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Essays in Financial Economics

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ESSAYS IN FINANCIAL ECONOMICS

by

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ABSTRACT

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This dissertation consists of three essays concerning financial economics. In the first essay, I focus on the role of the life insurance in the financial markets and the factors that drive the development of life insurance industry. The essay examines the causality of the banking sector development on the development of the life insurance market measured by the total premiums received by life insurers using panel estimation for about 90 countries over the period 1996-2010. I employ the dynamic System Generalized Method of Moments estimation technique to resolve the endogeneity problem between the development of the life insurance and the financial development. After controlling for country-specific effects, problems with lagged dependent variable, endogeneity and weak instruments, I find a strong significant link between the development of banking sector and life insurance industry. While the development of banking sector is important for implementing the investment function of life insurers, with the increasing savings type insurance, life insurers face vigorous competition from banks. The results show that the nature of relationship between banks and life insurers can change from complementary to substitute.

In the second and third essays, I study the role of the government in the financial markets, specifically, mortgage-backed securities (MBS) market, during the financial crisis and the impact of its monetary activities on the MBS prices, mortgage markets and the economy overall. The second essay utilizes the vector autoregression with exogenous regressors

(VARX) modeling technique to estimate the impact of MBS purchase program's announcements and the change in size of the Federal Reserve's MBS holdings on mortgage spreads. The estimation results of the second essay indicate that Federal Reserve's MBS purchase program has effect on the mortgage spreads through both signaling and portfolio rebalancing channels. The study finds that not only the announcements of the first and the third rounds of Quantitative easing, QE1 and QE3, but also the increase in the size of the Federal Reserve's MBS holdings has negative impact on MBS spreads. In addition to being used to reveal the forecasting ability of the changes in the Federal Reserve's MBS holdings variable, a triangular structural VAR model is used to generate the forecast of MBS spreads, conditional on tapering of Federal Reserve's reinvestments in its MBS portfolio. The third essay examines the quantitative impact of the Federal Reserve's MBS purchase program on the housing market and aggregate economic variables via mortgage spreads. I find that mortgage spread shocks reduce consumption, residential investments and GDP by both economical and statistically significant magnitudes. The estimation results of vector autoregressive model using quarterly data from 1986Q1 to 2017Q4 show that the reduction in mortgage spreads from the Federal Reserve's MBS purchase program has only partially passed through to borrowers due to widening of the primary-secondary mortgage market spread - the spread between mortgage rates and MBS yields - explaining a slow recovery of consumption in post-crisis period. The decline in mortgage rates did not keep pace with this on the secondary rates as the transmission of lower mortgage spreads in the secondary mortgage market to lower borrowing costs in the primary mortgage market has not happened due to a rise in originators' costs and profitability, as well as increases in g-fees.

To Carolina

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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The views expressed in this dissertation are solely the responsibility of the author and should not be interpreted as reflecting the views of Northwestern Mutual. All errors are my own.

Knowing is not enough; we must apply. Willing is not enough; we must do.

Johann Wolfgang von Goethe

Chapter 1

Introduction

Financial economics is the study of how individuals and institutions acquire, save and invest money. In this dissertation I concentrate on these monetary activities which are fundamental to institutions and individuals and have not been fully investigated to date. Financial economics focuses on asset pricing and decision making in which time, uncertainty and information play roles. In the first essay, I focus on the role of the life insurance in the financial markets and the factors that drive the development of life insurance industry. Life insurance plays an increasingly important role in the financial and economic development. Nowadays, life insurers do not only provide insurance against the financial hardship of the policyholder's dependents when the insured person, the policyholder, dies, but also allow policyholders to accumulate savings that can be used in a time of financial need. As financial intermediaries with long-term investment horizons, life insurance companies can contribute to the provision of the long-term instruments to finance public and private sector projects, and housing. Several studies examine the factors that drive the development of the life insurance industry and find the importance of development of the financial (banking) sector in the development of the life insurance market. However, since the direction of the causality runs in both directions, no research attached a structural interpretation to the results so far. This paper contributes to the literature by examining the causality of the banking sector development on the development of the life insurance market measured by the total premiums received by life insurers using panel estimation for about 90 countries over the period 1996-2010. I employ the dynamic System Generalized Method of Moments estimation technique to resolve the endogeneity problem between the development of the life insurance and the financial

development. After controlling for country-specific effects, problems with lagged dependent variable, endogeneity and weak instruments, we find a strong significant link between the development of banking sector and life insurance industry. While the development of banking sector is important for implementing the investment function of life insurers, with the increasing savings type insurance, life insurers face vigorous competition from banks. The results show that the nature of relationship between banks and life insurers can change from complementary to substitute.

In the second and third essays, I study the role of the government in the financial markets, specifically, in mortgage-backed securities (MBS) market, during the financial crisis and the impact of its monetary activities on the MBS prices, mortgage markets and the economy overall. The purpose of this research is two-fold: first, to estimate the impact of the Federsal Reserve's MBS purchase program on the MBS pricing; second, to review the effectiveness of the Federal Reserve's MBS purchase program as a part of the unconventional monetary policy in achieving the economic goals and the possibility of using it during future recession or financial crisis. The Federal Reserve has typically used short-term interest rate as a conventional monetary policy to achieve its macroeconomic objectives. Given the severity of the financial crisis of 2008, near zero short-term interest rates were not enough to revive output and employment growth sufficiently. The usual monetary policy rule would have prescribed much more than 5 percentage points cut in the federal fund rate occurred during the Great Recession. When short-term nominal interest rates reached the effective lower bound, the Federal Reserve turned to the unconventional monetary policy tools included forward guidance through communication about future short-term interest rates as well as quantitative easing (QE), the purchase of long-maturity government debt and other financial assets. The housing market was at the epicenter of the crisis and recession and it is a critical channel for the transmission of the monetary policy to the real economy. More than half of the total family mortgage credit in the U.S. is eventually securitized into Agency MBS in the secondary market, as of second quarter of 2016. In November 2008, the Fed announced that it

would purchase US agency mortgage-backed securities (MBS) and the debt of housing-related US government agencies (Fannie Mae, Freddie Mac, and the Federal Home Loan banks) with a goal to reduce the costs and increase availability of credit for the home purchases and to improve the broader financial conditions. Given a low interest rate environment, shall the Federal Reserve use QE once the next downturn arrives? The vast majority of literature focuses on the effects of unconventional monetary policy on the long-term interest rates and on the economic outcomes via interest rates. There are few papers which study the impact of the Federal Reserves mortgage-backed securities purchases on the mortgage spreads and the macroeconomic effects of the mortgage spreads. This work is intended to contribute to the literature on evaluating the impact of QE on the mortgage market as well as the economy and reviewing the effectiveness of unconventional monetary to achieve the economic goals.

The second essay examines the quantitative impact of the Federal Reserve's Mortgage-Backed Securities (MBS) purchase program on the secondary mortgage market spreads. The results indicate that the MBS purchase program has effect on the mortgage spreads through both signaling and portfolio rebalancing channels. We find that not only the announcements of the first and the third rounds of "quantitative easing", QE1 and QE3, but also the increase in the size of the Federal Reserve's MBS holdings have negative impact on MBS spreads. This paper employs a triangular structural VAR model to reveal the forecasting ability of the changes in the Federal Reserve's MBS holdings variable. In addition, the model was used to provide a scenario analysis to assess the effect of Fed's "exit strategy" of the normalization of its balance sheet by applying Kalman filter technique on the state-space form of VARX model for conditional forecasting.

The third essay examines the quantitative impact of mortgage spreads on aggregate economic variables. I find that mortgage spread shocks reduce consumption, residential investments and GDP by both economical and statistically significant magnitudes. The results indicate that the reduction in mortgage spreads from the Federal Reserve's MBS purchase program has only partially passed through to borrowers due to widening of the

primary-secondary mortgage market spread - the spread between mortgage rates and MBS yields - explaining the slow recovery of consumption in post-crisis period. The decline in mortgage rates did not keep pace with this on the secondary rates as the transmission of lower mortgage spreads in the secondary mortgage market to lower borrowing costs in the primary mortgage market has not happened due to a rise in originators' costs and profitability, as well as increases in g-fees.

