulty with the definition of OR it is very difficult to distinguish whether the problematic situation appeared because of failure of OR or other risk management. For example: "client fails to pay", is it a problem of Credit Risk management or human error of the loan officers?

Thus it is up to the management of a bank to clearly articulate and codify what is included in OR. Combined with the problem of quantification (these events do not appear regularly so no historical experience can be used) the management should pay a lot of attention to understand OR and its possible sources in the company (Lore, 2000).

Even regulators did not demand any capital requirements against operational risk before Basel II Accord. Now the separation of operational and credit risk management exists (see chapter risk management regulations). Thus nowadays there exists some specialized statistical tools used by banks for quantitative modeling of OR. Models use modified VAR, based on two types of probability distributions (frequency of the risk event and losses that arise when event occurs (severity), these methods are called Actuarial. Causal models that are used for frequent risk events with low severity also exist. The main idea is that every operational loss depends on the outcome of other events each of which can also be dependant, such as key risk indicators.

## **1.5. Regulations of risk management**

Banking regulation is almost as old as banking itself and these days the meaning influence on globalised finance sector is much more intensive than ever before. Almost all spheres of banking are deeply controlled by regulating institutions and have to be practiced according to rules.

Because banks are crucial establishments to provide smooth and unproblematic procedure of the whole world economy, the regulations and rules for risk management are even tighter than in any other sector of bank business. If any bank falls, it does not cause only many of dissatisfied customers with lost deposits but as we can see today in the worst-case scenario, it may influence stability of financial system. Thus regulators control all parts of bank risk management (Capital requirement, Reserve requirement, corporate governance, Reporting, Credit rating, Exposure restrictions and many more).

### **1.5.1. Basel I**

Basel I (International Convergence of Capital Measurements and Capital Standards) was a round of deliberation in 1988 by central bankers of G-10. The main task was to force banks to behave more risk averse and more secure. Now it is implemented in more than 100 countries worldwide. In the 70s and 80s, some international banks exploited the inherent geographical limits and relocated to the countries with less strict regulations. Basel I was designed for banks operating on the markets of G-10, thus it was not recommended for emerging markets.

The Main task of Basel I was to prevent banks from credit risk, in other words to make banks keep higher volume of capitalization. On the other hand, Basel I did not mandate capital to guard against market risk. In addition, minimum capital requirements were only recommended and local authorities were invited to put more effort in banking regulation (Bank for International Settlements, 2001).

Basel I is compound by four pillars. The first one “The Constituents of Capital” that divides into two tiers defines what type of bank’s capital can be counted as reserves and what amount can bank hold. Tier I capital is the core measure of financial strength of bank, common stock and disclosed reserves or retained earnings, are the key element of capital. Innovative capital instruments issued by banks can not (according to Basel I) exceed 15% of Tier I capital. Common shareholder capital can be easily used to absorb losses and is permanently available, plus it can be provided with discretion because good reputation is crucial in banking. To provide sufficient information to regulators and investors banks have to public report "Enhancing Bank Transparency" to periodically disclose information about their Tier I capital.

Minority interests in form of SPV could be included in Tier I capital only if the following requirements are satisfied (Bank for International Settlements, 1998):

- issued and fully paid;
- non-cumulative;
- able to absorb losses within the bank on a going-concern basis;
- junior to depositors, general creditors, and subordinated debt of the bank;
- permanent;
- neither be secured nor covered by a guarantee of the issuer or related entity or other arrangement that legally or economically enhances the seniority of the claim vis-à-vis bank creditors;
- callable at the initiative of the issuer only after a minimum of five years with supervisory approval and under the condition that it will be replaced with capital of same or better quality unless the supervisor determines that the bank has capital that is more than adequate to its risks;
- the main features of such instruments must be easily understood and publicly disclosed;
- proceeds must be immediately available without limitation to the issuing bank, or if proceeds are immediately and fully available only to the issuing SPV, they must be made available to the bank (e.g. through conversion into a

direct issuance of the bank that is of higher quality or of the same quality at the same terms) at a predetermined trigger point, well before serious deterioration in the bank's financial position;

- the bank must have discretion over the amount and timing of distributions, subject only to prior waiver of distributions on the bank's common stock and banks must have full access to waived payments; and
- Distributions can only be paid out of distributable items; where distributions are pre-set they may not be reset based on the credit standing of the issuer.

Tier II capital on the other hand is composed of supplementary capital, which is categorized:

- Undisclosed reserves
- Revaluation reserves
- General provisions
- Hybrid instruments
- Subordinated term debt

Second pillar of the Basel I is "Risk Weighting". According to this pillar all assets are distributed into five risk weighted categories. Each category has its percentage of minimal bank reserves (risk-weighted assets). The categories are as follow:

CAPITAL	CAPITAL REQUIREMENT
Cash, Sovereign Debt	0%
Corporal Debt (AA), Cash items in collection,	20%
Mortgage, Corporal Debt (A)	50%
Corporal Debt (BB), Fixed	100%

Assets	
Other Corporal Debts	150%

**Table 1 (Basel I capital Requirements, Mejstřík, 2008)**

Third pillar of Basel I is “A Target Standard Ratio”. This pillar sets the rule that Tier I and Tier II capital must cover 8% of bank’s risk-weighted assets and 4% must be covered by Tier I capital.

Criticism of Basel I rises from three sources. First, one was limited possible implementation (Basel covered only credit risk and later market risk of G-10 countries). The other criticism was intended against the presentation of Basel. Authors were unable to present Basel in layman speech and public did not understand properly the basic idea plus banks understood that Basel has to be implemented as soon as possible and will solve all risk problems. Since there was an absolute quantification in risk management rules in Basel, many banks got misaligned incentives to elude them and tried to put more risk on their assets comfortable with new frame.

### **1.5.2. Basel II**

Basel II purpose was initially published in 2004, the whole document in 2006 and accord was valid from first of January 1st 2007. Basel II compared to Basel I puts more effort on risk measurement, more flexible risk management and covers also an operational risk. Basel II offers more possibilities for banks how to manage their capital to cover risk. By better measurement of credit and market risk, banks can achieve lower mandatory capital reserves that can be used to cover operational risk.

#### *Pillar I: Minimal capital requirements*

According to Basel II banks do not have to use fixed capital approach but may choose from various models:

CREDIT RISK	MARKET RISK	OPERATIONAL RISK
Standardized Approach	Standardized Approach	Basic Indicator Approach
Foundation IRB Approach	Internal Model	Standardized Approach
Advanced IRB Approach		Advanced Measurement Approaches

**Table 2 (Basel II Capital requirements, Mejstřík, 2008)**

If bank uses and standardizes approach to credit risk management, it means that all counterparts' ratings are delivered from rating agencies, which are approved by the regulator. Internal rating based methods can be practiced by banks and thus they can rate their partners by themselves if regulator agrees with this approach. IRB approach can be divided into standardized one, when bank can use internal assumptions about probability of counterparts default and advanced IRB approach when bank may anticipate also all other risk components.

Market risk approaches in Basel II stayed in fact with no changes comparing with Basel I.

New operational risk management approach lets banks choose from portfolio of three approaches to this problem. Basic indicator approach is simple calculation of 15% of gross income as a capital reserve. Standardized approach is similar as BIA but banks activities are divided into eight groups (Corporate finance, Trading and sales, retail banking, commercial banking, payment and settlement, agency service, asset management, and retail brokerage) and reserves are calculated from each business line. The most sophisticated is Advanced measurement approach. Under this approach, banks are allowed to develop and use their own system to minimize operational risk. STA and AMA are allowed only if approved by competent regulator.

*Pillar II – Supervisory review process*

Second pillar of Basel II accord requires banks to develop a mechanisms of classification of necessary capital adequacy demanded by a regulator. The regulator has right to require higher capital adequacy than is calculated by the bank. Former 8% is understood as an absolute minimum. Big change from Basel I is intense of regulators to

encourage banks to settle a robust process of capital management and not to only rely on results of measurements.

*Pillar III: transparency and market discipline*

Pillar III is a complement to Pillars I and II and its target is to preserve market discipline by publication of information relevant for market players (capital adequacy). Effective publication of information is crucial for investors to have better overview on risk profile and capital position of the bank. Basel II thus sets requirements for information publication in various areas, including methods used to calculate capital adequacy. More detailed data are required from banks that use their own approaches to manage credit risk and assets securitization.

*Basel II criticism (Bank of International Settlements, 2003)*

Despite many improvements of Basel Accord, critics fault few imperfections. I will focus on following choice of three weaknesses of current rules.

**1. Complexity of accord**

Critics say that accord is too complex and not strict enough. On the other hand, present banking system is very wide-ranging and thus it is very difficult to set efficient rules of “one size fits them all”. Today risk management is highly sophisticated and not all loans could be risk weighted the same way. The other answer of authors is that banks can still use standardized approaches, but again on the other hand it is more difficult for market members to orient on the market when different subjects use different approaches.

## **2. Support of procyclicality of the financial system**

Idea of this problem is based on behavior of financial market. When an economic downturn occurs then the market is more vulnerable, thus the risk is higher, thus risk management of banks is stricter, and thus there is more downturn in economy. The answer to this criticism is that the financial system is procyclical by itself and this attribute is not caused by risk management regulations. The capital requirements are only minimal; banks may build up reserves in good times and spend more in worse times. It is very important to build banks risk management on a long-term and not only on a short-term (cyclical) basis. However, in my opinion, a problem of corporate governance enters here because it is very difficult for management to justify these saving in good times to shareholders.

## **3. Too much weight on rating agencies and penalties for small enterprises and some developing countries**

This problem affects especially emerging markets that complain about insufficient penetration of ratings in their economies and dispute quality of ratings. This imperfection is doubtless and even the price of loan to low rated counterparts is affected by the difference being very small. This situation is not ideal, as we have seen in past few years, rating agencies do not value market players very efficiently. So there is a question whether the banks can do that better. Here I think the biggest problem is not only ability to rank well enough but also incentives to overrate borrowers by loaners. The Basel is still more oriented on G-10 countries because they are the spine of global financial world and thus it is difficult to focus on special situations on emerging markets.

### **1.5.3. Basel III proposal**

Because of criticism and current instability on financial markets, there exists a plan of revision banking regulatory in the middle of year 2010. On 25<sup>th</sup> of September 2009 in London, there was a summit of Financial Stability Board (FSB) with G-20 leaders. Target

of this summit was to settle basic frame of change of financial market regulations, to stabilize market and preserve it from financial crisis. An ideal result is support of less procyclical system with less leverage and higher capital reserves so risks of individual profits have to be paid by ultimate public losses (Financial Stability Board, 2009).

