SUBPRIME MORTGAGE CRISIS IN THE UNITED STATES IN 2007–2008: CAUSES AND CONSEQUENCES (PART I)

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Abstract. *The main purpose of this article is to determine which factors and how contributed to the subprime mortgage crisis in the United States in 2007–2008, what their causal links and effects on the markets and the whole economy were, and to assess what actions could have been taken by the Federal Reserve and the Government in order to mitigate or prevent the consequences of subprime mortgage crisis and housing bubble. In order to obtain the research results, the authors performed a qualitative analysis of the scientific literature on the course of events and their development that led to the subprime mortgage crisis, and focused on the insufficiently regulated home mortgage market expansion, the impact on the subprime mortgage crisis of financial innovations and financial engineering, poorly evaluated systemic risks and policy undertaken by both the U.S. Government and the Federal Reserve before and after the crisis. The quantitative research focused on two main parts: firstly, analysis of the dependence between the causes of subprime mortgage crisis and the consequences, using a statistical and regression analysis, and secondly, an alternative path the Government and the Federal Reserve could have taken in their policy actions and the results they could have produced. The authors believe that the results of the research could give useful guidelines to the central bankers and government officials on how to make long-term decisions that can help in preparing for the financial distress, mitigating the consequences when the crisis strikes, accelerating the recovery and even preventing the crisis it in the future. The second part of the qualitative research will appear in the next issue of the journal.*

Key words: *banks, Central bank, subprime mortgage crisis, mortgages*

I. Introduction

Since August 2007, global financial markets have been shocked by catastrophic events and circumstances stemming from problems in the U.S. subprime mortgage segment. Financial institutions were forced to write down billions of losses in dollars, euro or Swiss franks. The main markets stagnated, their liquidity almost disappeared, and stock markets suffered massive recession. Central banks originated hundreds of billions of loans making interventions not only to support the exchange rate, but also in order to preclude the collapse of separate institutions. The USA and European governments also intervened in the large-scale support to financial institutions. Huge losses forced the

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great majority of financial institutions to recapitalise, some of them were taken over by other financially stronger institutions, and others simply went bankrupt. In August 2008, the International Monetary Fund (IMF) expected total losses to reach almost USD 1 trillion, but in October its expectations were revised up to USD 1.4 trillion, so the cost of the recent global financial and credit crisis for the global economy was one of the highest throughout its history.

The effects of many previous large-scale financial crises had been more localised – affecting the economy and financial sector of one particular country. The recent crisis was unique – it was more complicated than any previous crisis (e.g., the Great Depression of 1929–1930, the USA Savings and Loan Crisis of the 1980s and the 1990s, the USA Long-term Capital Management Crisis of 1998 or the collapse of "dot-com" (IT) bubble of 2000–2001), while its damage is considerably more widespread among both the countries and financial institutions – banks, pension funds, investment banks, insurance undertakings, etc.

It is widely agreed that the subprime mortgage crisis was caused by the credit boom and the housing market bubble. However, it is not so clear why this combination of events has evolved into such a severe financial crisis, i.e. why the financial system suffered the freezing of capital markets and the widespread collapse of financial institutions, why the housing market and credit bubble were so inflated, and how and what factors on the part of the private and public sectors had the essential impact. The subsequent systemic crisis reduced capital supply and availability to creditworthy institutions and individuals increasing the negative impact on the economy even more. The main hypothesis of this research is that the central bank, the government and the private sector have done not everything they could to control the formation, expansion and consequences of the crisis and, moreover, they themselves have contributed to the subprime mortgage crisis.

II. Literature review. Unregulated growth of the mortgage market

Over the last years, analysis of causes of the subprime mortgage crisis in 2007–2008 has become the subject discussed by many economists and governments. The U.S. subprime mortgage and credit crisis was analysed in research and papers of Acharya et al. (2009), Isard (2009), Crotty (2009), Donnelly et al. (2010), Lim (2008), Jaffee (2008), Demiroglu et al. (2011), Purnanandam (2010), Crandall (2008), Schwarcz (2008), Simkovic (2011), Moran (2009), Taylor (2007), Carrillo (2008) and other researchers. Authors basically emphasised the relevance of the contribution of both the private sector and governmental organisations to the subprime mortgage crisis.

After the prolonged period of rapid expansion, the economic activity started receding in many countries of the world. The sharp turnaround was associated with the end of the house price boom in the United States. It is necessary to understand how short-sighted

mortgage lending practices and financial engineering turned the global economy into a house of cards, and why the U.S. authorities did little to curtail the outrageous lending practices and financial engineering (Isard, 2009).

The direct cause of the financial turmoil was the steep increase and subsequent sharp decline of housing prices, which, together with poor lending practices, led to large losses on mortgages and mortgage-related instruments in many financial institutions (Moran, 2009). Although the recent financial crisis was caused by the burst of mortgage market bubble when massive default on obligations in the subprime mortgage market started, but the financial bubble of the housing market was the result of the development of financial innovations over the past three decades, which essentially is one of the main causes of the subprime mortgage crisis (Lim, 2008).

Subprime lending growth was boosted by more highly leveraged lending against a background of rapidly rising house prices. A strong investor appetite for higher-yielding securities contributed to looser loan granting and mortgaging standards. However, safeguards ensuring prudent lending were weakened by the combination of remunerations and bonuses at each stage of the securitization process and the dispersion of credit risk, which weakened loan monitoring and control incentives. Hence, intermediaries were remunerated primarily by generating loan volume rather than quality (Kiff et al., 2007).

As long as housing prices kept climbing, fuelled by ever-increasing levels of debt and leveraging, all these problems remained hidden. Rising house prices provided the borrowers in financial trouble with an incentive to sell their homes and pay off their mortgages prematurely. In 2006, when prices peaked and began to fall, things started to unravel. After several years of unsustainable housing pricing appreciation and imprudent lending practices, a housing market correction – the bursting of the bubble – was both inevitable and even necessary. As interest rates rose and house prices flattened with the loan value and then turned negative in a number of regions, many stretched borrowers were left with no choice but to default as prepayment and refinancing options were not feasible with little or no housing equity (Kiff et al., 2007). This subprime mortgage crisis, marked by home foreclosures of enormous scale and illiquid mortgage-related securities which have created huge capital holes on the balance sheets of banks and financial institutions has spilled over into the global economy, causing a global credit crisis and fuelling a deep, long, and painful recession (Moran, 2009).

While discussing the causes of the subprime mortgage crisis, different researchers and economists have pointed out and distinguished different factors contributing to the crisis. Different researchers have expressed different views about the relative importance of the contributing factors and how the blame should be shared (Isard, 2009). This paper introduces three groups of the root causes of the U.S. subprime mortgage crisis considered to be the main by the authors: 1) problems directly and specifically related

to the subprime mortgage lending practices; 2) causes related to the subprime mortgage securitizations; 3) causes related to the ability of financial institutions and public authorities to assess the systemic risks.

Roots of the crisis: collapse of "dot-com" bubble and 11 September

Moran (2009) notes that roots of the subprime mortgage crisis stretch back to another notable boom and burst, i.e. the tech bubble of the late 1990s and 11 September. In 1998, turmoil in the financial markets became rampant. The spectacular failure of the Long-Term Capital Management, a hedge fund of the U.S., in the 1990s led to a massive bailout by other major banks and investment companies and helped persuade the Federal Reserve to provide three quick interest rate cuts that contributed to the "dot-com" bubble. When in 2000 a steep decline began in the stock market and the next year the U.S. slipped into a recession, the Federal Reserve, once again, sharply lowered interest rates to diminish the effects of collapse of the "dot-com" bubble and combat the risk of deflation (Moran, 2009, p. 13–15).

The "dot-com" bubble collapse was followed by tragic terrorist attacks of 11 September, as a result of which the Federal Reserve cut the interest rate even further. Thus, Moran (2009) again emphasises that the series of actions by the Federal Reserve to lower interest rates and hold them at historically low levels (1%) for three years partially fuelled the housing bubble and eventual crash that triggered the subprime mortgage crisis and the recent financial crisis. Fisher (2006), president and chief executive officer of the Federal Reserve Bank of Dallas, stated that the Federal Reserve's policy of significant reduction of interest rates during this period was irrational first of all because of erroneously low inflation data and, therefore, contributed to creating the housing bubble.

These low nominal and even negative real inflation and adjusted inflation indicators sparked a building and buying boom in housing, which developed into a huge speculative bubble. Lower interest rates made mortgage payments cheaper, caused increased demand for homes, resulting in a considerable increase in their prices, and encouraged investors to pour money into the U.S. mortgage market. In addition, the demand was also fuelled by refinancing mortgages by millions of homeowners taking advantage of lower interest rates. However, while the housing market prospered, the quality of the granted mortgages deteriorated. Consequently, when in June 2006 the Federal Reserve brought interest rates back to 5.25%, the real estate bubble began to deflate, and about one year later the housing price correction developed into a financial crisis (Moran, 2009).

A study conducted by Stanford University Professor Taylor (2007) suggests that the federal government could have avoided a large portion of the turmoil associated with the financial crisis if the Federal Reserve had not cut interest rates so significantly and raised them again quicker. Taylor's simulated studies tried to increase interest rates quicker than

the Federal Reserve, and the result was positive – the increase in new homes' market was smaller than the one which actually occurred. These results show that if interest rates were raised sooner it would have helped in avoiding the building of such housing bubble and a sharp fall in the housing market, while concurrently mitigating the consequences of the financial crisis.

Obstfeld et al. (2009) also stress in their paper the role of the independent monetary policy in the context of the subprime mortgage crisis; however, they note that the monetary policy was accompanied by massive inflows of foreign investment to the U.S., which together stimulated an excessive domestic consumption. Household consumption was the main driving force behind the economic growth and accounted for about 2/3 of the GDP growth. Export surplus and excessive savings in other countries of the world (mainly Asian countries) allowed supporting the individual and government consumption in the U.S. In 2007, the U.S. trade balance deficit totalled USD 790 billion, 93% of which were financed by countries with trade balance surplus – China, Japan, Germany, and Saudi Arabia. In other words, since 2004, massive capital inflows reached the U.S. and financed the issues of asset-backed securities, while purchase volumes of government bonds declined. Thus, the subprime mortgage market was also flooded with investors from Asia and other countries holding large amounts of free funds and seeking profit, and this was another reason for the rapid expansion of the market.