Chapter 2

Banking and Life Insurance: Complements or Substitutes? An empirical analysis on the drivers of life insurance industry on a panel of developed and developing countries

2.1 Abstract

Life insurance plays an increasingly important role in the financial and economic development. Nowadays, life insurers do not only provide insurance against the financial hardship of the policyholder's dependents when the insured person, the policyholder, dies, but also allow policyholders to accumulate savings that can be used in a time of financial need. As financial intermediaries with long-term investment horizons, life insurance companies can contribute to the provision of the long-term instruments to finance public and private sector projects, and housing. Several studies examine the factors that drive the development of the life insurance industry. This chapter contributes to the literature by examining the causality of the banking sector development on the development of the life insurance market measured by the total premiums received by life insurers using panel estimation for about 90 countries over the period 1996-2010. I employ the dynamic System Generalized Method of Moments

estimation technique to resolve the endogeneity problem between the development of the life insurance and the financial development. After controlling for country-specific effects, problems with lagged dependent variable, endogeneity and weak instruments, I find a strong significant link between the development of banking sector and life insurance industry. While the development of banking sector is important for implementing the investment function of life insurers, with the increasing savings type insurance, life insurers face vigorous competition from banks. The results show that the nature of relationship between banks and life insurers can change from complementary to substitute.

2.2 Introduction

Recently the life insurance industry has played an increasingly important role in the development of the financial sector. Life insurers are major institutional investors, managing roughly 10 percent of all global investments[1]. In the past, life insurance products, known as term policies, specialized in the provision of insurance against mortality risk. Today, the majority of life insurance packages[2] bundle these insurance services with savings instruments, and through this metamorphosis, life insurance premiums have become an important source of long-term savings, and the life insurance industry as an intermediary of these savings, has played a role in improving the liquidity and depth of capital markets (Catalan et al., 2000; Haiss and Sumegi, 2008; Levine, 2000; Arena, 2006). Yet evidence of a common dynamic in measures of life insurance penetration and financial development does not imply that primacy necessarily belongs to the growth of the life insurance sector. There are many reasons for thinking that life insurance consumption and the development of the financial sector as a whole have common drivers, or that the causal arrow operates in reverse from a stronger

[1] Investments by life insurance companies in 2010 were estimated to be $21.5 trillion (Swiss Re, 2012).

[2] There are three general categories of life insurance policies: term policies offering mortality coverage; whole life (universal life, variable life, endowment and other names) combining mortality coverage with saving component and annuity policies offering saving component. Annuities are contracts, which in return for lump sum or periodic payments guarantee that the insurer will make periodic payments to the insured, for a fixed term of years or often until the ending of a life or two lives, or whichever is longer.

financial system to increased life insurance penetration.

For instance, by improving the quality and accessibility of information, a well-functioning financial system, can have positive environmental influences on life insurance consumption; a more financially literate and informed population will, presumably, be more inclined to participate in financial transactions (OECD, 2008). At the same time, stronger regulatory and institutional structures, such as entry and exit restrictions, the existence of a securities and exchange commission, and the quality of legal protections afforded to creditors and debtors can affect investor confidence in financial institutions, including life insurance companies (Ward and Zurbruegg, 2002). More specific channels, such as banks' incentivizing, or linking, the issuance of mortgages and other types of long-term loans, to the purchase of term life insurance policies, or similar products, may also be in operation (Feyen et al., 2011). In recent years, these inter-relationships between the banking sector and the life insurance industry have grown stronger. Many life insurance companies have forged partnerships with banks in order to facilitate the sale of insurance products (Lorent, 2010). This so called bancassurance relies on the network of bank branches to improve the distribution of insurance services (Swiss Re, 2007). Outside of banking, life insurance companies benifits from the growth in stock markets and particularly the market for fixed income securities, which are the primary sources of investment-income for life insurance companies (OECD Insurance Statistics, 2010; Swiss Re, 2012)[3].

Recent empirical research has attempted to quantify the sum of these various linkages (Outreville, 1996; Ward and Zurbruegg, 2002; Beck and Webb, 2003; Lorent, 2010; Feyen et al., 2011), by incorporating measures of financial development into an equation for life insurance consumption. Though the consensus finding that financial development is positively associated with life insurance consumption, is neither surprising nor controversial, attaching a structural interpretation to these results has proved difficult. Part of the problem is that

[3]In 2010, about 85% of the USD 2.4 trillion of in-force life premiums were directed toward saving products. For savings products with minimum return guarantees, investment income is most important (Swiss Re, 2012).

life insurance consumption and the financial sector may have common drivers. To the extent that controlling for unobserved country characteristics reduces the correlation between the dependent variable error and measures of financial development, existing research does attempt to address this issue through panel regressions. However, purging fixed-effects from the error term does not, by itself, validate the orthogonality assumptions implicit in most empirical specifications. At issue, it is the very sensible concern that the direction of causality runs in both directions: life insurance is as much a determinant of financial development as financial development is of life insurance. As a consequence biases have crept into most empirical studies on life insurance determinants.

This paper re-examines the role of the financial (banking) sector in the development of life insurance market measured by life insurance consumption and in so doing makes a number of contributions to the existing literature. First, the analysis is based on a newly collected dataset on life insurance penetration[4] sourced by hand from Sigma (Swiss Re) reports for various years. These data extend the country coverage to 92 and the sample period to 15 years, from 1996 to 2010 (in most instances the country coverage has been considerably narrower, typically around 70 countries). Second, unlike much of the previous research, which relies heavily on least squares estimation techniques, here the life insurance consumption equation is estimated using the system GMM estimator for panel datasets; thus an attempt is made to facilitate structural interpretations. This has been largely absent from the existing empirical research on life insurance consumption. Third, while much of the literature assumes linear specifications for the life insurance equation, here we relax that assumption. We find, in fact, that the relationship between the size of the financial sector and insurance penetration is characterized by non-monotinicities: in particular, increases in the size of the financial (banking) sector predict life insurance consumption, but only up to a point. Beyond this threshold, growth in the banking sector has hindered the further expansion of life insurance sector. These nonlinearities in the relationship between measures of financial

[4]The ratio of premium volume to GDP.

development and life insurance penetration suggest a shift in this relationship, from one where complementarities between life insurance industry and banking sector are dominant to one where life insurance penetration and the growth in the banking sector compete in substitutable capacities. With more developed banking sector the higher customers' confidence in the banking system encourages savers to invest in banking savings products rather in life insurance products. A higher banking efficiency allows banks to offer better returns to savers, fostering the sales of saving instruments and the competition with insurers. If life insurers are not responding with lowering the prices and increasing the expected returns, banks may increase their market share. Thus, life insurers can face a competition from banks which can better offer and sell the saving products.

The remainder of this paper is organized as follows. Section 3 discusses the drivers of life insurance industry in the framework of the life insurance consumption model and develops rationales for the empirical discussion to follow. Section 4 describes the data and the empirical methodology. Section 5 presents the primary findings along with a number of sensitivity checks. Section 6 offers some concluding remarks and discusses some policy implications.

2.3 Determinants of Life Insurance Consumption: Literature Review

The importance of the life insurance for financial and economic development (Levine, 2000; Arena, 2006) and the large variation in the use of life insurance across different countries have given a rise to an abundant literature exploring the determinants of life insurance consumption. The consumption of life insurance differs greatly between countries. While life insurance penetration in 2010 was 5.1% in the industrial markets, it was 1.7% in the emerging markets and 0.1% in the Middle East. See Figure 2.1.

As there is no literature that solely discusses the impact of the banking sector devel-

opment on the growth of life insurance market, we use the existing literature to develop theoretical viewpoint to support our empirical findings. Since the main function of banking sector to mobilize savings and the allocation of these resources to the private sector, we use a PRIVATE CREDIT, which is defined as credit to private sector by deposit money banks. According to Levine et al. (2000) it is the best variable to measure banking sector development because it includes not only banking sector size but also the efficiency side in its measure.

Since in our research we only use the most important measure of financial system development, the development of the banking sector, besides the direct relationship between the banking sector and life insurance, we need to trace the interdependence between banking and other components of financial system such as stock market and bond market that might affect the development of the life insurance market.

2.3.1 Financial Development

We investigate the nature of relationship between two components of financial system (life insurers and banks) in our paper. We start with investigation of a complementary nature of the relationship and then discuss the substitute relationship.

We first study the direct relationship between the banking sector and life insurance, then trace the interdependence between banking and other components of financial system such as stock market and bond market that might affect the development of the life insurance market. The Swiss Reinsurance company's Sigma Report No 1/2012 "Understanding profitability in life insurance" states that while for mortality protection products the earnings stem mainly from the difference between anticipated and actual mortality, and, hence, underwriting plays a critical role for profitability, for savings products with minimum return guarantees, investment results are key [5]. Hence, the development of financial markets (stock and bond markets) is important as an investment opportunity for life insurers, which will

[5]Sigma No 1/2012, Swiss RE

foster sales of life insurance products. Figure 2.2 on the investment portfolio allocation of life insurers for the selected countries shows that life insurers invest in bonds, equities and other financial instruments.