Since the meeting some improvements have been done:

- Items in Basel capital framework that motivated subjects to off-balance sheet securitization have been removed.
- New standards of using special purpose vehicles have been implemented
- Higher capital adequacy requirements
- Stronger oversight over rating agencies

Nevertheless, there many things remain to be done, such as:

- Government capital injections will be grandfathered
- Restricting dividends, share back buys and compensation rates
- Different capital requirements in good times and bad times

## **2. Sub prime crisis timeline (Retrospectively)**

In this chapter, I will focus on the series of events that led to real estate and financial crisis triggered by a dramatic rise in mortgage delinquencies and foreclosures across the world. As an initial point in my research I have chosen the fall of Lehman Brothers Holdings Inc., this event can be considered as crucial because in this case U.S. government did not use any bailout and implicitly admitted that the financial situation the economy was facing was more serious than expected before. Thus, the fall of Lehman Brothers can be seen as a breakpoint to the real financial crisis.

For tracking key events in the past I will use retrospective technique, in other words I will inquire the fall of Lehman brothers and determine significant events that had anticipated bankruptcy of this bank. Next, I will do the same procedure with new determined events and continue more to the past. As a result, I will get series of events in the time line that explicitly or implicitly contributed to the emergence and intensification of financial and economical instability.

### **2.1. The fall of Lehman Brothers (September 15th, 2008)**

“The speed at which some of the supposedly strongest and most respected financial institutions have melted down is stunning. Bear Stearns disappeared almost overnight. Shareholders in Freddie Mac and Fannie Mae are virtually wiped out. WaMu is down 93%, and Wachovia, AIG, Merrill and others have suffered huge losses” (Siris, 2008).

Lehman Brothers despite of its experienced and respected management failed to stand its problems (high leverage accompanied with irresponsible valuation of assets) and on the other hand was strong enough to survive first wave of bankrupts and became a bad example for other investment banks. According to U.S. Treasury Secretary Henry Paulsen it was obvious that it was necessary to draw a line and leave responsibility on creditors and bankrupted companies. After the fall of Lehman Brothers all economic indicators dropped significantly and the trust in financial markets was threatened.

After this major affair there were many ways Secretary Paulsen tried to cure the economy (Wyplosz, 2009):

- He half bailed out Bears Stearns.
- As he let Lehman Brothers fall, he put big pressure to Merrill Lynch that this last problem was not solved at taxpayer's cost.
- On the next day, though, the Fed and many other central banks were lending huge amounts of money – presumably to Lehman's creditors and to horrified financial institutions that realized that bailouts were not part of the plan anymore.
- The following day, he effectively nationalized AIG. This was not a bailout. AIG shares were so diluted that shareholders lost most of their money. The Treasury would keep this too-big-to-fail company functioning but over time it would dispose of its assets. For all practical purposes the old AIG was gone.
- Then, on the final day of the creation of the new financial order, Paulson did a mega-AIG – he offered to buy all the toxic assets that financial institutions would care to sell.

Despite various management failures of Lehman Brothers and other fallen organizations, which I will analyze later in this diploma, the crucial events before Lehman Brothers bankruptcy were scores of bankrupts of many other investment banks such as Bear Stearns and JP Morgan. Lehman brothers fall was so important because of its size and because many other players had many of its assets invested in Lehman Brothers. Thus, this event caused the first wave of bailouts and nationalization.

## **2.2. The Bear Stearns takeover, first significant victim of the crisis**

The Bear Stearns was a trading house with a long tradition (founded in 1923). Even in 2007 they Bear Stearn was seventh-largest security firm on US Market with high capitalization but also very high leverage (35.5)(Boyd, 2008). As one of biggest US largest mortgage bond underwriters they were significantly hit by first wave of subprime crisis.

Meanwhile other banks (such as Morgan Stanley or Merrill Lynch) announced devaluations; Bear Stearns took far more profit from its trading operations.

After first doubts about robustness of mortgage bond method in spring 2007, first two hedge funds of Bear Stearns. After this action, Bear Stearns tried to reduce its higher/risk assets categories and improve balance sheet liquidity. Despite Bears Stearns confidence in their own strong capital position, they could not avoid their fall and takeover by JP Morgan on March 16<sup>th</sup> 2008. First, I will analyze what happened few days before.

### 2.2.1. Takeover by JP Morgan Stanley

On Monday March 10<sup>th</sup> Bear Stearns applied for a 2 billion USD short/term repo loan to finance its daily business but the application has been denied. Unfortunately, this was a very pessimistic message for investors. After previous rumors about liquidity self-sufficiency of Bear Stearns, the panic among investors rose.

Despite negation of any liquidity problems from Bear Stearns CFO Sam Molinaro on Tuesday March 11<sup>th</sup> Goldman Sachs stopped trade derivatives with Bear Stearns and insecurity on market deepened. This unwillingness to fund on a secured basis caused higher stress on liquidity of the firm and company's liquidity pool declined from 18.1 to 11.5 billion USD (Chart1).

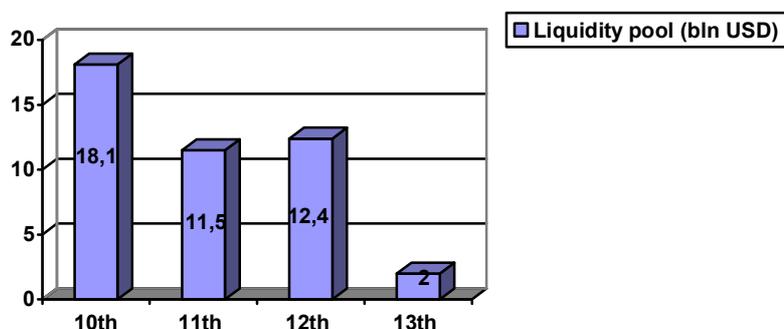


Chart 1 (Liquidity pool - Bear Stearns, Cox, 2008)

On Friday March 14th, Bear Stearns announced 30 billion USD 28-day emergency loan in funding provided by JP Morgan, backstopped by the government. Despite this cash flow and assurance of CEO Alan Schwartz that new loan facility would restore calm. Investors continued on withdrawing their investments and stock price of the company dropped nearly 40% in first hour and a half of trading.

On Sunday 16<sup>th</sup>, Bear Stearns entered into the transaction with JP Morgan Chase. The signed value was only 2USD (e.g. in late February the price reached over 90USD/share. In addition, Federal Reserves issued a non-recourse bond in value of 29 billion USD for JP Morgan to cover Bear Stearns less liquid assets (COX, 2008; BOYD, 2008). After a lawsuit from shareholders, JP Morgan raised an offer to 10USD/share and reached an agreement.

### **2.2.2. FED Bailout**

As was mentioned in the last point, US government (Federal Reserve) supported acquisition of Bear Stearns by JP Morgan. Ben Bernake (FED chairman) defended this unusual decision by fact that bankruptcy of banking giant like Bear Stearns could very negatively affect real US economy. This step was very controversial and opened a discussion about the role and rights of FED.

As a source of the fall of Bear Stearns was not seen only risky portfolio of investment. Liquidity problems were mostly caused by the deteriorating reputation of the company in the eyes of business partners and investor and consequently by difficult access to present money. Now I would like to find an answer to whether this approach was based on fundamental facts and calculations or if the CEO Schwartzer was right and problems had been caused only by rumors and following run on a bank.

On March 20<sup>th</sup> Christopher Cox (Securities and Exchange Commission Chairman) wrote an open letter to Nout Wellink (Basel Committee on Banking Supervision Chairman) (COX, 2008). In this letter, Cox supported statement of Basel Committee about a minimal liquidity conditions in banking organizations. Working group led by

Christopher Cox discovered that Bear Stearns fall happened even though all Basel II requirements toward capital adequacy were successfully met (even in the day of takeover). Nevertheless, counterparty withdraws cash and credit denials resulted in a loss of liquidity not a loss of capital. SEC offered results of their working group to be adapted on consolidated supervised entities (CSE). SEC have calculated that minimal capital requirements were crucial matter but nowadays they need to be accompanied with sufficient liquidity assets to avoid run like this.

“Due to importance of liquidity to the firms, CSEs have adopted funding procedures designed to ensure that the holding company has sufficient stand-alone liquidity financial resources to meet its expected cash outflows in a stressed liquidity environment where access to unsecured funding is not available for a period of at least one year” (COX, 2008). Therefore, not only amount but also assets that support capital are important. To assess the adequacy of liquid assets, the SEC uses a scenario-based approach. The CSE have developed also a set of scenarios that are recommended to be used to assess sufficient liquidity. Basically the principal is not to receive any additional unsecured funding but need to retire maturing unsecured obligations.

After bailout of Bear Stearns central banks have heavily intervened and provided big amount of liquidity to banks in exchange for collateral that included illiquid assets (such as packages of mortgage obligations) to avoid more situations like this.

Already in 1873 Walter Bagehot invented “Bagehot’s doctrine” that says that in crisis government should lend at a penalty rate money to solvent but illiquid institutions. This doctrine is very easy to state but quite difficult to apply, because very often the solvency of the institution is not clear. Thus, central banks should provide liquidity to solvent partners to give market enough confidence and keep interest rates low. The problem is when central banks extend their position of lender of last resort to entities outside traditional banking. Question is how FED could know that Bear Stearns were solvent enough if they were not under FED supervision and therefore FED did not have enough information (Vives, 2004).

From today’s point of view, opinions of FED bailout of Bear Stearns are little bit divided. On one hand it is true that global markets were facing serious threat of losing confidence, beginning of panic and government was supposed to act immediately. On

the other hand, any other „too big to fail“ players felt the opportunity of moral hazard. “For example, the main difference between what the U.S. government and banks pay to borrow in dollars for three months, the so-called TED spread, rose 23 points in the past two weeks to 133 basis points, compared with an increase of 38 basis points to 160 basis points in the period leading up to Bear's failure” (Paulden, 2008).

So here, we can see FED saved that bank only if there was appearing panic on markets and government wanted to calm it down. The original problems of Bear Stearns and many other banks investing in MBS (mortgage-based securities) were caused by increase of defaults of mortgages. These defaults were mainly influenced by declining prices of houses in USA in last years (described in the following chapter).

### **2.3. Falling prices of houses in USA (2006)**

One of the first seriously problematic moments for Bear Stearns (and many more other investment banks) was the drop of quality of MBS. Quality of these investment packages is determined by many variables. However, one is crucial and it is delinquency rate of households. Again, if we go further delinquency is not an endogenous variable but is clearly determined by many factors. Most of these factors cause drop of financial solvency of debtors (increase of unemployment, high inflation, drop of GDP, etc.). Nevertheless, the fact that most of these factors were really stable or positive (until 2007) I should focus on some others.