Jaffee (2008) expressed a slightly different view towards the origin and beginning of the subprime mortgage crisis, arguing that financial market innovations, as one of the driving forces behind the growth of the subprime mortgage segment, are commonly related to three main conditions all highly relevant to the origin of the subprime mortgage lending:

- the existence of borrowers and investors who have been previously underserved. Subprime borrowers were eager to use mortgage loans to finance home purchases, while excessive worldwide savings created large numbers of investors eager to earn the relatively high interest rates promised on subprime mortgage securities;
- the catalyst of technology advancement and know-how. Subprime mortgage securitization applied state-of-the-art tools of security design and financial risk management, expanding the successful implementation of such tools to earlier high-risk securitization practices ranging from credit card loans to natural disaster catastrophe bonds;
- a benign and even encouraging regulatory environment. Although the U.S. mortgage lenders face a complex network of state and federal regulations, only few of these regulations impeded the origination of subprime mortgage loans. Furthermore, the existing system of capital adequacy requirements of commercial banks provided banks with strong incentives to securitize many of the subprime mortgage loans they originated (Jaffee, 2008, p. 2).

Expanding volumes of homeownership and growth of the housing market

The events leading to enormous losses of the global economies began many years ago, starting with lax and imprudent lending practices by banks and financial institutions, and furthered by borrowers buying houses they could not afford and taking loans they could not repay (Moran, 2009). Carrillo (2008) in his paper noted the problems arising in the lending sector (Fig. 1, blue chain).

Homebuyers took loans betting on continued house price appreciation (Carrillo, 2008). Hirsch (2008) (Fig. 1, supplemented with the lower grey chain) also supplements this scheme attributing to the significant factors the favourable initial terms (no down payment, no or low payments for the first two years) and existing possibilities of refinancing, which, coupled with the problems raised by Carrillo (2008), resulted in overextended mortgage origination volumes, which in 2003 reached the peak at USD 4 trillion compared to the historical USD 1.45 trillion in 1998. At this point, Moran (2009) distinguishes one more negative aspect of such borrowing and house purchase, i.e. as home prices kept appreciating, even prime borrowers with an excellent credit history became more willing to assume risk to purchase homes for adjustable-rate mortgages further contributing to the inflating bubble of house prices.

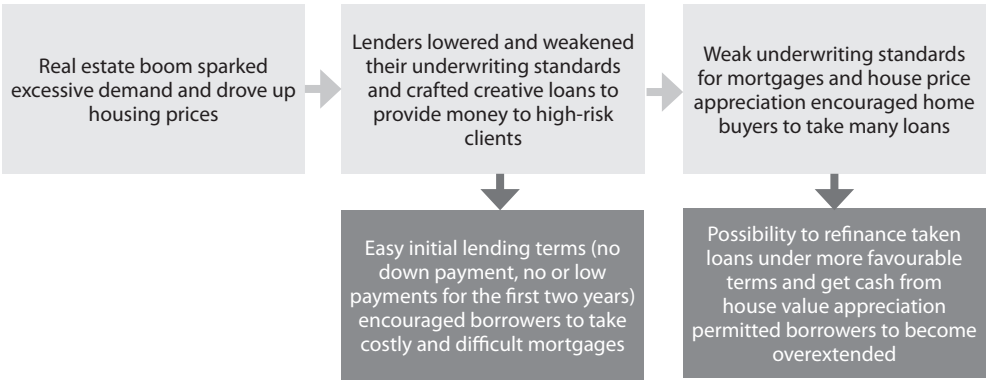


FIG. 1. Mortgage sector problems*

* prepared by authors based on Carrillo, 2008; Hirsch, 2008.

Mortgage brokers viewed their loans as well-secured by the rising values of their real estate collateral, but paid no attention to the ability of borrowers to repay the loans when due. Millions of homeowners took advantage of the interest rate drops to refinance their existing mortgages, but when the interest rates started increasing and housing prices decreasing in many parts of the U.S. in late 2006 and early 2007, the refinancing of their existing loans became more difficult (Brescia, 2008). According to Moran (2009), when housing price appreciation began to slow down, the consequences of weak underwriting

started manifesting themselves, including the above-mentioned little or no documentation and zero or minimal required down payments. Some homeowners unable to refinance their loans started defaulting as their mortgage loans reset to higher interest rates and payments, or the market value of the home fell below the value of the taken loan.

Jacoby (2008) investigated the behaviour of homeowners and related risks in her paper. The researcher argues that for most households in the United States "home equity" – a function of forced savings in fixed-rate mortgages and long-term real estate appreciation – has been the most substantial source of wealth. This, as also noted by Moran (2009), makes homeownership an efficient and effective way to develop wealth because:

1. Home equity appreciation remains the primary savings mechanism for a great majority of the U.S. population.
2. Non-conforming financing also brought about unexpected success to existing homeowners, which lenders capitalised on through the encouragement of home equity withdrawals.
3. Individuals and families accessed and used this new source of credit to extract previously illiquid home equity wealth through refinancing.
4. A huge real estate speculative bubble in housing prices caused millions of Americans to think of homes as a cash investment instead of as a place to live – over 2005 and 2006, almost 40% of homes purchased were not used as primary residences, but were instead used as vacation homes or for investment purposes (Moran, 2009).

Over this time period, the housing bubble naturally saw substantial increases in both homeownership (see Appendix 1) and home values. Homeownership rose to 67.4% of U.S. households in 2000 from 64% in 1994 and peaked in 2004 with an all-time high of about 69%. Between 1997 and 2006, home prices in the U.S. augmented by 124% (CSI …, 2007). Although home prices nationwide experienced a rapid price appreciation increases were especially pronounced in a few regions (such as California, Florida, Arizona, and Nevada) where house prices more than doubled between 2000 and 2006. To sum up, it can be concluded, that while constituting an admirable social goal and being a plus for the economy, the increased homeownership has come at a very substantial personal and financial cost to already financially strapped consumers as it allowed too many individuals and families to become overextended and hold mortgages they simply could not afford (Moran, 2009).

The rise of subprime mortgage lending and erroneous lending and borrowing practices

The 2007 subprime mortgage crisis was distinguished by an unusually high share of originated subprime mortgage loans, which was defaulted already in a few months, and borrowers were deprived of their ownership rights. Crandall (2008) in his research

argues that the first subprime mortgage expansion occurred in 1990s when governments encouraged lending to low-income borrowers, technology advancement and achievements made the credit risk assessment process easier, and the growth of the subprime mortgage market enabled lenders to transfer subprime mortgage risk to investors.

TABLE 1. **Origin of subprime mortgage loans and factors behind its rapid growth***

Scientist / economist	Factors behind the growth of subprime mortgage loans	Implications of factors for markets, economy and social environment
Moran (2009)	The Depository Institutions Deregulation and Monetary Control Act (DIDMCA) passed by the Congress in 1980.	The Act cancelled state interest rate ceilings for the majority of mortgage loans and was meant to foster lending. However, the principles of the Act also tolerated increased conventional mortgage interest rates in states with low interest rate ceilings and encouraged the growth of the subprime market regardless of the high interest rate limits on mortgage loans.
Moran (2009)	Alternative Mortgage Transaction Parity Act passed by the Congress in 1982.	The Act contributed to the increased flexibility of the mortgage lending industry by allowing lenders to offer adjustable rate mortgages as part of their business transactions.
Carrillo (2008)	Innovative and "exotic" lending vehicles.	While the housing market was still strong, lenders argued that innovative and "exotic" lending vehicles would increase consumer access to credit, which did in fact occur.
Moran (2009)	Placing more reliance on the collateral (home) value.	Easy credit and weakening lending standards, coupled with the assumption that housing prices would continue to appreciate, created an increase in homeownership rates and the demand for housing while encouraging many subprime borrowers to obtain adjustable-rate mortgages, which they could not afford.
Johnston et al. (2008)	Adjustable-rate mortgage loans.	For home buyers these lending mechanisms cost a lot less than a thirty-year fixed-rate mortgage, at least at the inception of the loan term. However, all types of adjustable-rate mortgage loans concurrently presented the substantial risk that interest rate increases will result in significantly higher monthly mortgage payments, which did in fact occur, and the majority of borrowers could no longer fulfil their obligations.

Prepared by authors based on Moran, 2009; Johnston et al., 2008; Carrillo, 2008.

What was peculiar to the he U.S. was the sudden rise of subprime lending. Different mortgage interest rates and terms are classified into two main categories – prime and subprime – based on the credit risk and the ability to repay of potential borrowers. The terms "prime" and "subprime" refer to the credit quality of the borrowers, not the interest rate of the loans. Generally, subprime mortgages are for those borrowers with a FICO credit score below 620, while borrowers with a FICO credit score above 620 qualify for prime mortgages (Crandall, 2008, p. 2–3). The prime segment has generally catered to the most creditworthy borrowers, and the subprime lending, on the other hand, focuses

on a greater number of higher-risk borrowers who do not qualify for market interest rates because of different risk factors, such as income level, the down payment amount, their credit history, and employment status (Johnston et al., 2008).

Different researchers look for the causes of subprime mortgage in different sources – some of them find these causes in federal laws, others – in the attempt to try financial innovations, or in the appreciation of house prices, or in the adjustable interest rates. Having summarised and analysed the differing opinions and arguments, the essential causes of the origin and rapid development of the subprime mortgage loans can be distinguished. They are classified in Table 1.

The specifics and types of the subprime mortgage loans were investigated to a wider extent by Jaffee (2008). In his paper, Jaffee provides a deeper explanation and elaborates on the development of the U.S. subprime mortgage loans, the tendencies and volume changes of which are explicitly shown in Fig. 2.