Banks can foster the development of insurance companies via more efficient payment systems. Commercial banks originating mortgage and other types of loans could require the purchase of life insurance to approve the loans. In many countries, the banking supervision is linked to the insurance regulation. A rule of law which strengthens creditor rights, contract enforcement and accounting practices increases confidence not only in banking sectors but also in life insurance industry. In the countries with well-developed banking sector financial literacy helps consumers use financial services with a confidence.

We have analyzed a complementary relatioship between banks and life insurance. However, over the last twenty years the insurance industry experienced significant changes of the market conditions and their relationship with banks. There are two trends that blur the boundaries between life insurers and banking activities: provision of savings type insurance products by life insurers and provision of insurance services by banks, known as bancassurance.

A potential negative relationship between the life insurers and banks is due to the "saving substitution effect", discussed by Haiss and Sumegi (2008). As Haiss and Sumegi (2008) say, insurance premiums may result from an additional flow from income to the financial market (no substitution) or may be a simple shift from one intermediary (bank) to insurance company. With the increasing savings type insurance, life insurers face a constant competition from banks, mutual and pension funds. With more developed banking sector the higher customers' confidence in the banking system encourages savers to invest in banking savings products rather in life insurance products. A higher banking efficiency allows banks to offer better returns to savers, fostering the sales of saving instruments and the competition with insurers. If life insurers are not responding with lowering the prices and increasing the expected returns, banks may increase their market share.

To the author's knowledge, a negative effect of the bankassurance on the sales of life insurance was only empirically tested by Lorent (2010). Lorent (2010) employs cross-section analysis of life insurance demand, where he introduces the BANCASSURANCE variable, which indicates whether country's banking regulator restricts the ability of banks to engage in insurance underwriting and selling. Lorent finds that life insurance consumption, measured as total life insurance premiums collected as a share of GDP, increases as banks are restricted to involve in the insurance activities. One of the reason is that life insurers have a specialization advantage in the offering and selling life insurance products.

However, contrary to Lorent's view we think the bankassurance can potentially have positive effect on life insurance consumption as bankassurance model implies not only direct involvement of banks in the underwriting activity but simply the distribution of insurance products through banks branches, which could allow to increase the sales of life insurance. Having a more frequent contact with their clients and developing a strong customer focus, banks could deliver simpler and more transparent products, mostly designed for the middle classes (Van den Berghe et al., 1999). Bancassurance is the main distribution channel for life insurance products in many European countries, such as France, Italy, Spain, Malta, Austria, Portugal and Romania. Its market share is expected to increase with the deregulation taking place in several Asian countries and in the UK. In US a recent Gramm-Leach-Bliley Act (1999) allowed commercial banks, investment banks, securities firms, and insurance companies to consolidate.

It is important point out that the bancassurance model does not bring success to all countries. For example, in Spain and Italy, the life insurance penetration is much lower than in France. While France is a world-wide model for bancassurance, the other countries possibly have not managed to take full advantage of the banking network and underwriting activities to achieve greater synergies. The question is whether it is preferable to act as a simple distributor of insurance products, gaining commissions free of capital and risk implications, to concentrate on banks' core business or to be directly involved in the underwriting activity

in order to access potential greater synergies and returns. There is no clear answer, as the strategies of banks depend on the particular position on the market and their relationship with insurers and many other factors.

Bond, Stock and Structured Securities Markets

Life insurers across the world invest heavily in fixed-income securities, government and private bonds. The high share of bonds in life insurers' portfolios is due to the fact that investment in long-term bonds allows for a better matching of assets with the long-term liabilities of life insurers[6].

Hawkins (2002) in his BIS paper states that banks play an important role in developing a private sector bond market as "they are often among the most important issuers, holders, dealers, advisers, underwriters, guarantors, trustees, custodians and registrars in this market". For this reason, healthy banks lead to the development of a sound bond market. Braun (2006) finds that the size of banking system is positively related to the size of private bond markets. In addition, Forslund et al. (2011) confirms the previous literature results that the size of financial system (M2/GDP) is positively related to domestic government bond market. Bond issuance is highly concentrated in a few highly developed markets. As of March 2012 the U.S. and Japan alone account for almost half of the amounts outstanding on the global bond market[7]. Domestic bond markets accounted for 70% of the total, and international bonds for the remainder. Government bonds accounted for 61% of the outstanding value of domestic bonds in March 2012[8].

The development of stock markets is important for life insurers which seek to match their long-term liabilities with long-term assets (Arena, 2008). Chinn and Ito (2006) find that the banking sector development is a precondition for the equity markets. For example, banks can provide complementary services to new equity issuers such as underwriting. The banking sector development promotes the stock market development according to Yartey (2008).

[6]Global Insurance Market Trends 2012, OECD
[7]Bank for International Settlements
[8]The City UK. Financial Market Series. Bond Markets. October 2012

Also, searching for higher yields life insurers invest in the structured securities, mortgages or loans other than mortgage loans. However, in the light of recent financial crisis and aging population life insurers in the developed countries were forced to reduce holdings of riskier assets. Again banks play an important role in the securitization and they increasingly use it to transform their illiquid assets into liquid assets. Banks sell some of their loans in order to reduce maturity mismatches, enhance their liquidity and diversify credit exposures. Also after selling part of their own assets, banks continue the administrative role of collecting interest payments. Hence, banks as securitizers provide life insurers with another source of assets.

The objective of our research is to find the causal relationship between the development of banking and life insurance industries and to test our hypothesis of non-linear relationship between banking and life insurance industries. In the next section we discuss the other drivers of life insurance industry which were used in the previous empirical studies.

2.3.2 Other Determinants of Life Insurance Consumption

To evaluate the strength of an independent link between banking sector development and life insurance development we include a set of control variables. We estimate the development of life insurance industry in the theoretical and empirical framework for life insurance consumption. According to the previous studies the most important economic determinants of life insurance consumption are income and inflation. Among the social determinants the most important determinants are life expectancy, dependency ratio, education, social security system and legal environment.

In theoretical framework the demand for life insurance is attributed to a person's desire to provide funds to dependants in case of premature death and to provide income for retirement (Yaari, 1965). But the life insurance consumption is not driven only by consumer demand. The supply side factors affect the availability of life insurance. The life insurance consumption can be expressed by an equilibrium demand and supply model: $Q = Q^s = Q^d$.

However, premium data as a combined measure of price P and coverage Q do not allow to observe the amount of coverage purchased. Thus, we estimate the following reduced-form equation :

$$\text{Premium income} = P * Q = f(\text{demand-side factors, supply side factors}).$$

Price is one of the important determinant of life insurance consumption. Beck and Webb (2003) assume that the price is a function of supply side factors such as monetary stability and financial development which lead to the cost-effective insurance. Outreville (1996) includes the life expectancy at birth as a proxy for the actuarially fair price of life insurance in a country. Longer life span, lower the price of insurance, greater incentives for human capital accumulation, and, thus, higher the demand for life insurance. We assume the insurance price is approximated by supply factors mentioned above as in Beck and Webb (2003).

As we are constrained with relatively small sample size, we include the most important economic and social determinants of life insurance consumption in our analysis. Economic factors include income, inflation, the size of social security system and financial development, which we discussed in the previous subsection. The level of education, dependency ratio and life expectancy represent social factors. In this section we discuss the relationship between each variable and life insurance consumption.

Income

As income increases, the life insurance becomes more affortable. Also as income increases, person's and his/her dependents' consumption increases. A higher level of income reflects greater loss of expected utility for dependents in the case of early death of primary wage earner leading to the increase in the demand for life insurance. It is not surprising, as income levels grow individuals will begin to save. Moreover, affluent investors are attracted by annuities offered by life insurers as they carry a tax advantage not available on bank time deposits and direct mutual fund investments. Using data on national level, all recent

studies (Outreville, 1996; Ward and Zurbruegg, 2002; Beck and Webb, 2003; Lorent, 2010; Feyen et al., 2011) conclude that income has a positive and significant effect on life insurance. However, few studies discuss non-homogeneous income effect across the emerging and developed economies. Enz (2000) proposed "S-curve" relationship, according to which life insurance consumption accelerates as economy begins to grow and, at higher level of income, the income elasticity for insurance decreases.