The change of variable I want to discuss in this chapter influence earnings of debtors indirectly but in quite a large scale. This variable is a value of real estate property. Many calculations of client solvency were based on a growth of price of homes (this is represented by HPI – Housing price index). This idea was not wrong by itself; there was a significant rise of prices in the beginning of 21<sup>st</sup> century (Chart 3). Except for regular incomes (wage, investments, special governmental payments, etc.), there was included a capital income in a way that if debtor cannot afford to repay the debt he can get more because collateral price increases. In this case, we can talk about something similar to Ponzi scheme. From 2000 to 2006 prices of houses in USA (S&P/ Case-Shiller Index) rose by 80% and the rise was convex, thus speeding up every year.

“The S&P/Case-Shiller Home Price Indices are the leading measures for the US residential housing market, tracking changes in the value of residential real estate both nationally as well as in 20 metropolitan regions. The indices are calculated monthly and published with a two month lag”. I used in calculations Composite-20 Index. Composite-20 Index is a price index for the top 20 Metropolitan Statistical Area’s (MSA) in USA. This index is based on weighted/repeat sales methodology that includes quality of houses sold, (Standard and poor’s, 2010).

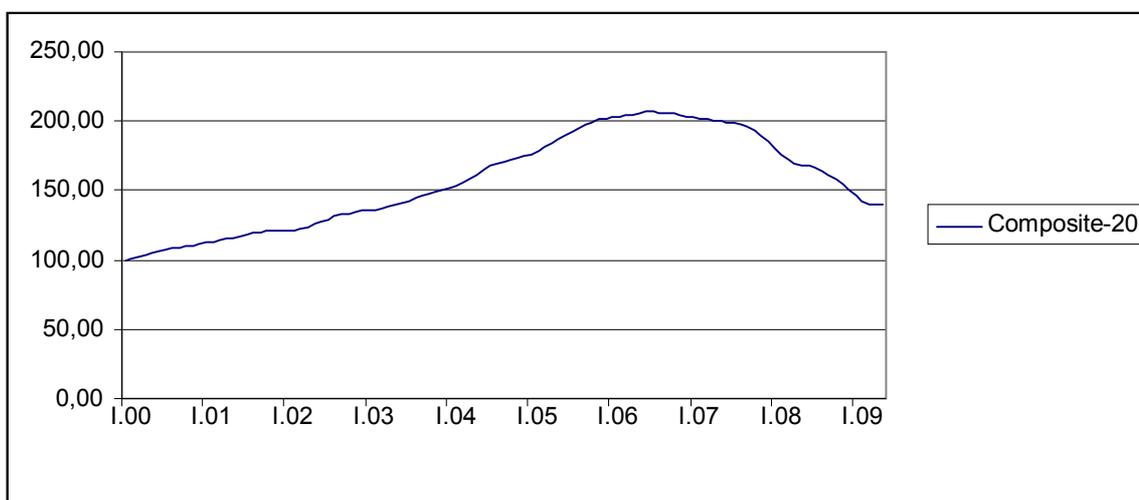


Chart 2 (Standard & Poor’s – Case – Shiller Home Price Index, [www.standardandpoors.com](http://www.standardandpoors.com))

### 2.3.1. Why prices stopped to grow

First small drop of CSI (Case – Shiller Index) in its history occurred in August 2006 when Composite-20 (SPCS20R) fell from 206.52 to 206.18 and was followed by many consequential drops until May 2009. The fall of prices was a result of unsustainable growth of real estate prices. After this market decline in 2006 many different opinions on that situation occurred.

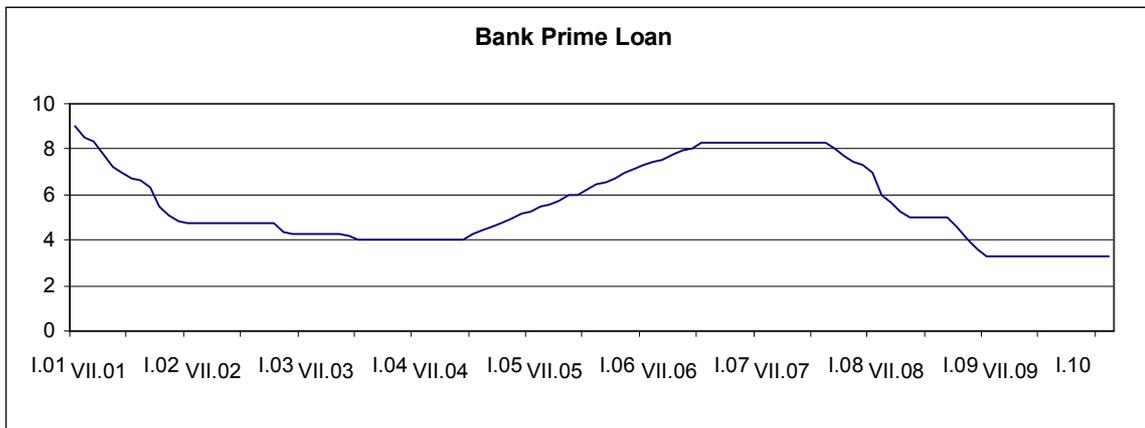
Join center for Housing Studies of Harvard University described the housing situation in 2006 as followed. Even though the housing market has weakened in 2006 they didn’t expect any serious problems and saw this as a natural moderation of heating market. According to the working paper “*The state of the nation’s housing 2006*” (Join center for Housing Studies of Harvard University, 2006) the only thing that could threat housing

market was the sharp fall of prices. In 2006 only small decreases of CSI were visible (CSI is based on 3 months Lag), more significant declines happened from August 2007 and later. In the paper it is also stated that even that market can easily handle drops in housing (as in 2001) and sharp price drops can only accompanied with massive overbuilding or rise of unemployment. Therefore, they understood the fact how house prices influence housing markets and whole economies, the problem was underestimating of temporary slowdown. Salvation of housing market was seen in high immigration and increase of fastest-growing housing segments. On the other hand underestimation of data that shows how dispensable income spend on housing is increasing dramatically relatively to other expenditures (since fifties), this fact clearly indicates higher elasticity of defaults on economic conditions.

Shawn Tully (Fortune editor) wrote an article as an answer to the situation on real estate markers. This answer was written on August 25 2006 and included several arguments why conditions for stable price growth could not have been met (S.Tully, 2006).

- *As long as job growth is strong, prices can't go down:* Of course good stable job market is important for real estate markets, but if number of new houses exceed number of houses that can be absorbed by new opened position, than developers are forced to sell houses cheaper, because of overhang of supply.
- *The builders learned their lesson in the last downturn. They will not swamp the market with new houses when the market turns:* Even with experience from history, homebuilders are still putting new houses on the market despite demand decline. The reason why they do that is much higher margin (comparing to history) on every new house. Even the builders need to use significant discounts; they will produce houses until their margin is squeezed out by price decline.

- *Low interest rates will keep values rising, or at the very least, put a floor under prices:* Every asset's value is determined largely by real interest rate (nominal interest rate minus inflations). But this effect is only temporarily (interest rates have significantly fell since 2001 and probably will not decrease(chart 4) thus when reserves on market made by decrease in years 2001-2004 will diminish then housing prices will take a further hit. In the end was shown that it was true and interest rate was climbing high until being artificially decreased by FED at 2008.



**Chart 3 (Bank Prime Loan, [www.federalreserve.gov](http://www.federalreserve.gov))**

- *Restriction on development in the suburbs ensures low supply, and guarantee rising prices:* It is true that famous policy “not in my town” makes difficult to use areas to build (especially in locations like New Jersey, New York and Washington). On the other hand US Labor market is very flexible. People and companies have no problem to move themselves or their production to cheaper areas when possible. This effect will not actually keep prices of real estates on high level.

Obviously, there already existed many theories that feared drop of real estate prices as a serious threat to mortgage market and to the global financial system. In the next chapter, I will focus on era that anticipated price index fall.

## **2.4. Signs of real estate bubble (2004 – 2005)**

Housing price index drop was first significant and clear sign of problems with subprime loans. Despite difficulty of revealing upcoming crisis (real estate bubble in this case) there were many opinions pointing at inconsistency of real estate market. This attitude started to occur especially between years 2004 – 2005. I have decided to focus on few situations there when risk management specialists or economists claimed, that there exists real estate bubble or any other risk coherent with subprime mortgages.

### **Freddie Mac case**

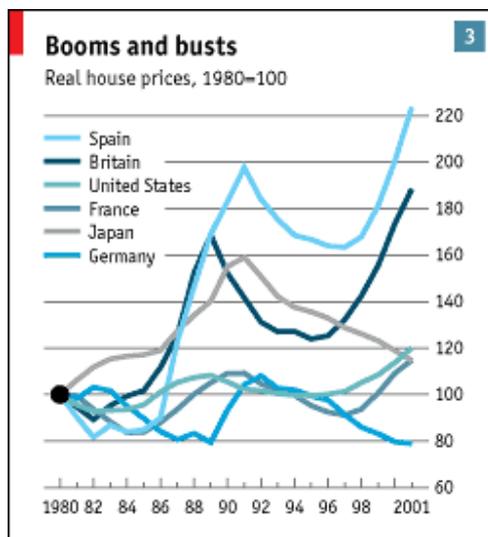
In 2004 chief of risk management of Freddie Mac David A. Andrukonis informed the chief executive of the company Richard F. Syron about financing of questionable loans that threatened its financial health. The document included information that Freddie Mac's underwriting standards were becoming less reliable and thus the company's business was threatened.

Mr. Syron was also warned that the firm needed to expand its capital reserves and to slow down mortgage purchase, but he expanded them. CEO was explaining his behavior by enormous pressure on earnings and stated that the company could not afford to refuse almost any loans.

An obvious problem in this case was failure of operational risk management (corporate governance problem). On one hand, Mr. Syron received 38 milion USD in compensations in total since 2003; on the other hand, his decision partly caused billions of dollars of loses for shareholders (stock price decline) and US government bailout. Mr. Syron was not of course the only entity that was responsible for situation in the company. US Congress motivated constantly banks to buy low/income borrowers mortgage to encourage cheap housing and thus to buy riskier investment packages (Duhigg, 2008).

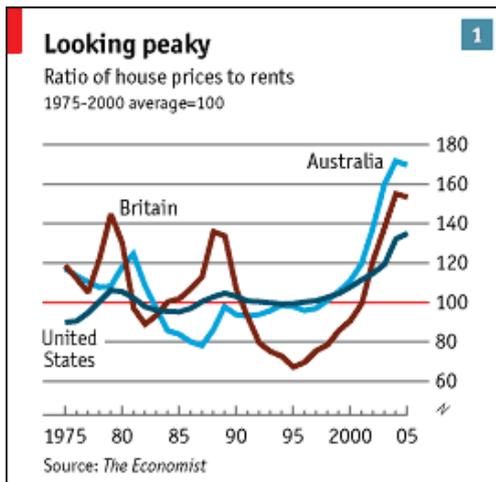
## Dramatic housing price increase comparing rents

In June 2005, respected journal, The Economist pointed on a fact that Housing prices were rising dramatically (not only in USA but also in Europe, Australia or China). Increase of prices in developed countries in years 2000-2005 was equivalent to 100% of their GDP (global stock market bubble in 1990 – 80%, in late 1920s – 55%) so it looked like one of the biggest bubbles in history (Picture 4).