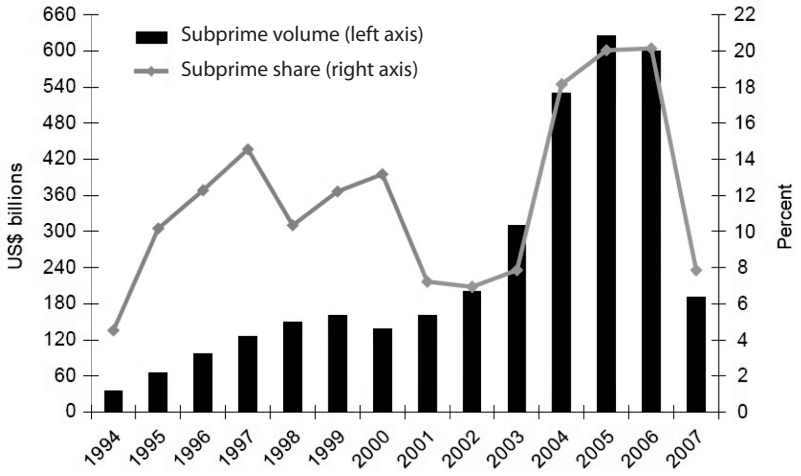


FIG. 2. **Development trends of the U.S. subprime mortgage lending volumes (Jaffee, 2008)**

Thus, it is obvious that starting with 1994 and continuing through 2007, subprime loans were increasing quite rapidly both in terms of their absolute value and relative share in the total volume of the originated loans. Figure 2 shows two distinct periods of expansion in the subprime lending. The first period occurred during the late 1990s, with subprime lending reaching an annual volume of USD 150 billion and as much as 13% of the total annual volume of originated mortgage loans. This expansion ended with the "dot-com" bubble collapse in 2000–2001. The second expansion started in 2002, reaching annual loan volumes of over USD 600 billion in 2005–2006 and representing over 20% of the total annual volume of mortgage loans originated in those years (Jaffee, 2008).

The subprime mortgage lending volumes and their percentage in the total volume of the originated mortgage loans reflect the lending practices of lenders – during the economic upturn loan granting terms and standards kept easing, and collapse of "dot-com" and later – the housing bubble was followed by the credit crisis in the course of which credit standards were tightened considerably, the number of defaults in the subprime lending sector increased, and credit institutions significantly reduced the amounts of granted risky subprime loans (Simkovic, 2011).

The mortgage contract design has played an essential role in the subprime innovation process during which numerous subprime mortgages have been created. Jaffee (2008) and Kirk (2007) distinguish the following main types of the subprime mortgages:

- adjustable-rate loans;
- interest-only mortgages allowing borrowers at the inception to pay only interest for a certain period, with the possibility of deferral of loan repayments;
- "balloon" mortgages, the repayment amounts of which kept increasing in the long run;
- standard long-term, fixed-rate mortgages;
- "option" mortgages, which allowed borrowers to defer some of their payments;
- converting mortgage loans which start with fixed rates, then convert to adjustable-rate loans;
- low document loans for borrowers that cannot provide complete documentation required for a conforming loan;
- "Alternative-A" (or "Alt-A") mortgage loans that essentially are between prime and subprime mortgage loans because of one or more substandard features of the borrower, ownership or loan.

These mortgage loans were all designed to meet specific needs: option mortgages for borrowers with widely fluctuating incomes, converting mortgage loans for borrowers who expected income growth in the future, etc. Many subprime mortgage loans were also originated with the expectation that the borrowers would soon refinance into higher-quality loans, assuming that the borrower's credit rating would improve or the borrower's equity in the house would rise as the result of continuously rising home prices. The subprime lenders also succeeded in attracting a significant number of borrowers who would otherwise have been among the borrowers of higher-quality conforming loans which made the effects of the crisis even more painful (Jaffee, 2008).

Consequently, due to the rapid expansion of subprime lending, the share of "Alt-A" and various other adjustable interest subprime mortgage loans in the total volume of the originated mortgages rose rapidly (Appendix 2). The transformation of the market was such that of mortgage loans originated in 2006 only 36% were conforming loans, 15% were prime "jumbo" loans (which exceeded the ceiling for conforming mortgages),

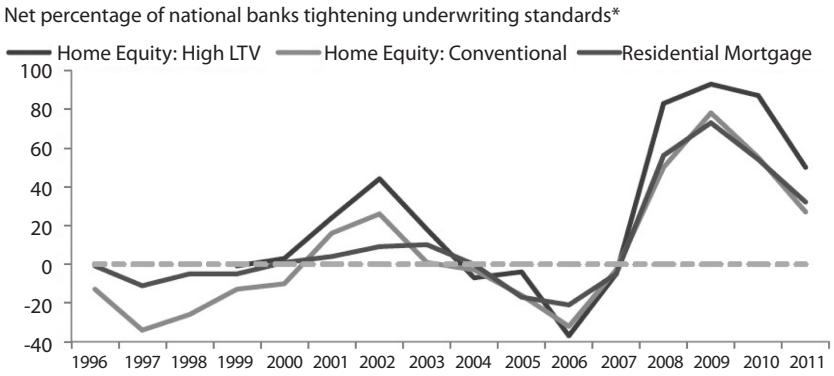
3% comprised mortgage loans guaranteed by the Federal Housing Administration (FHA), while the remainder comprised "nonprime" loans "Alt-A" (25 %) and subprime mortgages (21 %) (Kiff et al., 2007, p. 6).

Engel et al. (2007) focused on the lending policy pursued by banks and its relationships with predatory acts. Their research was supplemented by Crandall (2008). The predatory lending is defined by researchers as charging excessively high fees or interest rates or using deceptive or unfair (legal or illegal) lending practices. Therefore, they include the following behaviour of lenders in the "predatory" lending concept and also in the list of causes of the subprime mortgage crisis:

1. Loan structure. An example of the loan structure, which is considered to be predatory, is the so-called "2/28" (or "3/27") loans. Over the first two years of a "2/28" loan, a borrower pays a low fixed interest rate, the so-called "discount" interest rate, and after two years the interest rate is adjusted every six months. The adjusted interest rate usually was higher. Those borrowers who could not continue loan repayments due to the higher interest rate tried to return to the lender for refinancing their loan and obtaining one more loan with the "discount" interest rate for two years; therefore, lenders were paid excessively high refinancing fees, and even 85 % borrowers could not fulfil their "2/28" loan obligations soon after the adjustment of the interest rate.
2. Collection of fees / commissions. It covers fees or interest rates that are excessively high compared to the borrower's credit risk (e.g., fines for early repayment of a loan which has been originated by bank knowing that it will need refinancing).
3. Illegal fraud or deception. It covers violations of the legislation on consumer rights' protection and anti-predatory lending laws.
4. Non-transparency, discrimination. This category captures the non-disclosure of mortgage lending prices and terms, racial and ethnic discrimination in lending, etc.

Generally, lenders have no financial incentives to engage in predatory lending policies, because they don't benefit from defaulting borrowers, but when home prices rise, credit institutions are more inclined to pursue predatory lending because of the possibility to cover incurred losses in case of default.

Demyanyk et. al. (2008), who analysed the subprime mortgage market and the quality of originated loans in his scientific research, concluded that problems in the subprime mortgage market had manifested themselves already before the crisis (Fig. 3). In late 2005, the monotonic deterioration of the subprime mortgage market was already visible, and the quality of loans had been worsening for the fourth year in a row. The rapid growth of home prices temporarily disguised the deterioration of the subprime mortgage market and its actual risks, but when home equity appreciation stopped, market risk immediately came to light, whereas when the bubble of housing prices collapsed and borrowers started defaulting, the activities of banks became pro-cyclical, and in order to



* Changes in underwriting standards as reported by national bank examiners. Net percentage calculated by subtracting the percent of banks tightening from the percent of banks easing; negative values indicate easing.

FIG. 3. **Developments of mortgage underwriting standards, 1996–2011 (Simkovic, 2011)**

Source: Office of the Comptroller of the Currency Survey of Credit Underwriting Practices 2011. Tables 45, 47, 51; OCC Survery of Credit Underwriting Practices 2002 pg 33–36

avoid further losses they significantly raised the lending standards. Thus, while in 2006 almost 20–40% (depending of the mortgage loan type) of banks weakened their lending standards in order to generate higher benefits, from 2007 the situation changed to the opposite direction, and for three consecutive years mortgage lending standards were being significantly tightening until 2009 when they were made more stringent even by 80–90% of banks.

III. Analysis of the consequences and alternatives of the subprime mortgage crisis

When analysing the consequences and alternatives of the subprime mortgage crisis, the main ratio chosen for the assessment of consequences of the crisis and also of the housing market was the number of new housing starts, because the formation and collapse of the housing market bubble was the essential turning and starting point for all subsequent events and development of the crisis. In other words, the research mainly focuses on the number of new housing starts, therefore the analysis of the housing market bubble creation and losses aims at examining how and what causes of the subprime mortgage crisis covered by the first part of the paper affected the number of new housing starts, how and why the housing market bubble inflated and collapsed bringing about huge losses that are still being calculated for different financial institutions, country governments, taxpayers and the rest of the public.

The number of new housing starts in the research has been chosen as the dependent variable – a factor, consequence or result of several independent variables or causes

that have been influencing it for a prolonged time (see Table 2). The list of independent variables for the research was compiled in observance of the possibilities to assess them in quantitative terms over the reference period and also having regard to their potential direct impact on the number of new housing starts. Although the number of causes analysed in the literature review was considerably larger, the research focuses on those factors and causes, which could have been directly regulated or influenced by the central bank or government of the country.

TABLE 2. **Dependent variable and independent variables of the analysis***

Dependent variable (consequence, result)	Independent variables (causes)
Number of new housing starts	Federal funds rate
	Mortgage charge-off and delinquency rate
	Change in demand for mortgage loans
	Homeownership ratio
	Risk-weighted Tier I capital ratio
	Federal Housing Administration loans volume
	Change in mortgage lending standards

* Prepared by authors based on Taylor, 2007; Avery, 2011.

The period chosen for the analysis is between the first quarter of 2000 and the third quarter of 2013, therefore, it allows capturing the causes and consequences of the crisis from its very roots and beginning of formation until the period showing the signs of economic recovery. The assessment of the whole cycle (rise, fall, and recovery) makes it possible to present a wide review of the subprime mortgage crisis and provide conclusions and proposals based on calculations.

Graphical paired regression analysis of model variables

The main purpose of the regression analysis of the dependent variable and independent variables is to calculate and select the factors that could facilitate producing a model which adequately reflects the relationship with the number of houses and can be used in the calculations of the impact of changes of separate factors.

The first step towards such a model is the graphical analysis of the dependent variable and independent variables of the model. The paired dependence of the dependent variable on each independent variable is drawn, and different trend equations are selected, the coefficients of determination of which determine the form of data of independent variables, which is the best in terms of reflecting the relationship with the dependent variable. Thus, having entered all data of variables in the time series, Appendix 3 is produced.