Inflation

Inflation negatively effects insurance demand as it erodes the value of future money flows. Because life insurance savings products provide monetary benefits over the long term, the monetary instability decreases the demand for life insurance policies. Outreville (1996), Ward and Zurbruegg (2002), Beck and Webb (2003), Li et al. (2007), Feyen et al. (2011) support the hypothesis of negative effect of inflation on life insurance demand.

Social security/Welfare

The effect of social security on life insurance is ambiguous. The larger the public expenditures on social security and welfare as a share of GDP, the less demand for life insurance products since government provides the income for retirement and substantial benefits to families of prematurely died wage earners. In other words, social security displaces private insurance. The negative effect of social security expenditure on life insurance demand is found in Ward and Zurbruegg (2002) and Li et al. (2007), Feyen et al. (2011). Browne and Kim (1993) explain and empirically confirm, that social security benefits could produce a positive income effect on life insurance consumption.

Dependency ratio

A higher young dependency ratio (the ratio of young dependents to the working age population) increases the demand for policies with mortality coverage and decreases the demand for annuities resulting in an ambiguous relationship between the life insurance consumption and young dependency ratio. A higher young dependency ratio means that a large share of the population is too young to consider saving for the retirement. Brown and Kim (1993), Li

et al. (2007) and Feyen et al. (2011) found a significant and positive relationship. Outreville (1996), Beck and Webb (2003), Lorent (2010) found no significant effects.

A higher old dependency ratio (the ratio of old dependents to the working age population) increases the demand for policies with annuity components and decreases the demand for mortality coverage as the protection against the premature death of the primary wage earner loses importance. The effect of old dependency ratio on life insurance consumption is ambiguous. Beck and Webb (2003), Lorent (2010), Feyen (2011) found positive significant relationship. Outreville (1996) does not find significant effect.

Education

Life insurance consumption should increase with education for several reasons. Firstly, higher level of education increases understanding of the benefits of personal risk management and long-term savings. Secondly, Browne and Kim (1993) showed the education level is positively related to the risk aversion. Thirdly, the higher the enrollment in secondary and tertiary education, the higher the dependency ratio and the demand for life insurance. Finally, a higher educated population earn higher wages and need to protect their higher income. Surprisingly, only Browne and Kim (1993), Li et al. (2007), Lorent (2010) found a positive and significant relationship.

Life expectancy

The larger the number of years the average individual is expected to live implies the lower the probability of death, the less need for the mortality coverage and the greater incentives for savings. Thus, we expect a positive correlation with demand for annuities but a negative correlation with demand for the term policies. Hence, there is an ambiguous relationship between life expectancy and life insurance consumption. Browne and Kim (1993), Beck and Webb (2003) find no significant effects, Outreville (1996), Ward and Zuerbruegg (2002) found positive and significant relationship, Li et al. (2007), Lorent (2010) and Feyen et al. (2011) showed negative impact of life expectancy on life insurance consumption.

Legal environment

With life insurance policies offering investment opportunities, investors (policyholders) are at risk of opportunistic behaviour by insurance companies unless the legal system offers protection. The provision of protection stimulate the progress of efficient long-term contracting in the life insurance industry and foster the development of the industry while encouraging the purchase of life insurance products. We use the financial development indicators as proxy for the legal factors following results of Levine et al. (2000), where they found the main determinant of financial intermediary development is the legal/regulatory environment. Ward and Zurbruegg (2002), Lorent (2010), Feyen et al. (2011) found that a sound legal environment is essential for developing insurance industry, considering the long-term aspect of life insurance products.

The hypothesized signs of the relationship between life insurance consumption and other variables are presented in Table 2.1.

2.4 Data and Empirical Methodology

2.4.1 Data

The empirical analysis is conducted on a panel of around 90 countries over the period 1996-2010. The choice of countries included in the sample is based on the availability of life insurance data. The list of countries is provided in the appendix A. Because for some of the countries the data on variables for some years are missing, the analysis is based on unbalanced panel data. See Table 2.2 for the description of variables and the sources of data used in research.

In our research we use the life insurance penetration, a measure of life insurance consumption, as a dependent variable which captures the life insurance industry development. Life insurance penetration, defined as the ratio of life insurance premium volume to GDP, measures insurance activity relative to the size of the economy.

We study the impact of the banking sector development on the the development of

life insurance sector by employing several measures of financial intermediary development proposed by Levine et al. (2000) and obtained from the Financial Structure Dataset of World Bank created by Beck and Kunt (2009)[9]. Since the main function of financial (banking) sector is to mobilize savings and the allocation of these resources to the private sector, we use the indicators which capture these functions of banks. We employ the **Private Credit**, which is defined as credit to private sector by deposit money banks as a share of GDP, as our main indicator of banking sector development. According to Levine et al. (2000) it is a preferred indicator as it includes in its measure not only the banking sector size, but also the efficiency side. For the robustness check we use the following indicators banking sector development: **Deposit Money Bank Assets/GDP**, defined as the total claims of deposit money banks on domestic nonfinancial sectors as a share of GDP used in Beck (2003); **M2 to GDP**, defined as the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government divided by GDP. We include the last measure as it is commonly used measure of financial depth.

A vector of conditioning information that controls for other factors associated with life insurance consumption includes several economic, institutional and socio-demographic variables.

As a measure of level of income we employ Gross Domestic Product per capita measured in constant 2000 US$. The inflation is measured by the annual growth rate of the CPI index. We use government subsidies and other transfers as a share of GDP as an indicator of the size of the social security system[10].

We explore the socio-demographic drivers such as education, dependency ratio and life expectancy at birth. We employ the enrollment ratio of the second level of education, which

[9]The data are available at World Bank Global Financial Development Database (GFDD) as well.

[10] Subsidies and other transfers (% of expense) are subsidies, grants, and other social benefits include all unrequited, nonrepayable transfers on current account to private and public enterprises; grants to foreign governments, international organizations, and other government units; and social security, social assistance benefits, and employer social benefits in cash and in kind. Source: WDI

is measured by the number of students enrolled in secondary level of education, regardless of age, as a percentage of the population of official age for the corresponding level of education. Regarding the dependency ratio, we use the young dependency ratio which indicates the number of dependents younger than 15 years old as a percentage of the working age population (age between 15 and 65 years old). Life expectancy at birth measures the number of years a newborn would live if prevailing patterns of mortality at the time of birth will remain the same throughout his life.

Summary statistics for the full unbalanced panel dataset used in the regression analysis are presented in Table 2.3. We observe a large variation in life insurance penetration across the countries. The average value of life insurance penetration is 2.72% with standard deviation of 4.41%. The median is 1.05%, which implies the majority of countries has less than the average level of life insurance penetration. With Luxembourg having the maximum level of penetration of 55.66% in 2010 the data on life insurance penetration are highly skewed to the right. Vietnam has the lowest level of penetration is 0.0035% in 1997. The countries exhibit a large dispersion in the values of economic variables including the level of banking sector development. There is also variation in socio-demographic and other institutional variables.

In the further analysis we average data over non-overlapping, three-year periods, so the data permitting there are five observations per country (1996-1998; 1999-2001; 2002-2004; etc.). We average data over three years because some of our explanatory variables are not available at yearly frequencies; and some of them (e.g., inflation and banking sector development) are subject to short-term fluctuations related to the business cycle.

Table 2.4 presents the pairwise correlation coefficients between all variables for the transformed sample. All coefficients have signs supporting the hypothesized relationships including the relationship between the banking sector development and life insurance penetration shown in Table 2.1.

It is clear from Table 2.4 that richer countries have longer life expectancies, higher level of

education, lower inflation, lower young dependency ratios, better developed banking sector. Countries with high level of young dependency ratio has shorter life expectancies, lower level of education, lower level of spending on social security. Since the potential determinants of life insurance consumption are highly correlated with one another, we perform the multiple regression analysis in addition with inclusion of country-specific effects that might drive these explanatory variables.

In the next section we discuss the specifics of the methodology applied.

2.4.2 Empirical Methodology

To examine the significance of the hypothesized drivers of life insurance industry, we estimate the following model:

$$\log(penetr)_{i,t} = \alpha \log(penetr)_{i,t-1} + \beta \log(BankDev)_{i,t} + \gamma \log(BankDev)^2_{i,t} + \delta \log(CV)_{i,t} + \epsilon_{i,t}, \tag{2.1}$$

where the error term is $\epsilon_{i,t} = c_i + \lambda_t + v_{i,t}$ with country-specific effect c_i , time-specific effect λ_t and the idiosyncratic error $v_{i,t}$, the dependent variable $penetr_{i,t}$ is the life insurance penetration, $penetr_{i,t-1}$ is the lagged dependent variable, $(BankDev)_{i,t}$ is the indicator of banking sector development, $CV_{i,t}$ is the set of conditioning information, and i denotes country. Since we average data over non-overlapping, three-year periods, the subscript 't' designates one of these three-year averages.