Picture 4 (Housing Price Development, <http://media.economist.com/images/20020330/CSF597.gif>)

Increase of prices was caused mainly by two factors: historically low interest rates and lack of confidence in capital markets after dotcom bubble burst. An important factor proving over-valuation of house price is ratio of prices and rents. Using the same idea as in valuation of the company the value should be equal to sum of discounted earnings (dividends in case of the company and rents in case of real property). In picture 5 we can see development of this ratio in three regions (USA, Great Britain and Australia). When we take a look at the graph of USA ratio we can see the curve is really similar to curve of real housing price (picture 1), this implies that rents have not relatively changed significantly during the period, which is not reasonable. The same situation while P/E ratio of any company would be developing regardless to real dividend payments.



Picture 5 (House price/rent ratio, <http://media.economist.com/images/20050618/CSF107.gif>)

There is argument-explaining difference between rents and mortgage payments comprise the fact that with mortgage in many years the house becomes debtor's property. Nevertheless, concerning live time cycle the incentive to have a mortgage should not be that high to pay significantly higher payments comparing to rent. To this argument we can say that consumers life style in USA has not significantly change for many decades and thus even if we do not know fair value of the ratio we know that this value should be approximately constant.

To fix this inequality the rents would have to increase rapidly comparing to house prices or property prices would have to drop to appropriate level. In years, 2000-2005 the inflation rates were very low, comparing with history, so the scenario when rents would grow rapidly did not seem realistic even from 2005 point of view. When we use arguments explained, possible solutions and if we refuse hypothesis of super fast growing rents, then we have only one outcome. It was obvious that the only natural way in which market could solve this inequality was lower convergence of mortgage payments to rents. As I mentioned before because of low level of inflation and minimized interest rates, it was obvious that decrease of mortgage payments can be caused only by decline or long-term stabilization of the property price.

## **Speculative real estate business**

According to study of NAR (National Association of Realtors) from 2004, 23 percent of houses are purchased not for living housing reason but as an investment. Despite lower income from renting the houses, investors speculate on long term (only 3% of buyers sell their house within first year) price increase. Director of NAR and CEO of Coldwell Banker Residential Brokerage has stated to this facts: "Anecdotaly, most of the stories we've seen on investment speculation have focused on the new home or condo market, and they've been confined to a handful of areas with very tight supplies of available homes and sharp double-digit price gains," Mansell said. "It's true that some people have made fast profits, but it's not to be expected. In fact, it can be risky, and prospective buyers need to be aware of the facts before they think about jumping in." ([www.realtytimes.com](http://www.realtytimes.com), 2005).

Massive speculative investment was not the threat to market just buy itself. More disturbing fact is other data from the research. This data shows very low tension of the debtors to amortize their loans. 42% of first buyers and 25% of total buyers did not do any down payment on their property in year 2004. In California, 60% of all new mortgages are interest-only (no amortization of debt) or even negative-amortization (increase of debt in time). To have mortgages like that was possible only by speculation on house price increase. In fact, we are talking about special case of Ponzi scheme, debt payments are covered by inflation of debt.

Despite these facts banks had no problem with giving this kind of mortgages. Banks were encouraged by government to provide loans for housing to wider population that ever before (very low interest rates). Therefore, danger of these mortgages rose from flatting of house prices and increase of interest rates. Both factors were very probably to happen even from 2005 point of view, so danger of this kind of loans was not invisible ([www.realtor.org](http://www.realtor.org), 2005).

## **Conclusion of housing bubble visibility in 2005**

Based on information and implications I have stated higher the real estate bubble was predictable by many entities even before its burst but even before first housing prices drops in 2006.

On one hand, we can blame banks, risk managements of retail banks should have tight up loan requirements. However, it is difficult to put away core business of the company while the whole market and government are pushing forward. It would be very difficult to explain high management respectively shareholders that operational income has fallen because of the threat of real estate bubble. “The Federal Reserve failed to use its supervisory and regulatory authority over banks, mortgage underwriters and other lenders, who abandoned such standards as employment history, income, down payments, credit rating, assets, property loan-to-value ratio and debt-servicing ability. The borrower's ability to repay these mortgages was replaced with the lender's ability to securitize and repackage them” (Ritholtz, 2008).

Investment banks should have stopped massive investments into MBS for market price, which would have burst the bubble earlier and thus caused less damage to US and world economy. This case is very similar to the previous one with retail banking. High managers had to make a choice whether to cut incomes and make their investments more secure. As I showed on example of Freddie Mac higher, it is obvious that attempts of risk management to avoid possible future losses wrecked on short-term preferences of bank government units.

### **2.5. Economic recession (2000 – 2003)**

Firstly, we shall look where this recession started and we can see that first slowdowns of economy were seen in Europe. After introduction of Euro in 1999, European currency started to plummet. Big inflation occurred in European monetary union along with deflation of the economy caused by rapid rise of Euro in 2002. In United States, depression was started by so called “dot.com bubble”.

Dot.com bubble was caused by technological shock of fast developing online market. The boom in this industry was hugely supported by pioneer vision of almost unlimited incomes based on quite low investments. In times of loss, the companies received capital mostly by initial public offering and with combination of novelty of these stocks and thus difficult valuation, “dot.com” stocks were raising very fast. Stock market and thus whole US economy was growing fast (Picture 6).

Unfortunately stock price growth was not based on idea of undervaluation of the companies but on belief of their future growth. This anticipation is threatened by fact that all companies were pioneers those days and obviously not all of them would be able to face growing competition.

Business of dot.com companies was following the strategy “growth over profits” because only really big players were able to succeed, so even the company did not have any profit in its short history, their stocks were sold for astronomic prices. With industry, growth was with hand-to-hand growth of prices of technologies, because no company could afford to be left behind. So many e.g. communication companies got into big debt because of high-speed broadband fiber optic cables or 3G licences in Europe.



Picture 6 (Nasdaq Composite, [http://farm4.static.flickr.com/3619/3498233109\\_7034e72e08.jpg](http://farm4.static.flickr.com/3619/3498233109_7034e72e08.jpg))

The recession started after peak in March 2001. Technically, it was not a recession, because according to definition of recession, domestic gross product must fall in two successive quarters and GDP growth was moderate but still growth (0, 2 % for Q3, resp. 2, 7% for Q4). The first official recession since 1958 was after the first quarter of 2009 (Bureau of Economic Analysis, 2010). For burst of speculative bubble, there were several explanations, such as:

- a. Massive multi-billion dollars sells of major high tech companies settled accidentally in one day.
- b. Massive investments for protection against Y2K caused insufficient investment funds after 1<sup>st</sup> of January 2000.
- c. Not all expectations for economic results for 1999 were met.

Probably for political reasons (Presidency elections in 2000), FED hesitated to increase interest rates to slow down over-heated economy. Therefore, when interest rates dramatically rose, the economy slowed down rapidly and so obvious reaction in fear of economic crisis was drop of interest rates to historical minimum in 2002. The economy started to rise fast again, but as I have explained in chapter 3.4 extremely low interest rates were perfect condition for real estate investment bubble.

As usually, the main reason is probably combination of all these factors and many more. Until today there does not exist proper theory that would completely explain the burst. Nevertheless, what could banks and investors learn from this lesson is the fact that it is impossible that any assets price would grow by inappropriate tempo to the infinite.

## **2.6. Community Reinvestment Act (1993-1995) and its consequences**

If we want to look at the deepest history of mortgage loans and their unnatural behavior, we shall mention Community Reinvestment Act (CRA) in 1977. CRA was a document that tightened rules for providing mortgages. Because of this act, banks were obliged to lend money to lower-income borrowers than before. On the other hand, it was a kind of break to housing industry and barrier for lower income US citizens to reach their own living.

Community problems of inner cities and renovitalizations of regions was the reason why US President Bill Clinton got involved in this problem. In 1993, President Bill Clinton asked regulators to change rules of CRA to reduce cost and compliance burden to solve the problem of inner city communities.

CRA was under criticism, that rules are too strict and less flexible for banks and thus are not even used efficiently. Based on that criticism there few changes were made between years 1993 and 1994. Because of these changes, credit standards were even more eased to help finance revitalization of the low- and moderate-income communities of USA ([www.epa.gov](http://www.epa.gov), 2008). Here we can see connection between wide spread of subprime mortgages and CRA. CRA is a typical example of government intervention to banking system but not focused on risk minimalization but on support of more risky operations. Therefore, the question is how CRA contributed to emergence of real estate bubble and thus subprime crisis.

On the other hand, apprehensions that do not see any significant connection between CRA and subprime crisis are based on following arguments (Pressman 2008):

- Weakened role of CRA by US President G.W.Bush approved even before the biggest wave of bad lendings. Thus, CRA could not control subprime loans as it used to before.

- Low ratio of subprime mortgages provided by supervised institutions: 50% of subprime loans were provided by mortgage service companies, additional 30% of subprime loans by affiliates of banks thifts that are not subject to routine supervision or examination. Only 20% were made by banks that were subject to the CRA.
  
- CRA loans were earning lower interest rate, which was one of the reasons why they were less likely securitized into the mortgage/backed securities that have caused great losses and is the most important variable in models in this diploma.
  
- More effect might have the law "The Commodities Futures Modernization Act" in 2000 that allowed excluded commodities (Interest rates, Currency prices and stock indexes) and thus credit-default swaps to be traded unsupervised.

This list of facts and simple implications explain that CRA probably did not have any significant influence on real property investment bubble. However, it would be difficult to refuse connection between artificial easing of lending rules (even if obligatory for banks that provided only 20% of total loans) and increase of delinquency and thus financial crisis.

### 3. Econometric models

In the chapter I will try to prove previous hypothesis based on qualitative analyses. All hypotheses are based on theory that there many signs of approaching crisis existed long time before fierce drops of financial markets. Using econometric tools, such as linear regression I want to reveal that these signs were unseen or even baulked by most of important financial units. Using precisely defined variables (dependant and explanatory), I want to support statements I have done earlier in the text by econometric models.