Data in Appendix 3, beside the Federal funds rate, are provided already slightly modified – the best correlation with the dependent variable was of the Federal funds effective interest rate moved over 5 quarters (correlation coefficient -0.54113), because decisions of the central bank with respect to interest rates and their adjustment in the economy start functioning not immediately, but with a certain time lag.

Higher values of the Federal funds rate are followed by moderately lower and negative values of changes in the number of houses and vice versa – lower interest rates are related to greater and positive changes in the number of houses. This consistent pattern arises from the monetary policy pursued by the Federal Reserve Bank, the purpose of which is to monitor inflation and other different economic indicators and adopt decisions on the size of interest rates on their basis. Trend equations (linear and square) drawn in Fig. 4 do not contradict the economic laws – rising Federal funds rate reduces the number of houses, i.e. suppresses economic activity and housing demand, and housing supply concurrently decreases.

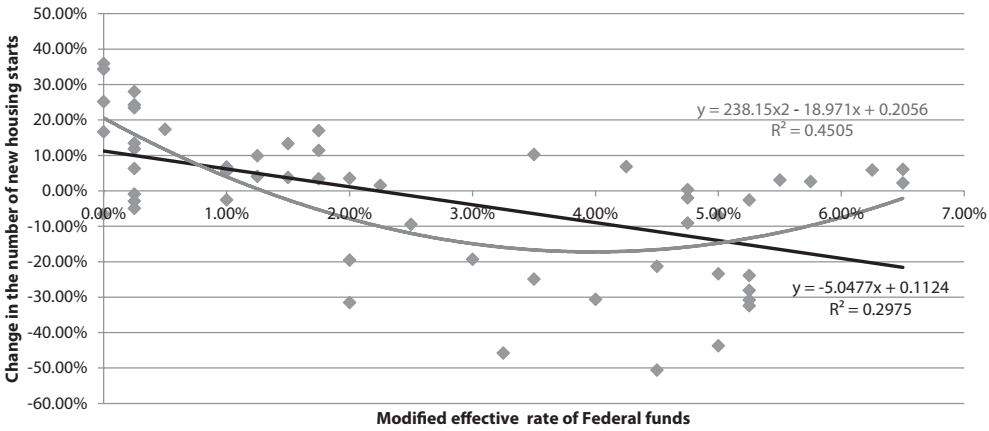


FIG. 4. **Dependence of the number of new housing starts on the modified effective rate of Federal funds***

*Prepared by authors based on New..., 2013; Selected..., 2013.

Although the coefficient of determination (0.4505) of the square trend equation in Fig. 4 is greater than that of the linear equation (0.2975), having regard to easier interpretation and calculations and acting on the basis of economic laws (increase of interest rates results in the slowdown of economy and reduction of prices, and the existence of the turning point would contradict the economic theory), the linear dependence of the number of new housing starts on the modified effective rate of Federal funds has been chosen.

Appendix 4 reflects the relationship between the dependent variable and the mortgage charge-off and delinquency rate. It is obvious that data are quite tendentiously distributed

in the descending direction, i.e. the relationship between these variables is negative – increasing changes in mortgage charge-off and delinquency rates predetermine smaller and negative changes in the number of new housing starts. Due to the minor difference between the coefficients of determination (0.4903 – of the square equation, 0.4864 – of the linear equation), the linear relationship between the dependent variable and this independent variable is chosen for the further estimates and calculations of the model. Such relationship between these two variables is explained by the fact that greater changes in the mortgage charge-off and delinquency rate testify to the poor quality of the originated loans and problems in the housing market at large, or the creation of the housing bubble. For market participants, this signals about a higher risk and the likelihood of crisis in this sector, thus resulting in negative expectations, avoidance of this sector, a lower housing demand, and concurrent reduction in the number of new housing starts. Contrarily, when the mortgage charge-off and delinquency rate fall, market participants' expectations become positive, and it testifies to the favourable situation both in the mortgage loans market and in the housing market at large, and, accordingly, the market is expected to grow further, which, in turn, encourages banks to increase lending and market participants to borrow and invest in residential houses. Accordingly, construction industry responds to a higher demand also by the growing volumes of new housing starts.

Appendix 5 shows the paired regression relationship between the dependent variable and increase in the demand for mortgage loans, reported by respondents. Although, due to relatively short data series and period covered by analysis, the data points are rather disorderly and widely dispersed, the trend equations defining the paired relationship during the period under consideration still reflect the tendency of growth (the linear equation trend coefficient is positive: 0.389). A comparison of the coefficient of determination of the linear and square paired regression equation also does not show any significant difference (0.3387 and 0.367, respectively); thus, like in other cases, the linear interdependence between these two variables is chosen because of the easier interpretation and calculations.

Although from the first sight it might seem strange why the interdependence existing between the demand for mortgage loans and new housing starts, which is the elementary economic law (increasing demand for loans results in a higher housing demand and concurrently stimulates the increase of house numbers) is not very distinct in this chart, but this question can be answered getting back to the statistical analysis of variables and ascertaining once again that this ratio included in the calculations is not a pure indicator of the amount or volume of demand, it is just the percentage of respondents who have reported the increase in the demand for mortgage loans. Therefore, this ratio shows the net percentage of banks that have faced a higher demand for mortgage loans

in particular quarters compared to the previous quarter; however, this ratio excludes the loan origination volume. It means that in one quarter the demand for mortgage loans might increase for 75% of banks and decrease for 25% of banks, so the ratio will reach 50%, but the extent of such increase may be smaller than the reduction of lending volumes in several banks; therefore, the interdependence between the number of new housing starts, and the net share of respondents reporting a higher demand for mortgage loans is not so obvious. However, as already mentioned above, the dependence of these factors manifests the tendency of growth – the higher percentage of banks facing a higher demand for mortgage loans predetermines a greater change in the number of new housing starts, and the lower percentage means a smaller change in the said number. Although this dependence does not precisely define the lending volume, it still reflects the approximate trend of the whole market and roughly shows the volume sign (+ / –); thus, we can see that the growing percentage of banks reporting a higher demand for mortgage loans predetermines the increase in the number of houses.

One more analysed factor that influenced the number of new housing starts is the tightening of mortgage lending standards. Paired dependence curves (Appendix 6) also show no contradictions to economic laws and economic logic in the relationship between the tightening of mortgage lending standards and the number of new housing starts during the reference period – the easing or slight tightening of the mortgage lending standards is followed by considerably higher values of the number of new housing starts, and greater tightening of the standards is related to an immediately smaller and in many cases negative change in the number of new housing starts. It is so because the easing of lending standards predetermines a larger volume and number of the originated loans – loans can be obtained both by lower-income individuals, borrowers who already have taken one or more loans, as well as individuals whose credit rating is insufficient when more stringent requirements apply. In that way, the larger amount and volume of the originated mortgage loans stimulates housing purchases and demand, which, in its turn, also increases the number of new housing starts. The tightening of mortgage lending standards, contrarily, narrows the number of individuals who are eligible and have the possibility to apply for mortgage loans, because the increasingly smaller share of potential borrowers meet the imposed tighter requirements, so the volume and number of the originated loans reduces as the mortgage lending standards become tighter, which in its turn also reduces the housing supply. As the coefficients of determination of the square and linear paired regression equation are practically the same (0.4948 and 0.4947), the model again uses the data provided in Appendix 3 without any modifications or changes.

Appendix 7 depicts the paired regression relationship between one more significant independent variable – the risk-weighted Tier I capital ratio of banks and the dependent variable. We can see that the dispersion of data is relatively great, and data points are

arranged in accidental order, without showing any obvious consistent pattern. However, after drawing the trend equations, we still have a negative slope which, due to a high data dispersion, is rather small. In other words, when the capital ratio significantly increases, the reduction of the dependent variable is quite inconsiderable. It is so because the bank capital, as a rule, is subject to the ongoing supervision and various established capital adequacy ratios, thus, the risk-weighted Tier I capital of banks may not fall below the established threshold of 4%. Many banks are trying to exceed this ratio, so they usually do not reach this threshold and maintain a secure "reserve" which changes only inconsiderably; however, banks avoid keeping this reserve excessively large, because they have to pay interest or dividends on (own or borrowed) capital, and its employment for minimum return is too expensive and can be loss-making. This stimulates banks to seek the maximum advantage of the possibilities of risks taken by them. Therefore, when the economy surges, banks, considering positive expectations of economic growth and situation, tend to take a higher risk and originate more loans, which increases housing demand and, concurrently, supply. When the economy stagnates, banks, again, act pro-cyclically and, because of uncertainty of economic forecasts and worsening expectations, tend to accumulate an additional capital reserve to cover potential losses, minimise risks taken by them, tighten lending standards and volumes, which, in turn, reduces housing demand and construction volumes. Due to the minor difference between the coefficients of determination (square – 0.0624, linear – 0.0318), the linear interrelationship of the factors is chosen; however, in addition to Appendix 7, the coefficients of determination also imply that the impact of Tier I capital ratio on housing numbers is minor and very insignificant.

The next variable covered by the regression analysis is the homeownership ratio. The development of this ratio in paired regression with the number of new housing starts does not require any additional modifications as the trend curves (Appendix 8) and the coefficients of determination (linear – 0.0057, square – 0.0114) show that the interrelationship of these two ratios, reflected by the linear trend equation, is essentially similar to the square trend equation; therefore, the linear relationship between these ratios is again chosen, because it favours easy calculations and the interpretation of the obtained results. The positive coefficient of relationship shows that when the homeownership ratio increases, the number of new housing starts also has the tendency to increase. To put it otherwise, the increasing homeownership ratio shows that the percentage of houses purchased and occupied by owners keeps growing; therefore, it is obvious that, due to that, housing demand and supply increase. As already mentioned above in this paper, the homeownership support programmes implemented by the government only partially justified the expectations – the bigger part of homes were acquired by individuals who were purchasing not their first home, and the homeownership ratio, therefore, reflects a considerably lower percentage of increase than actually was, but the relationship between these factors, albeit weak, still

exists. However, likewise in the case of Tier I capital ratio, it can be assumed that the relationship may be statistically insignificant, which is also indicated by a completely accidental distribution of points in Appendix 8 and a high data dispersion. In other words, it is quite difficult to identify a distinct tendency of the dependent variable's response to the developments of the independent variable on the basis of available data.