Assuming that the reactions of consumers/life insurers to changes in their environment resulting, for example, from changes in incomes or in financial sector, are not only instantaneous, but also distributed over time, we use $penetr_{i,t-1}$ to model the autoregressive dynamic on the dependent variable. We add unobserved country-fixed effects to address omitted variable bias. Time-invariant country characteristics, such as geography, demographics, religion, may be correlated with explanatory variables. We assume the financial (banking sector) development and GDP per capita are endogenous regressors, which means that they can be

affected by current and past realizations of life insurance development but must be uncorrelated with future error term, that is, $E(v_{i,t}|X_{i,t-1}, X_{i,t-2}, ..., X_{i,1}, c_i) = 0$, where X denotes the vector of regressors. This assumption implies that the future (unanticipated) shocks to life insurance development do not influence the current banking sector development. The other regressors including the lagged dependent variable are predetermined, that is, uncorrelated with current errors, but influenced by past ones, and, thus, potentially endogenous after first-differencing, that is, $E(v_{i,t}|X_{i,t}, X_{i,t-1}, ..., X_{i,1}, c_i) = 0$.

We start our estimation of the model with the classical OLS method applied to (2.1), which gives us the estimates with"dynamic panel bias" due to the correlation between the lagged dependent variable $penetr_{i,t-1}$ and the fixed effect c_i in the error term. In order to control for the country-specific effects, we estimate (2.1) using Fixed Effects (within-group) method, which gives us again biased and inconsistent estimates due to the correlation of regressor with the error term. For this reason we use the Arellano and Bond (1991) Difference GMM estimation method first proposed by Holtz-Eakin, Newey and Rosen (1988), which removes the fixed effect by transforming the regressors by first differencing and controls for the endogeneity of differenced lagged dependent variable and other variables by using "internal instruments", that is, the lagged levels of the independent variables.

The dynamic GMM estimator is given as

$$\hat{\theta} = (\Delta X' Z A_N Z' \Delta X)^{-1} \Delta X' Z A_N Z' \Delta \log(penetr), \tag{2.2}$$

where $\hat{\theta}$ is the vector of coefficient estimates on both endogenous and predetermined regressors, ΔX is the vector of the first differences of all explanatory variables, Z is the vector of instruments and A_N is a matrix used to weight the instruments. Alternative choices of A_N will produce one-step or two-step estimators. In the optimal two step estimator the weighting matrix A_N is formed using the residuals from initial consistent one-step estimation of θ and is the inverse of an estimate of $VAR[Z'\Delta v]$.

We employ both the one-step robust and two-step estimator, which produce standard error estimates consistent in the presence of heteroskedasticity and autocorrelation within panels. The one-step robust estimator was preferred by researchers in making inferences because the coefficient standard errors in two-step GMM estimator tend to be downward-biased when the instrument count is high (Roodman, 2009). Windmeijer (2005) finds that the extra variation due to the presence of the estimated from the first step parameters in the weighting matrix accounts for much of the difference between the finite sample and the asymptotic variance of the two-step GMM estimator. Windmeijer (2005) shows in a Monte Carlo simulations that the corrected variance estimate approximates the finite sample variance well, leading to more accurate inference. We report results of estimation of two-step GMM with Windmeijer correction as well.

In the differenced equation we instrument the lagged dependent variable $\Delta \log(penetr)_{i,t-1}$ with a natural candidate $\log(penetr)_{i,t-2}$; endogenous variables, the banking sector development and GDP per capita, with the second lag of the level values; predetermined variables, the rest of control variables in our analysis, with the first lag of the levels. Thus, the moment conditions for the regression in differences are

$$E[\log X_{i,t-1} \Delta v_{i,t}] = 0, \qquad t \geq 3 \tag{2.3}$$

for the predetermined variables including the lagged dependent variable,

$$E[\log X_{i,t-2} \Delta v_{i,t}] = 0, \qquad t \geq 3 \tag{2.4}$$

for the endogenous variables.

We use Holtz-Eakin, Newey, and Rosen (1988) set of "GMM-style" instruments, that is, only one lag of each instrumenting variable for each period since similar to Levine et al. (2000) and Roodman (2009) we understand the danger of instrument proliferation. As T rises, the instrument count (quadratic in T) can easily grow large relative to the sample

size, making asymptotic results and specification tests misleading. Holtz-Eakin, Newey, and Rosen type of the instrument matrix include a set of instruments from the first lag of the lagged dependent variable and other predetermined variables and from the second lag of the endogenous variables, and substitute zeros for missing observations.

The Difference GMM estimator is consistent if there is no serial correlation in the error term $v_{i,t}$ (Arellano and Bond, 1991). This condition is essential for the validity of lagged level values of explanatory variables as instruments. We perform two specification tests proposed by Arellano and Bond (1991): test for lack of second-order serial correlation in the first-difference residuals and the Hansen test of over-identifying restriction, indicating under the null hypothesis that the instruments appear exogenous. While the first-differences of serially uncorrelated errors need not be first-order serially uncorrelated, the lack of second-order serial correlation in the first-difference residuals will be certainly the case if the errors in model in levels are not serially correlated.

However, if explanatory variables are persistent over time, i.e., closer to the random walk, then difference GMM performs poorly because the past levels contain little information about the future changes, so the lagged levels are weak instruments for the differenced variables (Blundell and Bond, 1998). In small samples, the weakness of instruments can produce biased coefficients. We find that the lagged levels of regressors are poor instruments for the first-differenced regressors, in which case one should use the System GMM estimation method proposed by Arellano and Bover (1995) and developed by Blundell and Bond (1998). We run a 2SLS regression in differences with "GMM-style" matrix of instruments in order to obtain the Kleibergen-Paap rk LM stastic[11] for the underidentification test. The rejection of the null hypothesis will lead us to the conclusion that the excluded instruments are relevant, meaning correlated with the endogenous regressors.

The System GMM estimator involves the simultaneous estimation of the model in levels and in differences, with lagged differences used as instruments in the levels equation and

[11]Under the null hypothesis the matrix of reduced form coefficients on the L excluded instruments has rank=K-1 where K=number of endogenous regressors.

with lagged levels of the independent variables used as instruments in the differences equation. For the persistent over time variables, past changes may be more predictive of current levels than past levels of current changes so that the new instruments are more relevant (Roodman, 2009). The additional instruments for the level equation are valid under the following assumption: there is no correlation between the lagged differences of the explanatory variables and the country-specific effect, which results from the stationarity property $E(X_{i,t+p}c_i) = E(X_{i,t+q}c_i)$ for all p and q. In order to perform System GMM a stacked data set is created from a copy of the original data set in levels and another one in differences. The moment conditions for the regression in levels (the second part of the single-equation system) are

$$E[\log X_{i,t} - \log X_{i,t-1})(c_i + v_{i,t})] = 0, \qquad t \geq 2 \tag{2.5}$$

for the predetermined variables including lagged dependent variable and

$$E[(\log X_{i,t-1} - \log X_{i,t-2})(c_i + v_{i,t})] = 0 \qquad t \geq 3, \tag{2.6}$$

for the endogenous variables. Since most of the associated moment conditions are redundant, only one lag of difference is used as instrument in the levels specification (Blundell and Bond, 1998; Roodman, 2009).

Thus, we use the moment conditions presented in Equations (2.3), (2.4), (2.5) ,(2.6) and employ a GMM procedure to generate consistent and efficient parameter estimates. We report two specification test statistics (p-values) in order to test the validity of instruments proposed by Arellano and Bond (1991): a second-order serial correlation test with the null hypothesis that the error term $v_{i,t}$ is not serially correlated; the Hansen test of over-identifying restrictions with the null hypothesis that the instrumental variables are uncorrelated with the error term. The failure to reject the null hypothesis in both tests supports the model specification. Additionally, we report the difference-in-Hansen statistics (p-value) to test whether the subset of System GMM instruments, the instruments for the level equations

based on the lagged differences of the regressors are valid. The failure to reject the null hypothesis requires that the full set of orthogonality conditions be valid.