The biggest problem I was facing was source of used data. One problem was data acquisition (finding sources); many data are in limited profiles in Reuters or Bloomberg. So I decided to use limited Reuters data (with school access) or other public (free available) historical data (such as federalreserve.gov – FED data, standardandpoors.com – Housing Prices, bls.gov – Labor Statistics and many more).

#### 3.1. Ordinary least square – linear regression

Linear regression is a linear relationship between one dependant variable  $Y_i$  and at least one independent (explanatory) variable  $X_{1i}...X_{ti}$ . Final equation has a following form:

$$Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_t X_{ti} + u_i \quad i = 1, 2, \dots, n \quad (4.1)$$

Where  $Y_i$  denotes  $i$ -th observation on the dependant variable  $Y$ , which could be any result caused by combination of many various factors (Consumption, output, price, etc.). On the other hand,  $X_{1i}...X_{ti}$  denotes  $i$ -th observation of independent variables  $X_1...X_t$  explaining values of  $Y$  (Salary, Input, Properties, etc.) (Baltagi, 2002, pg. 51).

These observations could be collected on firms; households at a given point in time (cross-section) or observations could be collected over time for a specific industry or country in which case we call the data time-series. In this model, I want to examine

whether mortgage banks and private investors have developed tools sophisticated enough to price mortgage backed securities properly. This is the reason why I will use time-series data. In this case  $n$  is the number of years or months or any other time data values. In my models I used macro data, or financial data on monthly basis, so  $n$  is number of months.  $T$  is a number of explanatory variables included in the model.

$\alpha$  and  $\beta$ s are the intercept and slope of this linear relationship between  $Y$  and  $X$ s. They both are unknown parameters, estimated from historical data set.  $U_i$  (disturbance) is a natural error of the data (random variable). This variable is also called white noise, with zero mean and normal distribution.

In a real life the values of  $\alpha$ ,  $\beta$ s and  $u$  are not known, and have to be estimated from the observed data. Then we are facing the problem, how to evaluate which line is the best one fitting the data. One measure of misfit is the amount of error from the observed  $Y_i$  to the guessed line.

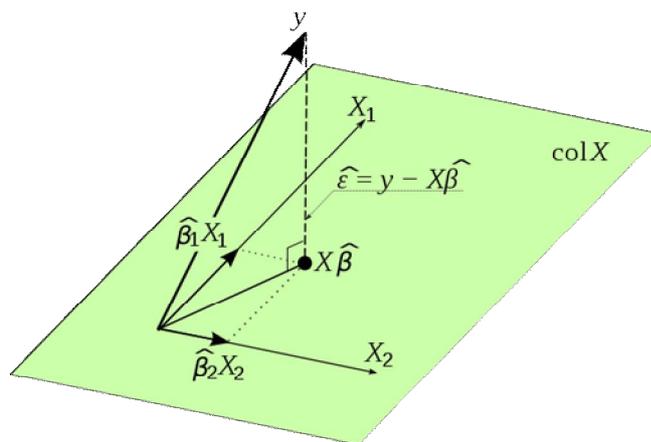
$$Y_i = \hat{Y}_i + e_i = \hat{\alpha} + \hat{\beta}_1 X_{1i} + \hat{\beta}_2 X_{2i} + \dots + \hat{\beta}_t X_{ti} + e_i \quad i = 1, 2, \dots, n \quad (4.2)$$

In this equation variable marked by “^” are represented by specific values, estimated by the model.  $e_i$  is an error value (residuals), difference between estimated value of  $Y$  ( $\hat{Y}$ ) and a real value of  $Y_i$ .

Total sum of these errors is a good measurement of misfit of the model. In my model, I will use method of ordinary least squares estimation. This linear modeling method is a method, when the sum of *squared* errors is minimized (residual sum of squares). Comparing with method with only sums of errors, least squares method has an advantage, because it “punishes” very bad estimations by squaring the errors.

$$RSS = \sum_{i=1}^n e_i^2 = \sum_{i=1}^n (Y_i - \hat{\alpha} - \hat{\beta}_1 X_{1i} - \hat{\beta}_2 X_{2i} - \dots - \hat{\beta}_t X_{ti})^2 \quad i = 1, 2, \dots, n \quad (4.3)$$

Minimalization of RSS from equation (4.3) is done by matrix of first-order conditions. Solving the least squares normal equations given for  $\alpha$ , and  $\beta$ s one gets optimal results for linear model (see picture 7).



Picture 7 (OLS geometric, two variables)

Ordinary least squares is a simple and reliable tool to examine relationship between many variables. On the other hand it is necessary to fulfill necessary conditions (Baltagi. 2002, pg. 53-56).

**Assumption 1:** The disturbances have zero mean.

$$E(u_i) = 0 \text{ For every } i = 1, 2, \dots, n \quad (4.4)$$

This assumption is needed to insure that on the average we are on the right line. If the assumption is not met, then we always can reach better result only by changing  $\hat{\alpha}$ .

**Assumption 2:** The disturbances have a constant variance (homoskedasticity).

$$\text{var}(u_i) = \sigma_i^2 \text{ For } i = 1, 2, \dots, n \quad (4.5)$$

This assumption can be tested by various tests (e.g. White test or Breusch Pagan test)

**Assumption 3:** The disturbances are not correlated

$$E(u_i u_j) = 0 \text{ For } i \neq j, i, j = 1, 2, \dots, n \quad (4.6)$$

This assumption avoids situation when some special observation influences results in following years (e.g. year 1945 for whole economy). This assumption can be verified for example by Durbin-Watson test.

**Assumption 4:** Explanatory variables  $X$  are non-stochastic (fixed in repeated samples, and hence, not correlated with disturbances).

$$\sum_{i=1}^n x_i^2 / n \neq 0 \text{ and } \lim_{n \rightarrow \infty} x = \lambda, \text{ where } \lambda \in R \quad (4.7)$$

This assumption implies, that  $X$  is not a random variable (hence not correlated with disturbances), plus that we have at least two distinct values for all  $X$ s.

### 3.2. MBS Price Model – Ordinary Least Squares

I want to use linear regression with simple parameters to explore banks behavior of investment. The best dependant variable in this case is price of MBS (Mortgage based securities). MBS are in fact very big investment packages of mortgages. Price (coupon) of MBS should be depended on many different circumstances, such as economic health, thus capability of debtors to avoid default, situation on financial markets and many more.

In previous chapters, I have stated suspicion that banks did not invest their resources according to reasonable assumptions, but on speculative expectations. This idea is based on visibility of speculative bubble long before its burst. I want to prove this speculation by quantitative modeling of MBS prices between years 2000 and 2007 (before crisis). Main target is to define variables that influenced prices of MBS and thus will of banks to invest in subprime mortgage loans.

For examination of banks, investment behavior I have selected eight variables, according to which banks should evaluate MBS packages. These variables can be divided into two following groups:

- Financial indicators: Data publicly available on financial markets connected with situation on real estate market and thus MBS pricing.
- Economic indicators: Data from real economy not necessarily connected only with housing

All data were used on monthly (if possible) and quarterly basis from year 2000 until August 2007 when crisis has not fully developed across USA.

- **MBS:** Explained variable. Data obtained from Reuters data base.
- **CSI:** As an index of housing price, I have used index Case-Shiller composite 20 (CSC20). Reason I have chosen Case-Shiller index is its announcement on monthly bases (the shortest possible in case of real estate price indicators). From all Case-Shiller regional and national indexes, I decided to use “Composite 20”.

“Composite 20” is a composite index of the home price in the top 20 statistical metropolitan areas in USA. Index is created and published every month by rating agency Standard & poor’s.

- **GDP:** Explaining economic variable. Obtained from BEA (Bureau of Economic Analysis), data are publicly available the website ([www.bea.org](http://www.bea.org)). The numbers are in billions of dollars and are used on quarterly basis. Technically, I used same number for quarter for three consecutive months. Here I expect positive influence; this expectation is based on idea that while economy is doing good, demand for real estate should increase and thus earnings for mortgages.

- **UNEM:** Data of US unemployment. Data source in this case was Reuter's wealth management database. Here I used closing amount of unemployed US citizens (in thousands) for every month. The idea in this case is very similar to GDP, so in case both variables will be significant and high correlation occurs I will remove less significant variable out of these two.
- **Interest:** Monthly closing data of Interest rate provided by FED. As a benchmark I used "Bank prime loan". Bank prime loan is reported by the wall street journals bank survey, among the most widely used benchmark in setting home equity lines of credit and credit card rates. The connection here should be positive, the higher interest rates, the higher mortgage rates and thus investment coupons from earned by MBS.
- **Bankruptcy:** Bankruptcy of non-business units in USA. Numbers are in pieces. Reuters provide this data on quarterly basis. This index is also economic (just as GDP and UNEM) and the idea of MBS reacting on change is the same. The more bankruptcy fillings happen, the lower level of MBS payments.
- **House:** Number of new houses started to build in specific month period (in thousands) in USA. Data are provided by Reuters on monthly basis. Reason why I have chosen this variable as possible explanation is the reason that while demand for houses increases, also MBS prices should follow.
- **Nasdaq:** Nasdaq composite is used as a financial ratio of whole economy. It is a price index of more than 3000 composites traded on New York Stock Exchange. Again, I downloaded data on monthly basis from Reuters Wealth Management. Correlation expected is again positive, the higher growth, the higher company prices (NASDAQ), the higher MBS earnings.

- **Delinquency:** Delinquency rate of residential mortgage debtors. The ratio of all individuals defaulted on paying mortgage during the specific month, out of all mortgage debtors. This factor should be very important for mortgage banks and for pricing of MBS. Default rate is indirectly related with real estate prices, but if investment banks do not use for pricing Housing prices (CSI-0) they should use at least delinquency rate.