Appendix 9 presents the interdependence between the number of new housing starts and the volume of mortgages insured by FHA. The distribution of data is rather uneven: the concentration of different values of changes in housing numbers can be observed both where the volume of mortgages insured by FHA is small and large. The slope produced drawing a square and a linear regression equation of the interdependence of these factors is negative (-0.0013 in the linear equation). Like for all other paired regression equations of the dependence of factors, in this case out of the two the linear relationship is chosen, although the difference between the coefficients of determination in this case is quite significant (square – 0.2909, linear – 0.0222). However, the data series is rather short, and the coefficient of determination of the square equation is to a great extent increased by extreme values. Furthermore, the existence of the turning point is also logically incompatible with the economic theory; therefore, the linear relationship between these factors is chosen to facilitate the calculations and interpretation. Such a distribution of the negative slope data can be explained by the relationship which exists between the smaller volume of loans insured by FHA and the FHA's role of providing liquidity support to the mortgage market. During periods of the economic upswing, loans and lending volumes of other market players due to the pro-cyclical lending policy pursued by banks grow significantly, thus reducing the market share and lending volumes of FHA and considerably increasing housing numbers due to the growth of housing demand and home purchases. In the periods of economic downturn, the number and volumes of bank loans begins to contract gradually, and lending standards are significantly tightened, resulting in the increase of market share and lending volumes of FHA, which continues originating the same loans of sufficiently good quality in support of liquidity, while the entire housing market at that time is contracting, also bringing down the housing demand and supply. It follows from the above that such interpretation and distribution of points in Appendix 9 shows that the interrelationship between these factors might be insignificant, because the data are too scattered, and the volume of loans insured by FHA might be a result of other independent factors and indicators.

Multiple regression analysis

A multiple regression model of the dependent variable and independent variables is produced using all data series of the relationship between the dependent variable and independent variables covered by the paired regression analysis. Given the linear

relationship existing in this case between all independent variables and the number of new housing starts, no modifications are made in the data table, and calculations are carried out using the same Appendix 3. It's just worth mentioning again that instead of the Federal funds rate the Federal funds rate carried forward for 1.25 years is used, but the relationship is still linear.

An important aspect in producing the regression model is to determine the multicollinearity. The existence of multicollinearity in the model being produced in this case would mean a correlation between one or more independent variables of the model, i.e. one variable can be obtained linearly from other variables with a sufficiently high level of accuracy. In that case, any small changes in the model or data can bring about significant and variable changes in the calculated multiple regression coefficients, and the signs of the coefficients may be incompatible with economic laws. The multicollinearity itself does not reduce the reliability and accuracy of the entire model, but it affects the calculation of separate variables of the model. It means that the multiple regression model with correlating variables can show with what accuracy and precision all independent variables predict the dependent variable, but the model cannot produce any particular results related to separate independent variables of the model or identify the variable which is insignificant. Given that the purpose of producing this multiple regression model is to assess the impact of separate factors and to calculate on its basis the results of alternative actions of the central bank and the government, the next step in this study is to verify whether the multicollinearity of the model exists, and if it does exist – to eliminate it by removing closely interrelated independent variables.

For the purpose of assessing the multicollinearity, the table of paired correlation coefficients is used. Although quite often a "rule of thumb" is used, according to which a model is considered to be multicollinear when the paired correlation coefficient module is greater than 0.8, however, in order to calculate the coefficients of the model with the maximum accuracy, in other stages this threshold is reduced to 0.7. The data of paired correlation coefficients are presented in Table 3. The yellow column shows the correlation coefficients of the dependent variable and independent variables, thus it is not taken into account when assessing the multicollinearity of the model. As we can see, the coefficient is greater than 0.7 only in one case of paired correlation (marked in red in the Table) – between the mortgage charge-off and delinquency rate and the net percentage share of banks that have tightened mortgage lending terms. For the purpose of examining which of these factors should be eliminated, other correlation coefficients are considered. As the correlation of both factors with the dependent variable is essentially the same and the ratio of tightening mortgage lending terms is more related to the residual independent variables, this factor is eliminated from the model.

TABLE 3. **Paired correlation coefficients of regression variables**

	Number of new housing starts	Modified effective Federal funds rate	Mortgage charge-off and delinquency rate	Net percentage share of respondent banks, reporting higher demand for mortgage loans	Risk-weighted Tier I capital ratio	Home-ownership rate	Volume of loans insured by Federal Housing Administration	Net percentage share of respondent banks, tightening mortgage underwriting standards
Number of new housing starts	1							
Modified effective Federal funds rate	-0.545459998	1						
Mortgage charge-off and delinquency rate	-0.697422904	0.39153705	1					
Net percentage share of respondent banks, reporting higher demand for mortgage loans	0.581982172	-0.196919902	-0.328274809	1				
Risk-weighted Tier I capital ratio	-0.178378582	0.092095953	0.339578764	-0.272314915	1			
Homeownership rate	0.075420517	0.108840919	-0.079543376	0.232735079	-0.149472854	1		
Volume of loans insured by Federal Housing Administration	-0.148920211	-0.189820144	0.293783563	0.131845193	0.295782417	-0.123085999	1	
Net percentage share of respondent banks, tightening mortgage underwriting standards	-0.703381497	0.38325213	**0.713196585**	-0.384287973	0.244943833	-0.193220708	0.471929955	1

Prepared by authors based on New..., 2013; Selected..., 2013; Senior..., 2013; Seasonally..., 2013; Charge-off..., 2013; BHCPR..., 2013; FHA..., 2013)

In order to make an even deeper assessment of multicollinearity between the residual factors, VIF statistics is used:

$$VIF(X_j) = \frac{1}{1 - R_j^2},$$

where X_j is the j-th independent variable, R_j^2 is the coefficient of determination of the j-th independent variable regression equation with other independent variables. Some authors suggest in their works that multicollinearity of a model exists when VIF (X_j) > 5 and others when VIF (X_j) > 10. Given that the present paper analyses the economic variables that are interrelated in one way or another and depend on the general economic situation, in order to achieve a better clarity of variables of the model and to calculate more precise and undistorted data, the lower VIF statistics measure is used, i.e. considering that multicollinearity of the model exists when VIF (X_j) > 5.

TABLE 4. **VIF statistics calculations of independent variables of the model**

Independent variable	VIF statistics value
Modified effective Federal funds rate	$VIF(X_1) = \frac{1}{1 - R_1^2} = \frac{1}{1 - 0{,}2682} = 1{,}36$
Mortgage charge-off and delinquency rate	$VIF(X_2) = \frac{1}{1 - R_2^2} = \frac{1}{1 - 0{,}3925} = 1{,}65$
Change in demand for mortgage loans	$VIF(X_3) = \frac{1}{1 - R_3^2} = \frac{1}{1 - 0{,}261} = 1{,}35$
Homeownership rate	$VIF(X_4) = \frac{1}{1 - R_4^2} = \frac{1}{1 - 0{,}0988} = 1{,}11$
Risk-weighted Tier I capital ratio	$VIF(X_5) = \frac{1}{1 - R_5^2} = \frac{1}{1 - 0{,}2134} = 1{,}27$
Federal Housing Administration lending volume	$VIF(X_6) = \frac{1}{1 - R_6^2} = \frac{1}{1 - 0{,}3062} = 1{,}44$

Prepared by authors based on New..., 2013; Selected..., 2013; Senior..., 2013; Seasonally..., 2013; Charge-off..., 2013; BHCPR..., 2013; FHA..., 2013.

As the calculated VIF statistics (Table 4) shows that the linear relationship between all six independent variables and the residual independent variables is very weak, the independent variables are not eliminated. Considering both the matrix of paired correlations and VIF statistics values that are relatively small and don't reach even the value of 2, it can be concluded that having eliminated the tightening of mortgage lending standards from the list of independent variables, the model with the residual factors is no longer multicollinear, and thus the calculation results are not distorted. Furthermore, the effect of the eliminated factor is not lost to a certain extent, because it was mainly the

result of the residual independent variables which are related to the eliminated variable and will continue influencing the dependent variable of the model.

The multiple regression equation coefficients are calculated for all residual independent variables. As part of the factors have been eliminated, the residual ones are marked as follows:

- Y – the number of new housing starts, percentage change compared to the last year's quarter (dependent variable);
- X_1 – the modified effective Federal funds rate (1.25 years time lag); X_2 – the mortgage charge-off and delinquency rate of 100 largest banks, absolute change compared to the previous quarter; X_3 – the net percentage share of banks reporting a higher demand for mortgage loans; X_4 – the risk-weighted Tier I capital ratio, the percentage change compared to the previous quarter; X_5 – the homeownership ratio, percentage change compared to the previous quarter; X_6 – the volume of loans insured by the Federal Housing Administration, USD billion.

In order to assess the impact of each independent variable on the dependent variable, the statistical significance of each factor is examined using *t* statistics (see Appendix 10) showing the independent variables of the model that should be included in the model at the particular confidence level. If $|t \text{ calculated}| > t$ notional, and null hypothesis is eliminated, the impact of the independent variable is statistically significant. As the model seeks the maximum accuracy, the confidence level chosen in this case is 99 %, and the notional value *t* is 2.6822 (Appendix 10, upper highlighted boxes, using TINV function). Having eliminated the homeownership ratio from the regression model, the same procedure is repeated until the modulus of *t* statistics of all residual factors becomes greater than the notional value *t* of the confidence level of 99 %. The risk-weighted Tier I capital ratio and the volume of loans insured by FHA appeared to be statistically insignificant, which to a certain extent was also shown by the previous paired regression analysis.