2.5 Empirical Results

2.5.1 Main Results

Table 2.5 presents the estimation results on the drivers of life insurance market development using difference estimators described above: (1) Pooled OLS; (2) Fixed Effects; (3)-(4) One-Step and Two-Step Difference GMM including Windmeijer small-sample correction; (5) 2SLS; (6) Two-Step System GMM including Windmeijer small-sample correction. The dependent variable is the logarithm of life insurance premium to GDP. We employ regression analysis on annual country-level data for the period 1996-2010 on 92 countries. Due to the missing values on the explanatory variables included in regression the sample size is reduced and varies from 167 (66 countries) to 249 (79 countries) annual country level observation depending on the model specification.

The dynamic panel estimates obtained using Two-Step System GMM method, an instrumental variable approach proposed by Arellano and Bover (1995), suggest that the exogenous component of the financial (banking) sector development exerts a significant impact on the development of life insurance industry.

The problem with the first method is that the Pooled OLS does not model the fixed country-specific effect in the error term, which gives the rise to the dynamic panel biased estimates. Most of the coefficients in Model (1) are insignificant with the coefficient on lagged dependent variable closer to one and highly significant suggesting the high persistence of the life insurance penetration time series.

The Fixed Effects Model (2) does not eliminate dynamic bias, since the regressor and error are still correlated after the within-group transformation. The estimate on the lagged penetration variable fell from 0.925 to 0.221. Bond (2002) points out, that the results from

theoretically superior estimators should lie in the range between these values. Model (2) produces significant coefficients only on the lagged dependent and GDP per capita variables.

Difference GMM estimator in Model (3)-(4) should solve the dynamic panel bias problem. However, the estimates on the lagged penetration variable outside of the credible range (0.221-0.925) for possible values indicate that the estimator performs rather poorly. As expected two-step Difference GMM produces more of significant estimates on the explanatory variables compare to the One-Step Difference GMM. After applying the Windmeijer small-sample correction the significance of the coefficients disappears. The first-order serial correlation tests in Model (3) and (4) with p-values equal to 0.729 and 0.433, respectively, fail to reject the null hypothesis of no first-order serial correlation in the first-differences of errors[12].

Since our life insurance penetration variable is highly persistent, the lagged levels of explanatory variables appear to be weak instruments for the differenced variables. In Model (5) we run 2SLS regression on the same matrix of the instruments used in Difference GMM in order to obtain the test-statistic for the underidentification test. The p-value for the Kleibergen-Paap rk LM statistic of 0.1952 fails to reject the null hypothesis that matrix of reduced form coefficients has $rank = 10 - 1$ [13], the equation is unidentified. Thus, we do not have enough statistical evidence that the excluded instruments are relevant, meaning correlated with the endogenous regressors. Also we do not expect 2SLS to behave better than the GMM estimator as 2SLS is efficient under homoskedasticity.

The results of estimation are considerably improved in Model (6), where the System GMM approach was employed. The highly significant coefficient on the lagged dependent variable lies within the credible range for possible values of estimates. The significance of almost all coefficients is increased for Two-Step System GMM in Model (6) as expected due to downward-biased standard errors in the presence of large amount of instruments. The

[12]By construction, the differenced error term is first-order correlated even if the original error term is not serially correlated

[13]The number of regressors in the equation 2.1 is equal to 10.

estimated coefficients with exception of life expectancy and education have the expected sign and are statistically significant at 0.1% level. The regression estimates on the Private Credit are also economically larger. The positive coefficient on the Private Credit variable of 1.914 and the negative coefficient on the squared Private Credit variable of -0.209 support our hypothesis of non-linearity in relationship between banking and life insurance industry and suggest that after reaching the level of Private Credit of roughly 97.4% banking and life insurance industry stop acting as complements and start acting as substitutes. For example, in the countries with the level of Private Credit to GDP of 20% an increase in the banking sector development of 10% will result in the increase of life insurance penetration by 6.6%; in the countries with the level of Private Credit of 150% an increase of 10% of Private Credit will result in the decrease of life insurance penetration by 1.8%.

We find that the development of banking sector plays an important role in the developing of life insurance sector. We also found that for countries with lower initial levels of banking sector development the development of life insurance industry is strongly positively affected by the increased development of banking sector. As we discussed before, the well-functioning and regulated banks increase the confidence of consumers in life insurance contracts. Banks provide life insurers with effective payment system. The development of banking sector is precondition for the development of bond and equity markets, which will promt the investment activity of life insurers. In the recent years many life insurance companies employ the bankassurance model of conducting their business, that is using bank branches as a distributional channel for life insurance products, which allow to increase the sales of products. However, countries with relatively high level of banking sector development experience the substitution relationship between banking and life insurance industry.

The positive coefficient on GDP per capita variable and the negative coefficient on the square of the income variable is supportive of the "S-curve" hypothesis where at higher levels of income the life insurance growth is less sensitive to the income growth. Since the life insurance is a type of long-term investments, people are concerned about the future values

of their money and reluctant in life insurance consumption during monetary instabilities. The coefficient on inflation variable is negative and equal to -0.387. The young dependency coefficient has a positive sign indicating larger increase in the demand for policies with mortality coverage compare to the decrease in the demand for annuties. Life expectancy exhibits positive relationship with life insurance consumption as individuals have greater incentives for savings. However, this relationship is statistically insignificant. Although the coefficient on education is insignificant, it has positive sign which is consistent with our hypothesis of understanding of the benefits of risk management and long-term savings with higher education. The social security expenditure produces a positive significant income effect on life insurance consumption.

Since we do not rely solely on the uncorrected two-step errors for inference, we report Two Step System GMM with Windmeijer small-sample correction in Model (6). The significant coefficients are the lagged life insurance penetration, the Private Credit and inflation variables with coefficient on the income variable being close to significant (t-statistic=1.30). Although we could not fully disentagle the contemporaneous effects of GDP per capita and the other drivers, after contolling for country-specific effects, problems with lagged dependent variable, endogeneity and weak instruments, the data suggest a strong link between the development of banking sector and life insurance industry. Consistent with results of Beck and Webb (2003), education, young dependency ratio, life expectancy and social security expenditures appear to have no robust association with the development of life insurance sector. The estimation results highlight the importance of price stability and banking sector development for implementing the investment function of life insurers.

The System GMM regressions satisfy the specification tests. There is evidence of first-order serial correlation in the differenced error term. We can not reject the null hypothesis of no second-order serial correlation at any reasonable significance level. The regression passes the Hansen overidentification test with p-value 0.528. In addition the Difference-in-Hansen test returns p-value equal to 0.550. Thus, we can not reject the null hypothesis

that the lagged differences of the explanatory variables are uncorrelated with the residuals. Hence, the System GMM produces consistent and efficient estimates. The banking sector development enters significantly even after we instrument for it. These results show that the relationship between banking sector development and life insurance industry is not due to reverse causality.

2.5.2 Sensitivity Analyses

Our results are also robust to a variety of sensitivity analyses.

First, we use alternative measures of financial (banking sector) development such as BANK ASSETS, the ratio of deposit money bank domestic assets to GDP, which does not distinguish between credits issued to the private sector and those issued to the public sector, and the ratio of M2 to GDP, a traditional measure of the financial deepening. M2 is a measure of the money supply that includes cash, checking, and saving accounts.Assuming the size of the financial sector is positively correlated with the provision of the financial services, the measure of the financial depth is tested as well. As you can see in Table 2.6 in models (2)-(4) there is a strong impact of the financial development on the development of the life insurance market.

Second, besides the development of financial institution, the impact of the development of the financial markets (stock and bond markets) was tested as well. In model (5) the significant coefficient on the STOCK MARKET CAPITALIZATION enters positively. However, the impact of the stock market development on the development of the life insurance is not very pronouced, with a 10 % increase in the stock market capitalization leading to a 2.2 % increase in life insurance consumption, as the share of life insurers' assets devoted to stocks is relatively small.In order to estimate the independent link between banks and life insurers additional control variables were considered. The measures of the stock market, public and private bond capitalization were included in order to better assess the direct link between the development of banking and life insurance industry. As you can see in model (7) in

Table 2.6 the coefficient on the STOCK MARKET CAPITALIZATION is still suggestive, however, the impact of the banking development on the life insurance is less pronounced. The hypothesis of the complementary and then substitutionary relationship between banks and life insurers is confirmed here again.

Third, in addition to the internal instruments, the legal origin variables were included as external instruments in the dynamic panel estimates. A strong relationship between the exogenous component of the financial development and life insurance penetration is present again.