We will estimate the dependence how the change of the independent variables influence the change of the MBS coupon. We will use the log values (Horská, 2005) and by OLS method, we will estimate the coefficients from:

$$\ln \frac{MBS_{t+1}}{MBS_t} = \beta_0 + \beta_1 \ln \frac{CSI_{t+1}}{CSI_t} + \beta_2 \ln \frac{GDP_{t+1}}{GDP_t} + \ln \beta_3 \frac{UNEM_{t+1}}{UNEM_t} + \ln \beta_4 \frac{Inerest_{t+1}}{Interest_t} + \ln \beta_5 \frac{Bankruptcy_{t+1}}{Bankruptcy_t} + \beta_6 \ln \frac{House_{t+1}}{House_t} + \beta_7 \ln \frac{House_{t+1}}{House_t} + \beta_8 \ln \frac{House_{t+1}}{House_t} + e_t \quad (4.8)$$

After using explained variables for linear regression (OLS) and estimation of the coefficients  $\beta_0 \dots \beta_8$  we will be able to compute future change of MBS price.

$$\frac{MBS_{t+1}}{MBS_t} = \hat{\beta}_0 + \hat{\beta}_1 \ln \frac{CSI_{t+1}}{CSI_t} + \hat{\beta}_2 \ln \frac{GDP_{t+1}}{GDP_t} + \ln \hat{\beta}_3 \frac{UNEM_{t+1}}{UNEM_t} + \ln \hat{\beta}_4 \frac{Inerest_{t+1}}{Interest_t} + \ln \hat{\beta}_5 \frac{Bankruptcy_{t+1}}{Bankruptcy_t} + \hat{\beta}_6 \ln \frac{House_{t+1}}{House_t} + \hat{\beta}_7 \ln \frac{House_{t+1}}{House_t} + \hat{\beta}_8 \ln \frac{House_{t+1}}{House_t} \quad (4.9)$$

### 3.2.1. MBS Price Model – Monthly data

In the first model, I want to examine MBS prices by variables based on monthly data. Reason of dividing models into two data sets is that some variables or their announcement change only once a quarter (GDP, UNEM, Bankruptcy, Delinquency). I have tried to solve the problem by expecting values to be constant during another two

months until next quarter (via. Chapter 4.2.2). To run regression I have chosen data from January 2000 until first signs of crisis in July 2007. This data set contains 89 observations on monthly basis.

The results of linear regression are following:

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,236 <sup>a</sup>	,056	-,019	,056572
a. Predictors: (Constant), DELINQUENCY, GDP, NASDAQ, HOUSE, BANKRUPTCY, UNEM, INTEREST, CSI				

**Table 3 (MBS - Month - Model overview)**

From table 3 it is obvious that reliability of this model is very low (R square only 0,056 and adjusted R square even below zero). These results implicates that this variables do not explain MBS pricing on sufficient level. Now I will examine specific variables and their significance.

ANOVA <sup>b</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,019	8	,002	,743	,654 <sup>a</sup>
	Residual	,323	101	,003		
	Total	,342	109			
a. Predictors: (Constant), DELINQUENCY, GDP, NASDAQ, HOUSE, BANKRUPTCY, UNEM, INTEREST, CSI						
b. Dependent Variable: MBS						

**Table 4 (MBS - Month - Model significance)**

From table 4 we can see that even significance of the model is very low (on 90% significance level).

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-,007	,007		-,955	,342
	CSI	,222	,619	,046	,359	,720
	GDP	,784	,847	,093	,926	,357
	UNEM	-,019	,084	-,024	-,229	,820
	INTEREST	,201	,166	,140	1,212	,228
	BANKRUPTCY	-,005	,024	-,020	-,203	,839
	HOUSE	-,003	,048	-,006	-,058	,954
	NASDAQ	-,012	,071	-,017	-,168	,867
	DELINQUENCY	-,050	,094	-,057	-,531	,596

a. Dependent Variable: MBS

**Table 5 (MBS - Month - Coefficients)**

From table 5 it is obvious that none of all eight variables explains MBS coupons significantly. The most significant variable (INTEREST, sig. 0,228) still cannot be used in model.

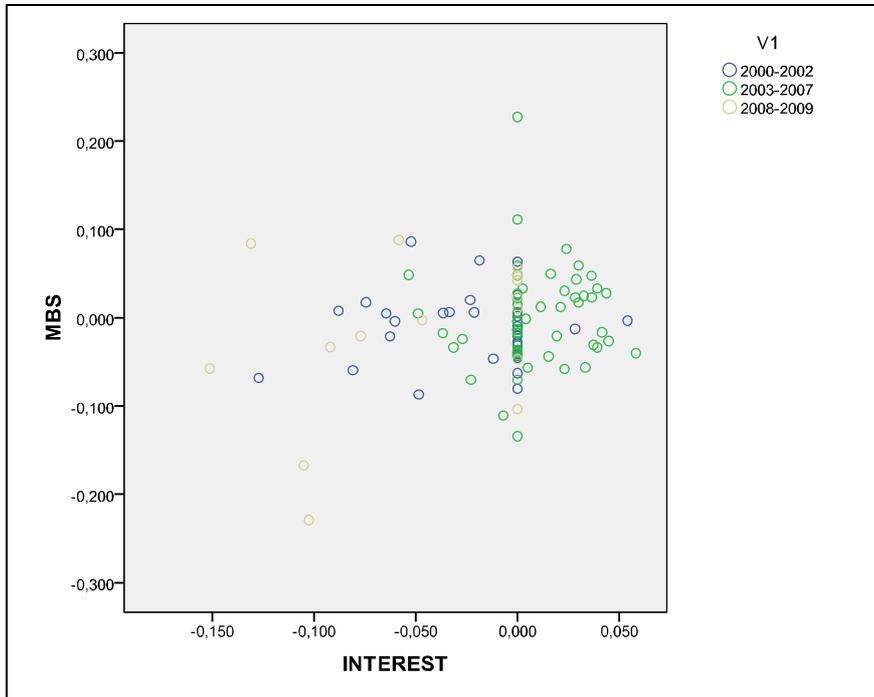
As a following step, I tried to exclude variables one after the other to find out whether the significance reaches required level (10%).

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-,003	,005		-,640	,524
	INTEREST	,283	,135	,198	2,099	,038

a. Dependent Variable: MBS

**Table 6 (MBS - Month – Coefficient INTEREST)**

After excluding all variables, only one that appeared to be significant is interest rate. Slightly positive correlation of these variables is obvious even from chart 5. But this variable does not explain MBS pricing sufficiently (Adjusted R square only 0,03). So I will not discuss this model and necessary conditions any more and will now try the same process with quarter data when I do not have to artificially estimate development of some variables during each quarter.



**Chart 4 (MBS - Month - INTEREST Scatter Plot)**

### 3.2.2. MBS Price Model – Quarterly Data

Because of different timing of variables (months and quarters), I have excluded all observations between quarter data. Thus, number of observations has dropped to number 30. On one hand, quantity of data has fallen, but on the other hand, I expect higher quality of data and also solution of possible lagged variables. I have used again the same regression with the same independent variables in SPSS software as in previous case, with following results:

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,345 <sup>a</sup>	,119	-,216	,098573
a. Predictors: (Constant), Delinquency, Bankcrupcy, Nasdaq, GDP, Housestart, UNEM, Interest rate, HousePrice				

**Table 7 (MBS - Quarter - Model Overview)**

ANOVA <sup>b</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,028	8	,003	,356	,932 <sup>a</sup>
	Residual	,204	21	,010		
	Total	,232	29			
a. Predictors: (Constant), Delinquency, Bankcrupcy, Nasdaq, GDP, Housestart, UNEM, Interest rate, HousePrice						
b. Dependent Variable: MBS						

**Table 8 (MBS - Quarter - Model Significance)**

As we can see from table 7 and table 8, results of MBS pricing model have not significantly improved comparing with results for monthly data. Nevertheless, I will examine significance of variables, because R – square value is now 0,119, so I might find some dependency on some explaining variables. Even if I found any dependency between one or two variables, I could hardly specify OLS model with sufficient explanatory characteristics.

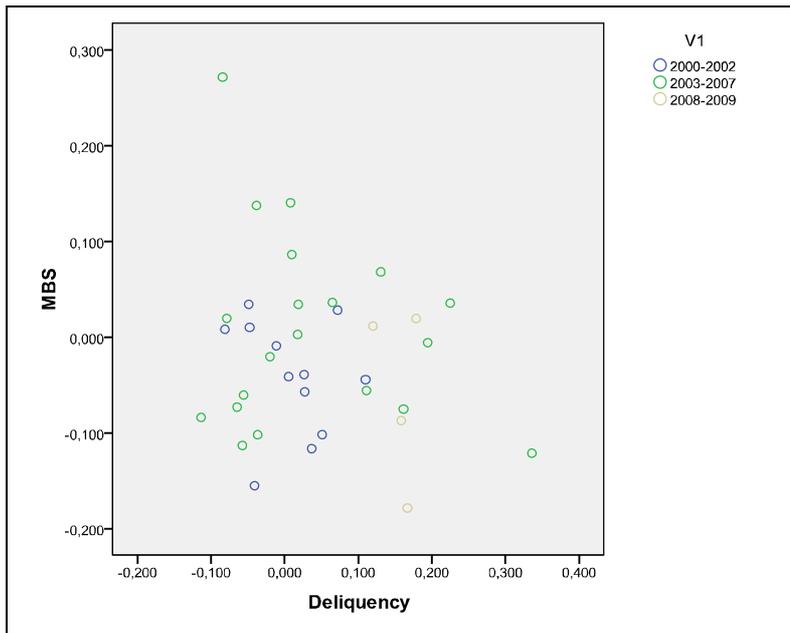
Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-,038	,064		-,596	,558
	HousePrice	,417	1,568	,088	,266	,793
	GDP	1,706	4,433	,101	,385	,704
	UNEM	-,122	,214	-,141	-,569	,575
	Interest rate	-,065	,280	-,063	-,233	,818
	Bankcrupcy	,005	,044	,025	,111	,913
	Housestart	-,058	,108	-,121	-,543	,593
	Nasdaq	,128	,137	,228	,937	,359
	Delinquency	-,021	,357	-,018	-,058	,954

a. Dependent Variable: MBS

**Table 9 (MBS - Quarter - Variable Significance)**

Despite higher R-square, all variables included in the model are insignificant (Table 9). I even tried to exclude variables one after the other, no dependency has occurred. Just an example proving no correlation I show scatter plot of MBS and delinquency rate on chart 6 (this dependency should be obvious). However, even in any specific time

interval between years 2000 and 2009 there is no observation of any correlation. Therefore, with high probability, the mortgage agencies have not used proper tools to evaluate packages of mortgages (Mortgage Backed Securities). Otherwise there would be obvious relationship between MBS coupons and any of eight chosen explanatory variables.



**Chart 5 (MBS - Delinquency rate - Scatter Plot)**

Despite no observed relationship between independent and dependent variables, it is still necessary to examine that data whether they are correspondent with all assumptions of OLS modeling. Testing model will have all eight proposed variables, because there was no reason to prefer any of their subsets.