Therefore, having calculated and assessed the impact of separate three residual independent variables of regression on the dependent variable, the equation coefficients are obtained (column *Coefficients* in the lower part of Table 5). The final calculated regression equation is as follows:

$$Y = -2.69811 \cdot X_1 - 13.02445 \cdot X_2 + 0.24955 \cdot X_3 + 0.10301.$$

The relationship between the independent variables and the dependent variable in the paired regression analysis and the slope in the multiple regression equation is confirmed, i.e. the increase of the modified Federal funds rate and mortgage charge-off and delinquency rate reduces the number of new housing starts, and the increase in the percentage share of respondent banks reporting a higher demand for mortgage loans increases the number of new housing starts. The graphical paired analysis of variables also produced analogous

TABLE 5. **Results of calculations of the final regression equation**

SUMMARY OUTPUT						
Regression statistics						
Multiple R	**0.835233692**					
R Square	**0.697615319**					
Adjusted R square	0.679827985					
Standard error	0.1126636	**F-distribution value =**		**4.190618788**		
Observations	55					
ANOVA						
	df	*SS*	*MS*	***F***	*Significance F*	
Regression	3	1.493460187	0.497820062	**39.21977929**	2.76454E-13	
Residual	51	0.647347426	0.012693087			
Total	54	2.140807613				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	**0.103011612**	0.025059616	4.110662092	0.000143479	0.052702335	0.153320889
Modified effective rate of Federal Funds, time lag of 5 quarters, %	**-2.698110366**	0.776807609	-3.473331536	0.001057084	-4.257616681	-1.13860405
Mortgage charge-off and delinquency rate of 100 largest banks, absolute change compared to the previous quarter, %	**-13.0244469**	2.463088322	-5.287852158	2.60941E-06	-17.96930294	-8.079590863
Net percentage share of banks, reporting higher demand for mortgage loans, %	**0.249545473**	0.054659102	4.56548797	3.17442E-05	0.139812749	0.359278197

Prepared by authors based on New..., 2013; Selected..., 2013; Charge-off..., 2013; Senior..., 2013.

results. The coefficient values as such do not say much about the strength of the impact on the dependent variable, because they depend not only on the strength of the relationship, but also on the limits of change of the analysed period and measurement units – the modulus value of the trend coefficient of the independent variable, which changes significantly and frequently, producing high values which will always be lower than the variable which is more stable and changes less frequently or develops lower values.

The coefficient of determination (line *R Square* in the upper part of Table 5) is 0.697615319, so it can be stated that the regression equation explains almost 70% of dispersal of the dependent variable's values around the mean; thus, generally speaking, the produced model sufficiently accurately defines the dependence of the number of new housing starts on the independent variables included in the model, which can be directly influenced by the central bank and the country's government. The strength of the linear relationship between the dependent variable and independent variables is also testified by the multiple correlation coefficient (line *Multiple R* in the upper part of Table 5), which is 0.835233692. According to the general "rule of thumb", the closer its value is to 1 the stronger is the relationship, and when it exceeds 0.8 the relationship between

model variables is considered to be strong. The examination of statistical significance of the whole regression is also an important step in assessing the calculated regression.

The calculated value of F statistics (intersection of line *Regression* and column *F* in the middle part of Table 5), which is used, is 39.21977. The calculated actual value of *F* statistics is compared with the notional $F_{a;\ k;\ n\text{-}k\text{-}1}$ value of the chosen confidence level (in this case, the selected significance is also 99%, a = 0.01) from F-distribution tables, where *k* is the number of independent variables of the model and *n* is the total number of observations. Thus, in this case, $F_{0.01;\ 3;\ 51} = 4.19$ (column *F-distribution value* in the middle part of Table 5, used function – FINV), whereas $F_{\text{calculated}} > F_{0.01;\ 3;\ 51}$ (39.21977 > 4.19), the null hypothesis that the regression is statistically insignificant at the 99% confidence level is refuted, and the alternative that the impact of at least one independent variable on the dependent variable is statistically significant is accepted. Consequently, the produced regression model is statistically significant.

All three residual plots in Appendix 11 show that errors are quite accidental – both positive and negative error values are distributed sufficiently evenly and more or less equally. Such an accidental distribution shows that the linear regression model adequately reflects the impact of data, while the nonlinear model would suit better when the distribution of errors is more U-shaped or upside-down U-shaped or takes any other form (Residual..., 2013).

To test for heteroscedasticity, the White test is applied making calculations with the help of the *Eviews* programme (see Appendix 12). A model is heteroscedastic when it has a varying error dispersion, i.e. dispersion of certain errors differs from dispersion of other errors. Heteroscedasticity does not move the regression coefficients calculated using the ordinary least squares approach, but it moves standard errors of the model above or below the actual values. Due to that, the confidence intervals and tests of hypotheses generate unreliable results, thus in the case of the heteroscedastic model the null hypothesis can be accepted at a certain confidence level, although actually it should be refuted.

The results of the White test calculations carried out using the *Eviews* programme are presented in Appendix 12. As the calculated value of the chi-square is 7.331295 (Appendix 12, top line *Obs*R-squared*) and the notional chi-square value at the 95% confidence level and 9 degrees of freedom is 16.919, then $X^2_{calculated} < X^2_{distribution\ table\ value}$. Thus, at the 95% confidence level, the null hypothesis is accepted ($\alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = \alpha_9 = \alpha_{10} = 0$), and it can be concluded that the regression model produced is not heteroscedastic.

Conclusions

In summarising the views, theories, arguments, evidence, and considerations of economists and researchers about the causes and factors of the U.S. subprime mortgage crisis of 2007–2008 in the review of literature, the following conclusions were drawn:

1. Income and growth were excessively highlighted, with too little attention devoted to the risks and risk volumes on the part of both the private and the public sectors. The concentration of banks on growth was motivated by competition and investments in the markets of mortgages and securities comprising them. Seeing a too wide competitive gap in the sphere of fixed-income securities, the majority of banks focused their resources towards the growing markets of asset-backed securities, mortgage securities, and adjustable-rate mortgages, which were considered to offer huge possibilities for income growth.
2. Nobody cared about analysing in detail the strategy of banks and its risks. Overreliance of risk management and control on credit ratings assigned by rating agencies prevented it from predicting and analysing the credit risk of mortgage securities.
3. Financial institutions relied too much on the quantitative methods of analysis, stress tests and statistical risk assessment models based on the data of a few last years. At the same time, the correlation between the risk of securitization and the risk of securities held in balance sheets of banks was ignored.
4. The majority of financial market participants devoted insufficient attention to the systemic risks, such as reduction of liquidity in certain markets or the drop of housing prices.
5. The new information about growing default indicators or the dependence of results of the mortgage securities market on the U.S. housing market at large has not been taken into account.
6. Risk incentives of financial institutions were inadequate: higher-yielding investments in riskier securities or other financial instruments were stimulated by huge bonuses and payments, disregarding the long-term impact of taken risks; the change of a more effective and expensive risk insurance scheme by a cheaper and less effective insurance scheme was generously rewarded.

Summing up the research of the causes and consequences of the U.S. subprime mortgage crisis of 2007–2008, conducted by the authors, the following conclusions were drawn:

1. The performed statistical and paired regression analysis of the independent variables and the number of new housing starts at the beginning of the research has shown that the Federal Reserve Bank has deliberately replaced the "dot-com" bubble by the housing bubble, by increasing money supply and keeping low interest rates for an extended period. It was further concluded that until 2007 the housing schemes had too actively promoted lending to lower-income individuals, and due to that mortgage default rates increased, and the housing construction volumes and prices started falling.
2. Upon calculating and assessing multiple regression equations and different statistical coefficients of significance and determination, it was concluded that the subprime

mortgage crisis and housing bubble was not an isolated and independent event. It was a result of a parallel functioning of several factors, the sources of which stretch not only to the risky activities of the private sector but also to the imprudent policy of the Federal Reserve Bank, the actively pursued housing support policy and the inadequate control of financial institutions.

3. After systematising the available data and indicators, the model of dependence of new housing starts on the factors which were directly and significantly affected by the central bank and the policy of the government, was produced. With the help of this model, it was established that housing numbers in the model were influenced by the Federal funds rate, the growing demand for mortgage loans, and the mortgage charge-off and delinquency rate.

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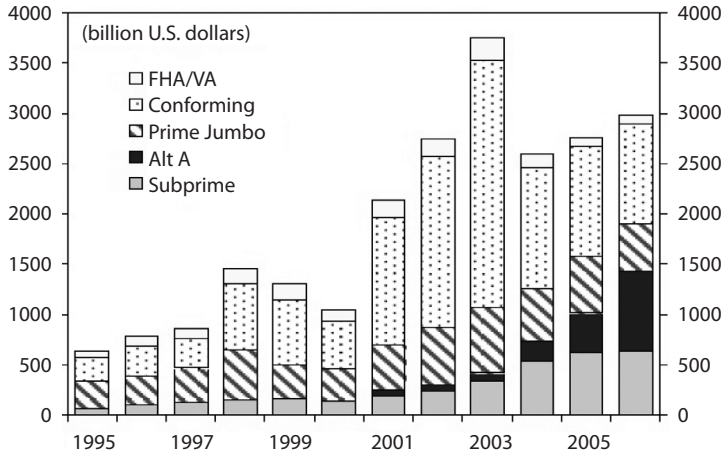
APPENDICES

APPENDIX 1**. U.S. homeownership rates in 1998–2007** (Census ..., 2007)

Year	Homeownership Rates[a]			
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
2007	68.4	68.2	68.2	
2006	38.5	68.7	69.0	68.9
2005	69.1	68.6	38.8	69.0
2004	68.6	69.2	69.0	69.2
2003	68.0	68.0	68.4	68.6
2002[b]	67.8	37.6	38.0	68.3
2002	67.8	67.6	68.0	68.3
2001	67.5	67.7	68.1	68.0
2000	67.1	67.2	67.7	67.5
1999	66.7	66.6	67.0	66.9
1998	65.9	66.0	66.8	66.4
1994	63.8	63.8	64.1	64.2

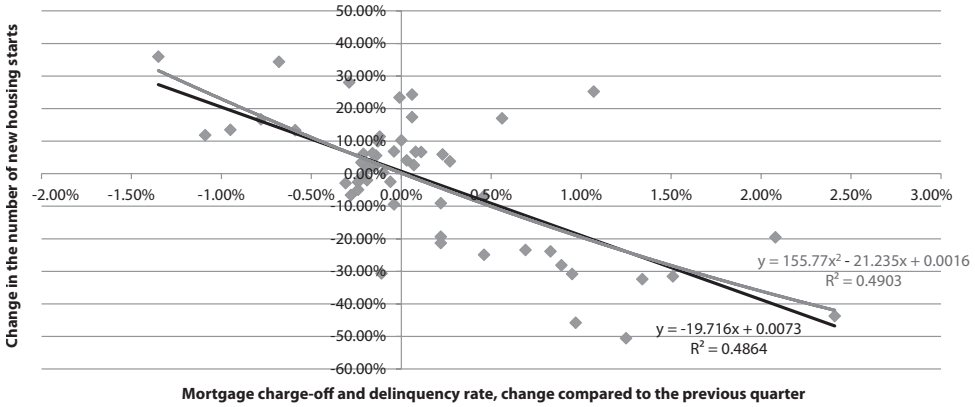
APPENDIX 2. **Distribution of mortgage loans by type in 1995–2006** (Kiff *et al.*, 2007)