Finally, the potential influence of outliers is checked. Figure 2.3 illustrates the relationship between private credit and life insurance penetration. Since Luxembourg is far from the regression line, this country was dropped and the estimation was redone. The new System GMM results are not substantially different from the Table 2.6 results. The sensitivity results are available upon request. The strong relationship between the exogenous component of the financial development and the life insurance penetration does not seem to be driven by the outliers.

2.6 Conclusion and Policy Implications

In this paper we investigate the evidence of causality of the financial (banking sector) development on the development of the life insurance market measured by the level of life insurance consumption using panel estimation across around 90 countries over the period 1996-2010. While the developed banking sector facilitates the development of the life insurance market by offering effective payment services, raising confidence in the financial intermediaries and increasing the investment opportunities for life insurers, life insurance sector might foster the development of capital markets and, consequently, banking sector through the demand for instruments of long-term investments. We correct for endogeneity bias due to bidirectional causality between the financial development and life insurance con-

sumption by employing System GMM estimation method using lagged levels of the financial development as instruments in the differences equation and lagged differences as instruments in the level equation. We use the measure of banking sector development as a proxy for the financial development. We investigate not only the direct relationship between the banking and life insurance sectors, but also the interdependence between banking and other components of financial system such as stock market and bond market that affect the development of the life insurance market. After controlling for country-specific effects, problems with lagged dependent variable, endogeneity and weak instruments, we find a strong significant link between the development of banking sector and life insurance industry.

In order to evaluate the strength of an independent link between the financial development and life insurance consumption we include the set of control variables, which are the other important drivers of life insurance industry. Our estimation results confirm some of the findings of the previous research results and add some new findings. Consistent with results of Beck and Webb (2003), education, life expectancy, young dependency ratio and social security expenditures appear to have no robust association with the development of life insurance sector. Consistently with previous research on the determinants of life insurance consumption we could not fully disentagle the contemporaneous effects of GDP per capita and our drivers. Two-step System GMM with Windmeijer correction estimation method provides insignificant coefficient on income per capita, which suggests the stronger effect of the financial development compare to the GDP per capita. Our results highlight the importance of price stability and banking sector development for implementing the investment function of life insurers in line with Beck and Webb (2003) results.

The main contribution of our empirical reserch to the previous research on the drivers of life insurance industry is our additional findings of non-linear relationship between banking and life insurance industries. The complement or substitute relationships between banking and life insurance depends upon the level of banking sector development of the country at first place. The development of life insurance industry is strongly positively affected by the

increased development of banking sector for countries with relatively lower levels of banking sector development (e.g., India, Russia, Zimbabwe, Botswana, Italy, United States). As we discussed before, the well-functioning and regulated banks increase the confidence of consumers in life insurance contracts. Banks provide life insurers with effective payment system. The development of banking sector is precondition for the development of bond and equity markets, which will prompt the investment activity of life insurance. In the recent years many life insurance companies employ the bancassurance model of conducting their business, that is, the sale of insurance products through a bank. Bancassurance has proved to be an effective distribution channel in a number of countries in Europe, Latin America, and Asia. However, countries with relatively high level of banking sector development experience the substitution relationship between banking and life insurance industry (e.g., Spain, Austria, Malta, Iceland, Cyprus). With the development of bankassurance, banks may involve not only in the distribution of the life insurance products but also in the underwriting activities. However, the increase of provision of life insurance services by banks does not lead necessary to the increase of the life insurance sales, as banks along with more capital and risk implications may not achieve specialization advantages compare to the life insurance companies. Also given the nowadays increasing savings type insurance, life insurers face the enormous competition form banks, mutual funds and pension funds. With more developed banking sector the higher customers' confidence in the banking system encourages savers to invest in banking savings products rather in life insurance products. We use "private credit", which includes the efficiency side in its measure, as a main measure of the banking sector development. A higher banking efficiency allows banks to offer better returns to savers, fostering the sales of saving instruments and the competition with insurers. If life insurers are not responding with lowering the prices and increasing the expected returns, banks may increase their market share. Thus, banks engaged in life insurance activities and life insurers face a constant competition from banks which can better offer and sell the saving products.

Our results have a real significance not only for the policymakers of developed and de-

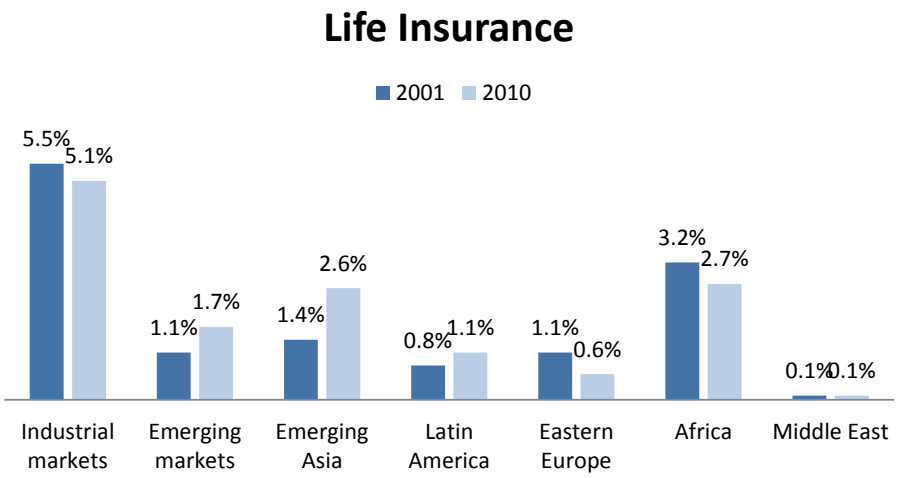
veloping countries but also for the foreign entrants which plan to expand in the emerging markets and for the present incumbents in the insurance market. Although the main drivers of the life insurance sector can not be influenced by policymakers over the short period of time, the supportive policies can positively effect the development of the life insurance sector. Over the last 30 years the governments across many developed countries are concerned with the issue of the retirement savings as the current public pension systems are unable to provide the adequate retirement insurance in the light of the increased longevity risk. It is in the interests of the government to stimulate the demand and supply factors of private retirement savings offered by life insurers, banks and other investment firms. On the demand side, our results show the importance of the economic stability, inflation and the banking sector development for the development of life insurance. Taking into account the importance of life insurance development on economic growth, the policymakers of the developing countries should understand the drivers of life insurance sector, especially from the supply side. For example, Zarezkyi (2013), the president of the Association of Life Insurers in Russia[14], asserts that the one of the key unsolved issue of the development of life insurance market in Russia is the increase of the investment opportunities for life insurers. Zarezkyi says: "If the russian financial market will develop with the current temps, we will not have enough of it. We need more financial instruments, including the long-term". On the supply side, our results show the importance of the banking sector development along with the development of the stock and bond markets. From the demand side, we pointed out that the supportive legal environment, the increased confidence and the transperancy of the life insurance products will foster the development of the life insurance market. The foreign entrants and incumbents have to take into account a vigorous competition with the banks before they start the business or choose the right business model.

Our research was not able to capture several factors that may influence the development of the life insurance sector due to the lack of the appropriate data. It would be interesting to