**Assumption 1: Zero mean of residuals**

MODEL	RESIDUAL MEAN	STATUS
MBS – Month	0,003	OK
MBS – Quarter	0,009	OK

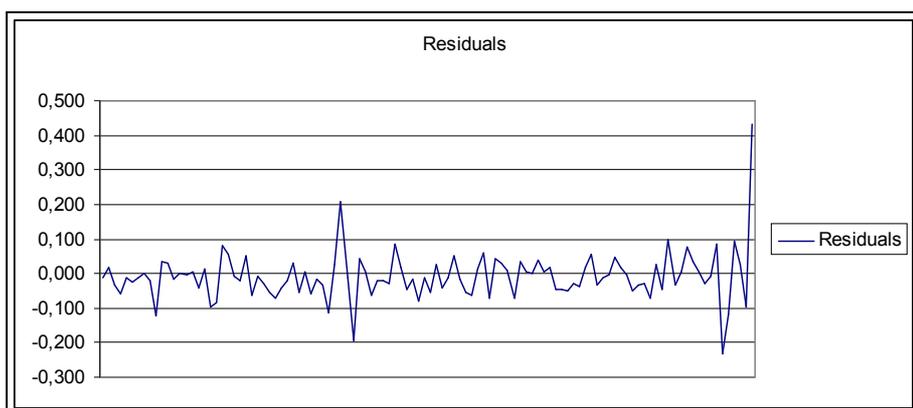
**Table 10 (MBS - Residual means)**

As we can see from table 10 mean of residuals of models, for monthly and quarterly data, is very low. Therefore, I can assume with high confidence that assumption of zero mean of residual is met.

**Assumption 2: Constant variance of disturbances - homoskedasticity**

To examine homoskedasticity of the models i first created virtual explaining variable MBSE (estimated value of MBS by the model). Then I plotted value of model error  $e_t$ . For simplification, I will plot only data on monthly basis, when any pattern would be more obvious.

$$e_t = MBS_t - MBSE_t \tag{4.10}$$



**Chart 6 (MBS month - residual plot)**

As we can see from chart 7 there is no reason to expect changing variance of results during time period between 2000 and 2009. Only at the end of this period, the error rate is higher because of nonstandard market condition (Subprime and financial crisis). So we might accept hypothesis of homoskedasticity. For further testing we can use White test or Breusch-Pagan test. For simplicity I use specific White test with following results in table 11.

MODEL	TR2	P-VALUE	STATUS
MBS - Month	19,181	0,999	OK
MBS - Quarter	11,932	0,7486	OK

**Table 11(MBS - White Test)**

On table 11 I used a data for White test, run in Gretl. As we assumed, the p- value of the test does not show any suspicion for existing heteroskedasticity of the data, therefore we can expect third assumption to be met. Therefore, we can say that model, showing no connection between variables is unbiased for both, monthly and quarterly data sets.

**Assumption 3: Uncorrelated disturbances**

MODEL	DW – STAT	INTERVAL (5%)	STATUS
MBS - Month	1,932	1,490 – 1,827	OK
MBS - Quarter	2,714	0,926 – 2,034	OK

**Table 12 (MBS - Durbin Watson Test)**

I ran a Durbin-Watson statistics on results from monthly and quarterly data models. In next step, I compared critical intervals (from table) for specific number of observations, number of explanatory variables and confidence level. As we can see from table 11, in both models value of DW-STAT exceed higher value of critical interval that means that on 95% disturbances of the model are not correlated. Therefore, the assumption 3 is complied without any problems.

If the value would fit between two numbers, the test would be inconclusive, if the results were under lower value then it would imply autocorrelation of the model.

#### **Assumption 4: Uncorrelated independent variables with residuals**

There is no statistical test to examine assumption of nonstochastic explanatory variables. Therefore, I expect this assumption as fulfill. The aim of this diploma is not econometric, but economic only.

As we can see my computation and observations in previous points, all necessary assumptions for OLS modelings are met. Now there are no barriers to interpret obtained results of the model for both data sets.

#### **3.2.3. MBS Price Model – Conclusions**

After proving that both OLS models (monthly and quarterly data) fulfill all four assumptions, concerning about correctness of using OLS, we might commit statements about their results. After all examinations of the data, there was no observed relationship between dependent variable (MBS) and any of eight explanatory variables. Not even by OLS modeling but even using simple plotting there was not any significant correlation proven.

Therefore, it is obvious that mortgage agencies used different methods to evaluate MBS than I have chosen into my models. On the other hand, as I have explained in analysis of historical events and whole periods, there should be a significant connection between MBS prices and macroeconomic factors, such as unemployment, GDP, mortgage default or real estate property prices. In problem of MBS evaluation, I can see one of the biggest failures in risk management among completely private mortgage providing industry. In next chapter, I will focus on valuation of mortgages by whole stock market. As an example, I will use stock emitted by mortgage agency Fannie Mae.

### 3.3. Mortgage Banks Stock Price Model - OLS

In MBS pricing model I have examined behavior of investment banks and pricing of their investment assets. In Mortgage banks stock price model I want to focus on investment behavior of investors on stock exchange. The target is to determine whether pricing of shares if mortgage banks was influenced by fundamental variables or was determined only by market sentiment.

As an independent variable I will use the same portfolio as in the previous model. The reason to do so is the fact that even mortgage banks' and even investors' earnings are supposed to be based on the same fundamentals (mortgage payments) with additional variable MBS used in the previous model as an independent variable. The reason is that MBS prices should influence stock prices and not vice versa.

As MBS price model showed, banks did not include fundamental parameters such as condition of the economy, or defaults of resident mortgage loaners. Now I want to examine whether even investors used the same philosophy.

As a dependent variable I will use a value of the biggest mortgage agency Fannie Mae (in model I use shortcut FNM). This portfolio will be used as a investors' opposite of MBS prices. MBS prices is the value how mortgage banks evaluate emitted mortgages, on the other hand stock market (investors) value these loans as a value of emitor companies.

As a technical method, I will use again OLS, as a simple and reliable tool of data examination. In the first part, I will again try to find the most significant variables suitable for the model.

The model should have a following form:

$$\ln \frac{FNM_{t+1}}{FNM_t} = \beta_0 + \beta_1 \ln \frac{CSI_{t+1}}{CSI_t} + \beta_2 \ln \frac{GDP_{t+1}}{GDP_t} + \ln \beta_3 \frac{UNEM_{t+1}}{UNEM_t} + \ln \beta_4 \frac{Inerest_{t+1}}{Interest_t} +$$

$$\ln \beta_5 \frac{Bankrupt_{t+1}}{Bankrupt_t} + \beta_6 \ln \frac{House_{t+1}}{House_t} + \beta_7 \ln \frac{NASDAQ_{t+1}}{NASDAQ_t} + \beta_8 \ln \frac{Delinquency_{t+1}}{Delinquency_t} + \beta_9 \ln \frac{MBS_{t+1}}{MBS_t} e_t$$

(4.11)

As in previous MBS model, I will split the data into two models (on monthly and quarterly basis).

### 3.3.1. Stock Price Model – Monthly data

As a first result from linear regression, we have obtained following table.

Model Summary <sup>b</sup>					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,341 <sup>a</sup>	,116	,017	,074181	2,186
a. Predictors: (Constant), Delinquency, Bankruptcy, GDP, Nasdaq, MBS, Housestart, Interest rate, UNEM, HousePrice					
b. Dependent Variable: FNM					

**Table 13 (Stock - Monthly - Model Overview)**

Values from this table do not imply good explanatory value of the model (R Square 0,116); on the other hand, we still might find some fundamental influence of some explanatory variables on stock price.

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,021	,014		1,530	,130
	MBS	,194	,162	,128	1,200	,234
	HousePrice	-2,998	1,377	-,258	-2,177	,032
	GDP	,618	1,207	,055	,512	,610
	UNEM	-,164	,119	-,151	-1,370	,174
	Interest rate	-,131	,261	-,055	-,503	,616
	Bankcrupcy	-,099	,076	-,139	-1,303	,196
	Housestart	,032	,079	,045	,407	,685
	Nasdaq	-,076	,102	-,081	-,743	,460
	Delinquency	-,332	,189	-,196	-1,755	,083

a. Dependent Variable: FNM

**Table 14 (Stock - Monthly - Variable coefficients)**

As we can see from table 13, there are many insignificant variables included in the model. However, some of them might be influencing the stock price. Now I will exclude insignificant variables one after the other, starting with the least significant. After excluding, those variables on 10% confidence interval there were only two variables remaining (table 14).

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,019	,012		1,523	,131
	HousePrice	-2,419	1,280	-,208	-1,890	,062
	Delinquency	-,331	,187	-,195	-1,771	,080

a. Dependent Variable: FNM

**Table 15 (Stock - Monthly - Significant variables)**

The R Square of this model is still low (0,055) but we can see that probably partly stock prices were influenced by some fundamental variables. As we could expect, there exists negative impact of delinquency level on stock prices. Nevertheless, we can observe negative effect also of House prices on stocks of Fannie Mae. Probably this is caused by higher demand for houses following after price drop. I will now plot all the data from 2000 to 2009 to examine whether there exists any correlation between both explaining variables. Behind this theory is a simple idea explained before, that price drop concludes higher delinquency rate. However, this relationship will be examined in next part, where I will run the regression on quarterly data. Plotting of monthly data (CSI) against quarterly, (Delinquency) might be very confusing.

### 3.3.2. Stock Price Model – Quarterly Data

After examining data on monthly basis, I ran a linear regression on quarterly data too with the same variables included. As a first result I obtained quite promising results with solid R Square value (0,411) and much better significance coefficients than in previous models (Table 15 and 16).

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,641 <sup>a</sup>	,411	,145	,121346
a. Predictors: (Constant), Delinquency, MBS, GDP, Bankruptcy, UNEM, Nasdaq, Housestart, Interest rate, HousePrice				

**Table 16 (Stock - Quarter - Model overview)**

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-,020	,078		-,259	,798
	MBS	-,077	,269	-,052	-,286	,778
	HousePrice	-3,892	1,938	-,561	-2,008	,058
	GDP	8,657	5,319	,348	1,627	,119
	UNEM	-,494	,262	-,388	-1,887	,074
	Interest rate	-,646	,342	-,425	-1,892	,073
	Bankruptcy	-,177	,130	-,247	-1,365	,187
	Housestart	-,080	,134	-,112	-,596	,558
	Nasdaq	-,015	,171	-,018	-,088	,931
	Delinquency	-,483	,451	-,283	-1,071	,297
a. Dependent Variable: FNM						

**Table 17 (Stock - Quarter - Significance of coefficients)**

As we observed in previous model, again we still have many insignificant variables included. After excluding all insignificant variables I have computed quite solid OLS model with five significant variables (Table 17). R Square of the model is 0,364 which is suitable value for partly macroeconomic data.