APPENDIX 3. **Regression variables and their data, 2000-2013**

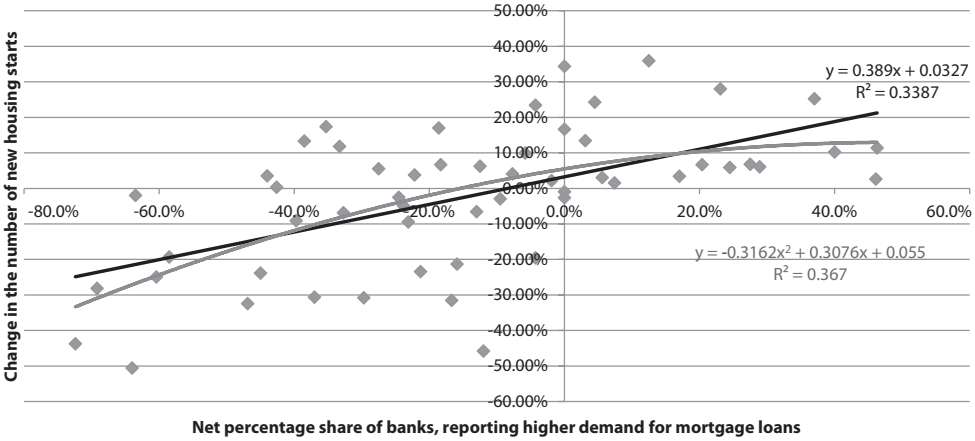
Quarters	Number of new housing starts, percentage change compared to the corresponding quarter of the previous year, %	Modified effective rate of Federal Funds, time lag of 5 quarters, %	Mortgage delinquency rate of 100 largest banks, absolute change compared to the previous quarter, %	Net percentage share of banks, reporting higher demand for mortgage loans, %	Risk-weighted Tier 1 capital ratio, percentage change compared to the previous quarter, %	Homeownership rate, percentage change compared to the previous quarter, %	Volume of loans insured by Federal Housing Administration, bill. USD	Net percentage share of banks, tightening underwriting standards, %	Federal Funds effective rate, %
2000 Q1	-1.98%	4.75%	-0.19%	-63.5%	1.84%	0.30%	19.1	-1.9%	5.75%
2000 Q2	0.34%	4.75%	-0.10%	-42.6%	1.90%	0.15%	24.6	-5.6%	6.25%
2000 Q3	-9.08%	4.75%	0.22%	-39.7%	3.62%	0.74%	22.9	0.0%	6.50%
2000 Q4	-6.88%	5.00%	0.46%	-32.7%	0.00%	-0.30%	21.4	0.0%	6.50%
2001 Q1	-2.60%	5.25%	-0.24%	0.0%	-2.85%	0.00%	33.0	0.0%	5.50%
2001 Q2	2.63%	5.75%	0.07%	46.1%	1.90%	0.30%	42.5	3.8%	4.25%
2001 Q3	5.90%	6.25%	0.23%	24.5%	3.62%	0.59%	39.5	3.8%	3.50%
2001 Q4	2.21%	6.50%	-0.15%	-1.9%	0.00%	-0.15%	36.9	3.8%	2.25%
2002 Q1	6.10%	6.50%	-0.21%	28.9%	1.48%	-0.29%	30.4	1.9%	1.75%
2002 Q2	3.06%	5.50%	-0.17%	5.6%	1.56%	-0.29%	39.2	1.9%	1.75%
2002 Q3	6.83%	4.25%	-0.04%	27.5%	0.10%	0.59%	36.4	3.9%	1.75%
2002 Q4	10.26%	3.50%	0.00%	40.0%	-0.82%	0.44%	34.0	10.0%	1.50%
2003 Q1	1.54%	2.25%	-0.19%	7.4%	1.03%	-0.44%	36.0	11.1%	1.25%
2003 Q2	3.39%	1.75%	-0.22%	17.0%	0.82%	0.00%	46.0	5.7%	1.25%
2003 Q3	11.43%	1.75%	-0.12%	46.3%	0.10%	0.59%	43.0	1.9%	1.00%
2003 Q4	17.00%	1.75%	0.56%	-18.6%	1.93%	0.29%	28.0	0.0%	1.00%
2004 Q1	13.34%	1.50%	-0.59%	-38.5%	5.97%	0.00%	24.0	-1.9%	1.00%
2004 Q2	9.92%	1.25%	-0.13%	-5.8%	-6.95%	0.87%	25.0	-7.8%	1.00%
2004 Q3	4.11%	1.25%	0.03%	-7.7%	-0.50%	-0.29%	19.0	-5.8%	1.50%
2004 Q4	-2.50%	1.00%	-0.06%	-24.5%	1.83%	0.29%	16.0	1.9%	2.00%
2005 Q1	5.53%	1.00%	-0.14%	-27.5%	-1.89%	-0.14%	14.0	-7.8%	2.50%
2005 Q2	6.66%	1.00%	0.11%	-18.3%	0.41%	-0.72%	16.0	-2.1%	3.00%
2005 Q3	6.69%	1.00%	0.08%	20.4%	-2.73%	0.29%	15.0	0.0%	3.50%
2005 Q4	3.81%	1.50%	0.27%	-22.2%	0.10%	0.29%	12.0	-3.7%	4.00%
2006 Q1	3.53%	2.00%	-0.22%	-44.0%	-1.66%	-0.72%	13.0	0.0%	4.50%
2006 Q2	-9.46%	2.50%	-0.04%	-23.1%	1.48%	0.29%	16.0	-9.4%	5.00%
2006 Q3	-19.33%	3.00%	0.22%	-58.5%	-0.52%	0.44%	14.0	-9.3%	5.25%
2006 Q4	-24.92%	3.50%	0.46%	-60.4%	1.57%	-0.14%	13.0	1.9%	5.25%
2007 Q1	-30.63%	4.00%	-0.11%	-37.0%	-2.68%	-0.73%	12.0	16.4%	5.25%
2007 Q2	-21.31%	4.50%	0.22%	-15.9%	-0.74%	-0.29%	18.0	45.5%	5.25%
2007 Q3	-23.42%	5.00%	0.69%	-21.3%	-0.21%	0.00%	20.0	40.5%	5.00%
2007 Q4	-23.87%	5.25%	0.83%	-45.0%	-3.95%	-0.59%	27.0	60.0%	4.50%
2008 Q1	-28.11%	5.25%	0.89%	-69.2%	-1.56%	0.00%	38.0	84.6%	3.25%
2008 Q2	-30.79%	5.25%	0.95%	-29.7%	3.16%	0.44%	66.0	75.6%	2.00%
2008 Q3	-32.40%	5.25%	1.34%	-46.9%	-1.10%	-0.29%	73.0	84.4%	2.00%
2008 Q4	-43.75%	5.00%	2.41%	-72.4%	15.39%	-0.59%	67.0	89.7%	0.50%
2009 Q1	-50.56%	4.50%	1.25%	-64.0%	3.93%	-0.30%	78.0	48.0%	0.25%
2009 Q2	-45.79%	3.25%	0.97%	-12.0%	-1.29%	0.15%	100.0	64.0%	0.25%
2009 Q3	-31.52%	2.00%	1.51%	-16.7%	2.43%	0.30%	89.0	45.8%	0.25%
2009 Q4	-19.56%	2.00%	2.08%	-4.3%	4.57%	-0.59%	90.0	30.4%	0.00%
2010 Q1	17.40%	0.50%	0.06%	-35.3%	6.99%	-0.15%	56.0	29.4%	0.25%
2010 Q2	11.83%	0.25%	-1.09%	-33.3%	4.65%	-0.30%	78.0	4.8%	0.25%
2010 Q3	-0.92%	0.25%	-0.22%	0.0%	1.72%	0.00%	68.0	4.5%	0.25%
2010 Q4	-2.92%	0.25%	-0.31%	-9.5%	-0.54%	-0.60%	67.0	9.5%	0.25%
2011 Q1	-6.55%	0.00%	-0.28%	-13.0%	1.23%	-0.15%	47.0	13.0%	0.25%
2011 Q2	-4.94%	0.25%	-0.24%	-23.8%	1.07%	-0.75%	48.7	10.0%	0.00%
2011 Q3	6.28%	0.25%	-0.16%	-12.5%	-0.98%	0.61%	46.3	-4.2%	0.00%
2011 Q4	24.29%	0.25%	0.06%	4.5%	0.84%	-0.45%	46.1	0.0%	0.00%
2012 Q1	23.43%	0.25%	-0.01%	-4.3%	3.09%	-0.91%	47.0	4.3%	0.00%
2012 Q2	28.01%	0.25%	-0.29%	23.1%	-2.71%	0.15%	59.7	11.5%	0.25%
2012 Q3	25.22%	0.00%	1.07%	37.0%	-0.53%	0.00%	62.8	11.1%	0.25%
2012 Q4	35.93%	0.00%	-1.35%	12.5%	-2.72%	-0.15%	62.9	0.0%	0.25%
2013 Q1	34.34%	0.00%	-0.68%	0.0%	1.17%	-0.61%	58.3	2.9%	0.25%
2013 Q2	16.67%	0.00%	-0.78%	0.0%	0.38%	0.00%	62.0	0.0%	0.00%
2013 Q3	13.46%	0.25%	-0.95%	3.1%	1.07%	0.46%	45.0	-6.3%	0.00%

Prepared by authors based on New..., 2013; Selected..., 2013; Senior..., 2013; Seasonally..., 2013; Charge-off..., 2013; BHCPR..., 2013; FHA..., 2013.



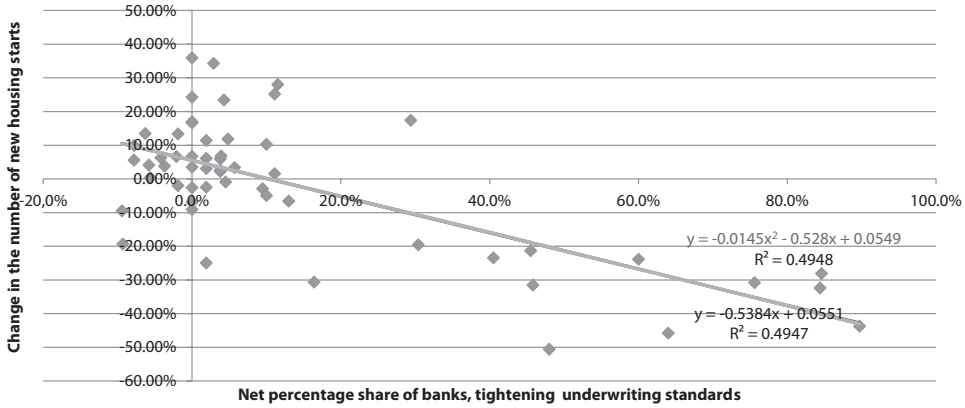
APPENDIX 4. **Dependence of the number of new housing starts on the mortgage charge-off and delinquency rate**

Prepared by authors based on New..., 2013; Charge-off..., 2013.



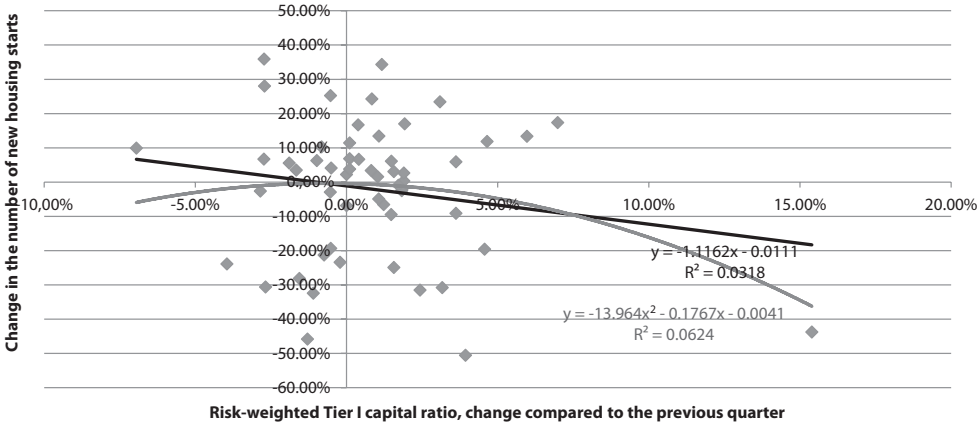
APPENDIX 5. **Dependence of the number of new housing starts on the reported higher demand for mortgage loans**

Prepared by authors based on New..., 2013; Senior..., 2013.



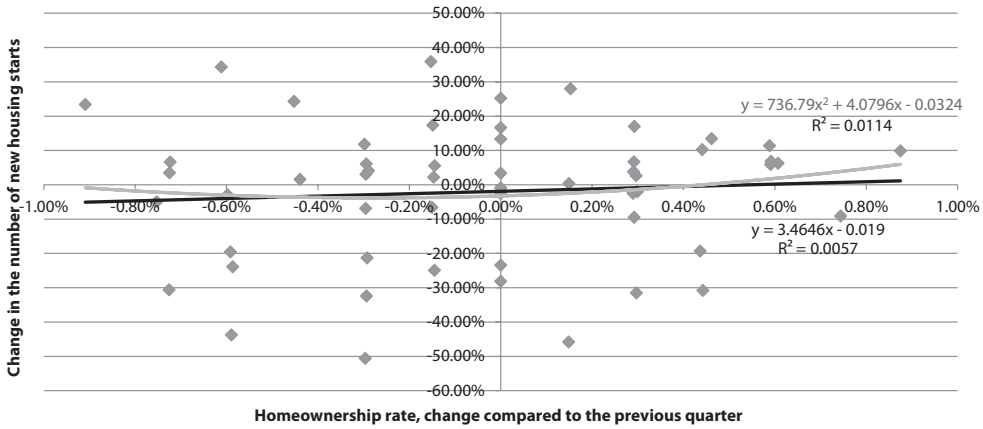
APPENDIX 6. **Dependence of the number of new housing starts on the tightening of mortgage lending standards**

Prepared by authors based on New..., 2013; Senior..., 2013.



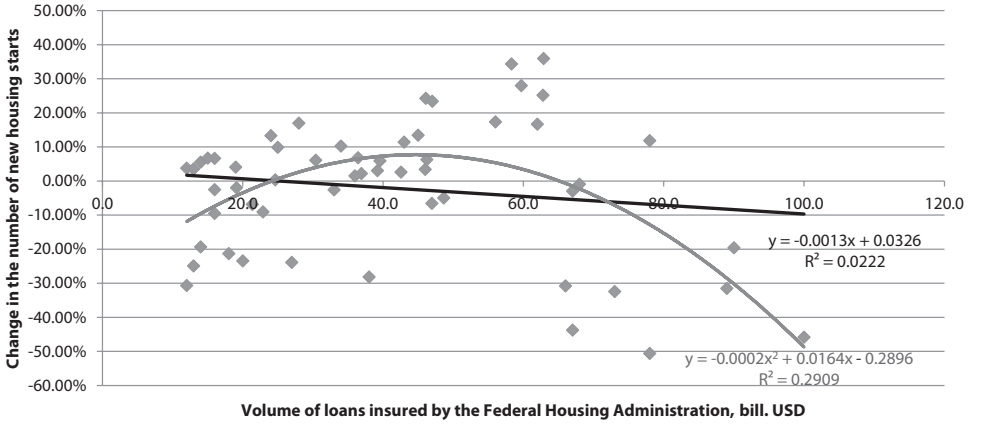
APPENDIX 7. **Dependence of the number of new housing starts on the risk-weighted Tier I capital ratio**

Prepared by authors based on New..., 2013; BHCPR..., 2013.



APPENDIX 8. **Dependence of the number of new housing starts on the homeownership rate**

Prepared by authors based on New..., 2013; Seasonally..., 2013.



APPENDIX 9. **Dependence of the number of new housing starts on the volume of loans insured by FHA**

Prepared by authors based on New..., 2013; FHA..., 2013.

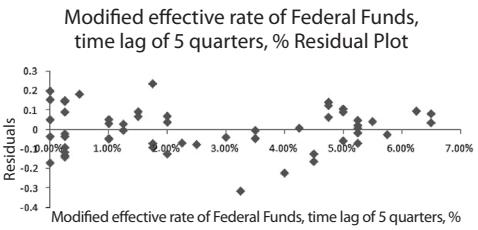
APPENDIX 10. **Regression equation calculation results**

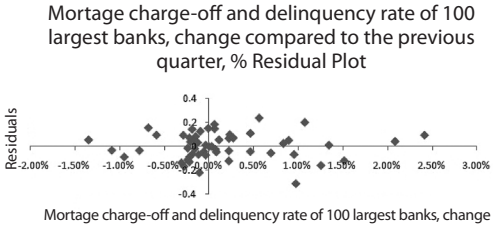
SUMMARY OUTPUT			
Regression statistics			
Multiple R	0.861263309		
R square	0.741774487		
Adjusted R square	0.709496298	**t-distribution value =**	**2.682204027**
Standard error	0.107316815		
Observations	55		

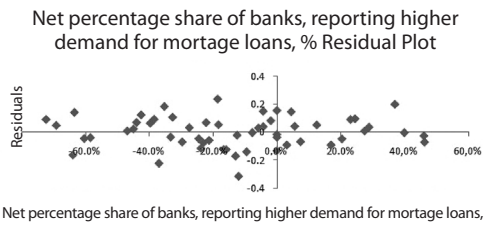
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	1.587996469	0.264666078	22.9806723	1.42067E-12
Residual	48	0.552811144	0.011516899		
Total	54	2.140807613			

	Coefficients	*Standard Error*	**t Stat**	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.18787908	0.044748829	**4.198525064**	0.000115628	0.097905531	0.27785263
Modified effective rate of Federal Funds, time lag of 5 quarters, %	-3.215419553	0.793464836	**-4.052378137**	0.00018464	-4.810787503	-1.620051604
Mortgage charge-off and delinquency rate of 100 largest banks, absolute change compared to the previous quarter, %	-11.60068789	2.660261195	**-4.360732665**	6.82882E-05	-16.94950142	-6.251874363
Net percentage share of banks, reporting higher demand for mortgage loans, %	0.308060109	0.057033307	**5.401407065**	2.02911E-06	0.193386961	0.422733257
Risk-weighted Tier 1 capital ratio, percentage change compared to the previous quarter, %	1.106674607	0.517499827	**2.138502373**	0.037593119	0.066171487	2.147177728
Homeownership rate, percentage change compared to the previous quarter, %	-1.201308603	3.549283396	**-0.338465112**	0.736488804	-8.337621037	5.935003831
Volume of loans insured by Federal Housing Administration, bill. USD	-0.001824145	0.000762641	**-2.391879289**	0.020727712	-0.003357538	-0.000290753

Prepared by authors based on New..., 2013; Selected..., 2013; Charge-off..., 2013; Senior..., 2013.







APPENDIX 11**. Model error distribution**

Prepared by authors based on New..., 2013; Selected..., 2013; Charge-off..., 2013; Senior..., 2013.

APPENDIX 12**. White test calculation results**

Heteroskedasticity Test: White

F-statistic	0.768984	Prob. F(9,45)	0.6451
Obs*R-squared	7.331295	Prob. Chi-Square(9)	0.6027
Scaled explained SS	6.762925	Prob. Chi-Square(9)	0.6618

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 01/04/14 Time: 20:52
Sample: 2000Q1 2013Q3
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.017995	0.006080	2.959852	0.0049
X1	-0.197822	0.547273	-0.361469	0.7194
X1^2	0.403040	8.568065	0.047040	0.9627
X1*X2	-0.923531	34.37676	-0.026865	0.9787
X1*X3	-0.255200	0.497074	-0.513405	0.6102
X2	1.129532	0.716275	1.576953	0.1218
X2^2	-26.88546	39.80221	-0.675476	0.5028
X2*X3	1.018830	1.921185	0.530313	0.5985
X3	4.87E-05	0.018514	0.002629	0.9979
X3^2	-0.018583	0.027775	-0.669057	0.5069

R-squared	0.133296	Mean dependent var	0.011770
Adjusted R-squared	-0.040044	S.D. dependent var	0.017400
S.E. of regression	0.017745	Akaike info criterion	-5.062490
Sum squared resid	0.014169	Schwarz criterion	-4.697520
Log likelihood	149.2185	Hannan-Quinn criter.	-4.921353
F-statistic	0.768984	Durbin-Watson stat	1.665124
Prob(F-statistic)	0.645149		

Prepared by authors based on New..., 2013; Selected..., 2013; Charge-off..., 2013; Senior..., 2013.