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-,043	,069		-,630	,534
	HousePrice	-2,842	1,202	-,410	-2,364	,027
	GDP	8,483	4,931	,341	1,720	,098
	UNEM	-,456	,223	-,359	-2,051	,051
	Interest rate	-,593	,311	-,390	-1,905	,069
	Bankruptcy	-,205	,119	-,286	-1,726	,097

a. Dependent Variable: FNM

**Table 18 (Stock - Quarterly - Selected variables)**

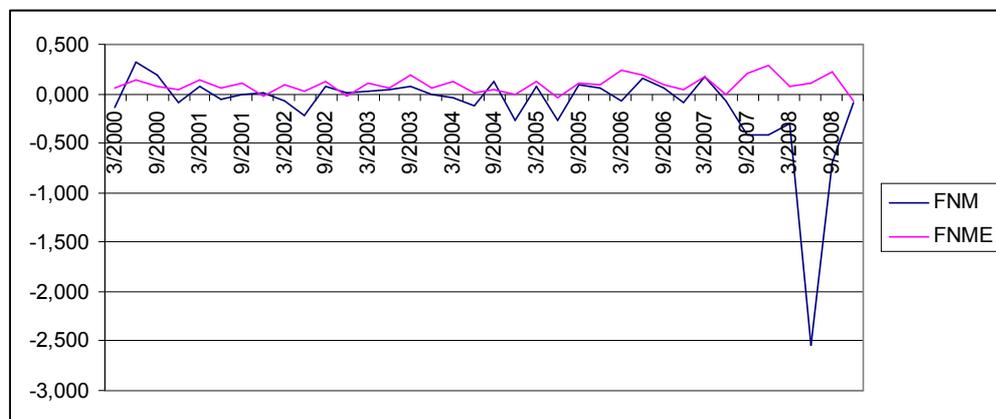
So final value of estimated FNM (FNME) is:

$$\frac{FNME_{t+1}}{FNME_t} = \exp(-0,43 - \ln 2,824 \frac{CSI_{t+1}}{CSI_t} + \ln 8,483 \frac{GDP_{t+1}}{GDP_t} - \ln 0,456 \frac{UNEM_{t+1}}{UNEM_t} - \ln 0,593 \frac{Interest_{t+1}}{Interest_t} - \ln 0,205 \frac{Bankruptcy_{t+1}}{Bankruptcy_t}) \quad (4.12)$$

As we see, this model has confirmed idea of negative effect of house price change on mortgage business and thus on stock price of Fannie Mae, this effect overpowers the effect of higher delinquency rate during drop of real estate prices (real estate bubble burst). This result has proven the theory that market and banks have

ignored the effect of inappropriate high prices of houses and danger of their stagnation (mortgages financed by increase of value of capital (house)).

Positive dependency on GDP and negative on unemployment and bankruptcy signifies that at least market was reacting to macroeconomic situation on the market. On the other hand no direct relationship between share price of Fannie Mae and resident mortgage delinquency rate was observed. As a result of this we can say that market was evaluating companies much better than companies were evaluating its core business (Mortgage backed securities). Despite this fact this model explains only app. 36% of the whole evaluation process. In chart 7 I show the difference between estimated logarithm of stock price change and real stock price change.



**Chart 7 (FNM vs. FNME)**

The modeling as we expected was copying the real pricing. But after year 2007 we can observe very different attitude. Because of first occurrence of higher mortgage defaults the share price drops. On the other hand modeling expects stock price raise because of lower real property prices and thus higher demand for housing.

The target of this diploma is not to develop complex evaluating model, but only to examine what data were considered as relevant for investors and banks. Even though I have to test this final model (Stock – Quarterly) if it fulfils all assumptions necessary for OLS modeling. The major problem, obvious from the model is different approach to house prices change. As I explained in chapter 3.3 and 3.4, the annual rise of real property prices was the real engine of housing and mortgage business. But we shall take care while pointing any implications. I will first test all OLS assumptions before I can consider results to be accurate.

**Assumption 1: Zero mean of residuals**

MODEL	RESIDUAL MEAN	STATUS
STOCK - Quarterly	0,04	OK

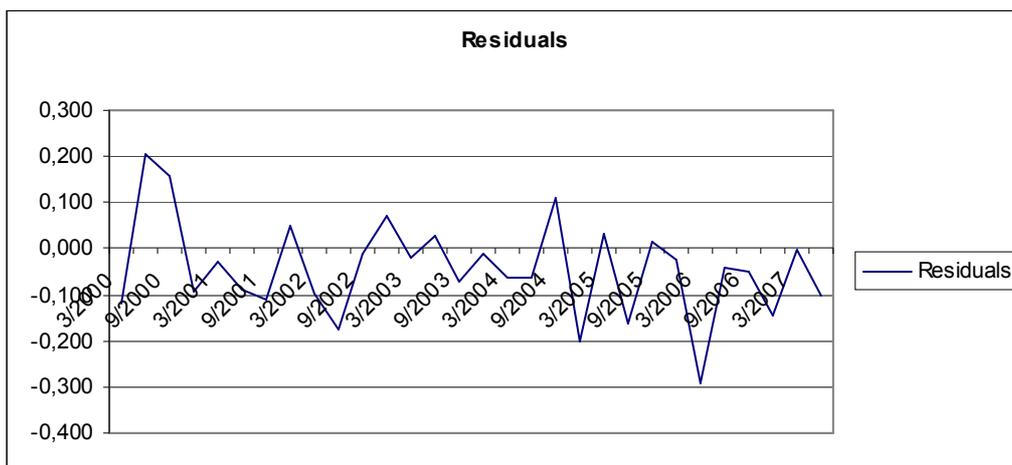
**Table 19 (Stock - Residual means)**

As we can see, the mean of the residuals is 0.04, this number is acceptable not even because it is a low number, but also because we used only 30 observations using quarterly data. Because of this reasons I find assumption 1 as met.

**Assumption 2: Constant variance of disturbances - homoskedasticity**

To examine homoskedasticity of the models I first created virtual explaining variable MBSE (estimated value of MBS by the model). Then I plotted value of model error  $e_t$ . To simplify I will plot only data on monthly basis, when any pattern would be more obvious.

$$e_t = FNM_t - FNME_t \quad (4.10)$$



**Chart 8 (STOCK - Quarterly - residual plot)**

On chart 8 I can see that variance of residuals does not change over time, so there is no need to expect any heteroskedasticity in this model. Just in case that observation is not proper I will run the white test. To run White test I have to use different software from SPSS, because this software does not include possibility of White or Breusch-Pagan Test. To get results from White test I use Gretl 1.9.0.

MODEL	TR2	P-VALUE	STATUS
STOCK - Quarter	27,022	0,13465	OK

**Table 20 (Stock - White Test)**

From the results of white test and its p-value (table 20) I can see, that really there is no heteroskedasticity in model data. Thus, also assumption 2 is met in this case and OLS is still the best estimation. Heteroskedasticity of the model would mean that not all OLS coefficients are biased or underestimation of their variance (standard errors of the data used in model).

### **Assumption 3: Uncorrelated disturbances**

MODEL	DW – STAT	INTERVAL (5%)	STATUS
STOCK - Quarter	2,251	1,143 – 1,739	OK

**Table 21 (Stock - Durbin Watson Test)**

I ran a Durbin-Watson statistics on results from monthly and quarterly data models. Comparing result with critical values for  $n=30$  and  $k=5$  on 5% significance level I can see that disturbances of the model are not correlated. If the result was opposite then I would have to use different model from OLS, more robust model (e.g. ARIMA - Autoregressive integrated moving average).

If the value fit between two critical values, the test would be inconclusive; if the results were under lower value then it would imply autocorrelation of the model. While it does not bias the OLS coefficient estimates, the standard errors tend to be

underestimated (and the t-scores overestimated) when the autocorrelations of the errors at low lags are positive.

#### **Assumption 4: Uncorrelated independent variables with residuals**

Fourth and last assumption of OLS properties are stochastic independent variables in the model. As I mentioned in testing part of last model, there is no statistical test to examine this presumption, therefore I assume that the data comply this condition.

After examination of necessary presumptions of the model with quarterly data, there is no reason to expect that OLS modeling is not best linear unbiased estimation. Therefore, I can analyze further results of the model.

### **3.3.3. Stock Price Model – Conclusions**

According to the results of tests, I have proven, that model of pricing Fannie Mae shares based on quarterly data comply all requirements of OLS modeling. Model based on monthly data has not been tested because the results were very inconclusive for purposes of this diploma, so this whole data set has been denied.

Data set based on quarterly values has shown that despite the mortgage agencies (Fannie Mae, Ginnie Mae) did not value MBS coupons according to fundamental economic or financial data, the investors showed more responsibility in process of valuation of their investment (Fannie Mae Stocks) during the years 2000 and 2007.

The valuation of stock was based on fundamental indicators from our model only partly (R square – 0,41) but this number is very solid when we look at the valuation tools or other buying incentives followed by investors on capital markets (market sentiment, theory of waves etc.). So we can say that small investors behaved rationally and used responsibly all public data. So again I see mistakes on side of mortgage agencies such as Fannie Mae, that the company was managed only with short term financial and operational goals and to public they pretended that all risks were fully covered and there was no reason to expect drop of equity price. This result corresponds for example with

case study of Freddie Mac explained in chapter 3.4, where opinions on market prices nonstandard situation (Real estate bubble) were neglected even by the Chief Executive Officer of the company.

## 4. Conclusion

In this work, I examined an events concerning risk management decisions or usage of risk management tools. The time period including the events has lasted from Community reinvestment act revision (1993) to the fall of Lehman Brothers (2008).

I did not examine the fall of Lehman Brothers from the governmental point of view (pros and cons for bailout), but from the point of view of corporate governance. Lehman Brother was a typical case of high leverage company with irresponsible valuation of assets. On the other hand, Bear Stearns takeover was an understandable act done by US government to calm financial markets down. Bear Stearns was not an example of insufficient capital but insufficient liquidity. This was an example of liquidity risk management failure. On the other hand here we can see that part of the fault is on side of regulators, because only minimum requirements concern only capital, not liquidity. After crisis, area was only an outcome of behavior in the period before, between dotcom crisis and real estate bubble burst. This problem was accelerated by massive interventions by FED, because interest rates have changed many times significantly as a result of solutions for solving economic recession after year 2001.

After analyzing of real estate prices and loan prices there was obvious imbalance between these two parameters in years 2002 and 2006. Housing prices were growing much faster than loans. This fact in connection with results from empirical part have revealed that house prices changes were heavily underestimated from mortgage banks. The main problem was caused by high level of loaners that have financed their mortgage payments by price growth of their property. Outcome of this fact was a mortgage delinquency problem, while real estate prices stopped to grow. Using the linear regression in modeling part I showed that mortgage agencies have not taken into account. This fact and fact that even macroeconomic indicators like GDP, delinquency rate, unemployment or bankruptcy of companies did not influence MBS pricing by Fannie Mae and Ginnie Mae. I found Insufficient quality of pricing MBS as a very important failure of risk management.

Result of my master thesis is confirmation of hypothesis that any units (mortgage banks, investment banks, FED, private investors) have made serious failures during last 20 years period that contributed to occurrence of subprime crisis and eventually into global financial crisis.

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