[14]www.aszh.ru

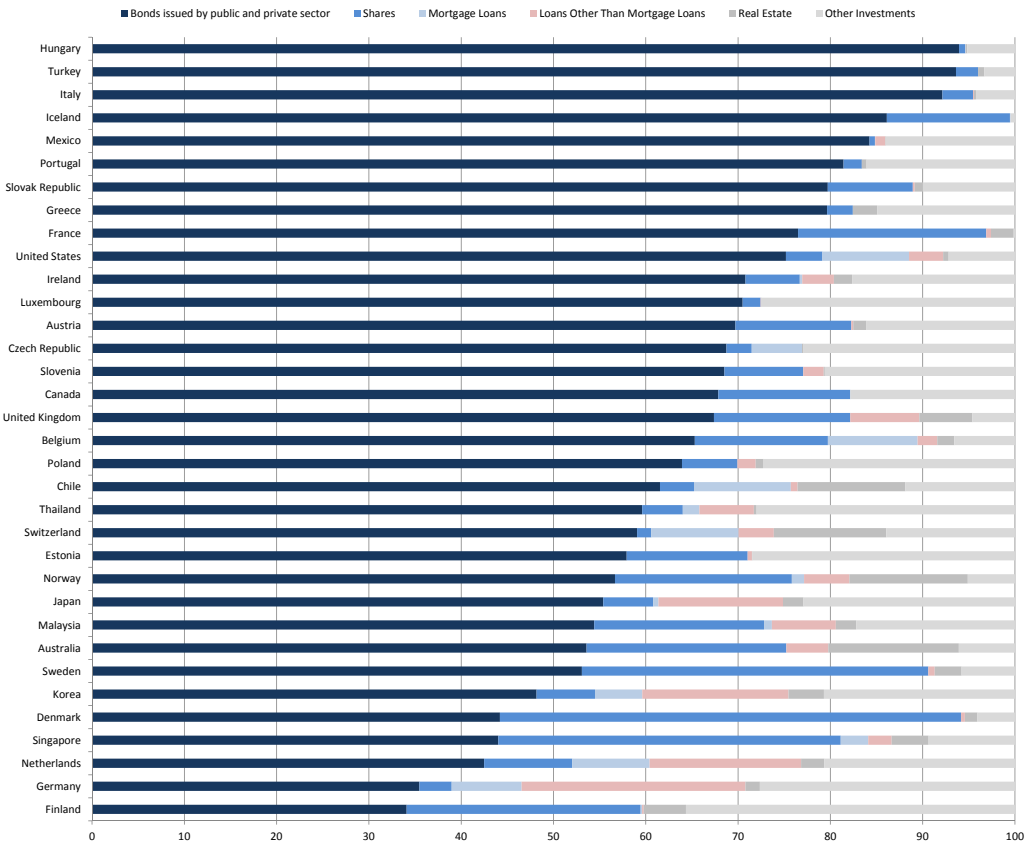
include and estimate the effect of the fiscal incentives to the sales of life insurance products, especially saving products. There are different tax benefits from purchasing the savings products. However, our data on the life insurance premiums collected are of the aggregate character and do not distinguish between type of the products sold. Also there are no data on life insurance regulation. We proxy the supervision of life insurers by the banking regulation. In order to investigate the effectiveness of the bankassurance model in more details and to have a close look on the competition between the banks and life insurers, the separate data on the premiums collected directly by life insurers, through banking distribution channel and by banks involved in the underwriting activities will be helpful.

Figure 2.1: Insurance Penetration as a % of GDP



Source: Sigma No 5/2011 Insurance in emerging markets: growth drivers and profitability.

Figure 2.2: Investment Portfolio Allocation: Life Insurers (2010), As a Percent of Total



Source: OECD Insurance Statistics. Author's calculations

Table 2.1: Determinants of Life Insurance Consumption: Expected Results of the Regression Analysis

Variables	Hypothesized sign
Economic variables	
Income (GDP per capita)	+
Inflation	-
Financial Development:	
Private Credit	+
Liquid Liabilities/GDP	+
Deposit money bank assets / GDP	+
Social Variables	
Education	+
Dependency ratio, Young	Ambiguous
Life expectancy	Ambiguous
Institutional variables	
Social Security	Ambiguous

Table 2.2: Description of Variables and Sources

	Variable	Description	Source
Dependent	(l)penetr	(log) Life insurance premium volume to GDP (%)	Sigma, Swiss RE
Economic	(l)gdppc	(log) GDP per capita (constant 2000 US$)	World Bank WDI
	(l)infl	(log) Inflation, consumer prices (annual %)	World Bank WDI
Social	(l)dep_y	(log) Age dependency ratio, young (% of working-age population)	World Bank WDI
	(l)lifexp	(log) Life expectancy at birth, total (years)	World Bank WDI
	edusec	School enrollment, secondary (% gross)	World Bank WDI
Institutional	ruleoflaw	Rule of Law: Estimate	World Bank WDI
	welfare	Social Security expenditure as a percentage of GDP	World Bank WDI
Financial Development	(l)llgdp	Liquid liabilities (M3) as % of GDP	World Bank GFDD
	(l)prcdbgdp	(log) Private credit by deposit money banks to GDP (%)	World Bank GFDD
	(l)dbagdp	(log) Deposit money bank assets to GDP (%)	World Bank GFDD
	(l)m2gdp	(log) M2 to GDP (%)	World Bank GFDD
	(l)stmktcap	Stock market capitalization to GDP (%)	World Bank GFDD
	(l)prbond	Private bond market capitalization to GDP(%)	World Bank GFDD
	(l)pubond	Public bond market capitalization to GDP (%)	World Bank GFDD
	(l)roa	Bank return on assets (%)	World Bank GFDD
	(l)roe	Bank return on equity (%)	World Bank GFDD
	(l)zscore	Bank z-score (%)	World Bank GFDD
	legor_fr	= 1 if the country's legal system is of French origin	La Porta et al. (1999)
	legor_ge	= 1 if the country's legal system is of German origin	La Porta et al. (1999)
	legor_sc	= 1 if the country's legal system is of Scandinavian origin	La Porta et al. (1999)
	legor_uk	= 1 if the country's legal system is of British origin	La Porta et al. (1999)

The sample consists of country-level annual data for the period 1996-2010.

Table 2.3: Descriptive Statistics

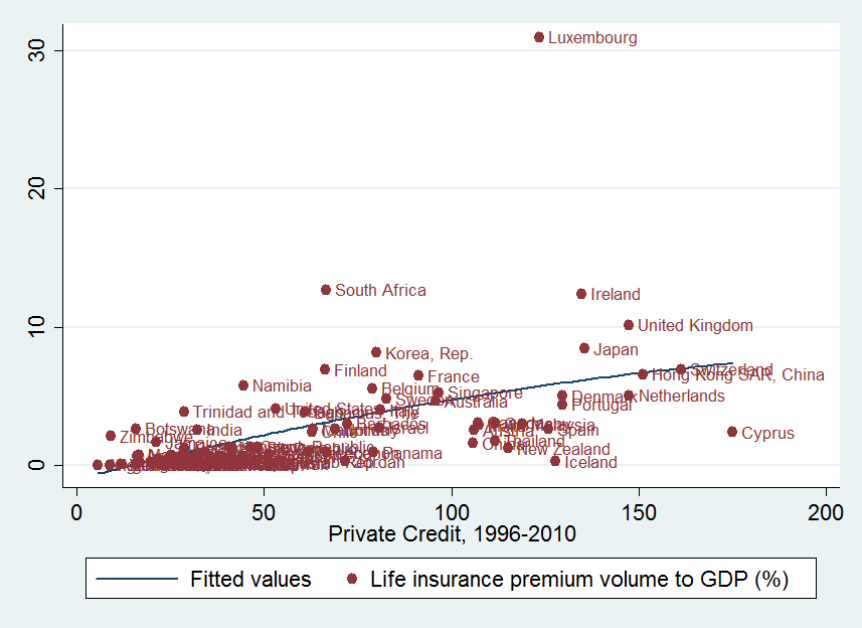
variable	mean	median	sd	min	max	N
penetr	2.72	1.05	4.41	0.00	55.66	1210
gdppc	11152.38	5288.42	11810.11	272.29	56285.28	1365
infl	13.35	3.72	123.98	-4.86	4145.11	1312
dep_y	40.08	34.99	17.18	15.19	95.78	1380
welfare	14.41	12.83	8.62	0.04	36.38	940
edusec	88.17	90.85	22.68	12.96	162.35	1152
lifexp	72.58	73.63	7.61	42.50	82.93	1377
pcrdbgdp	60.91	47.11	47.03	0.20	272.80	1272
m2gdp	79.40	57.64	71.07	8.57	669.88	1336
dbagdp	72.65	59.17	49.84	0.29	296.64	1284
ruleoflaw	0.39	0.41	0.98	-1.82	2.00	1104
stmktcap	76.49	36.60	640.65	0.03	22306.30	1218
roa	0.89	0.96	3.10	-66.42	20.30	1266
roe	11.05	11.84	42.75	-692.71	1001.16	1266
zscore	19.47	17.81	12.11	-1.99	118.58	1259
prbond	28.37	17.85	33.67	0.00	303.37	646
pubond	32.18	28.00	23.86	0.01	201.23	741
legor_uk	0.30	0.00	0.46	0.00	1.00	1380
legor_fr	0.49	0.00	0.50	0.00	1.00	1380
legor_ge	0.15	0.00	0.36	0.00	1.00	1380
legor_sc	0.05	0.00	0.23	0.00	1.00	1380

We specify variables which have highly skewed distributions in the log form. The log-linear specification will also provide the estimation of elasticities. Before we log-transform a possibly negative inflation rate variable, we had to add value slightly larger than the minimum value of inflation rate. We also dropped the outlier value of inflation rate (4145%) for Angola in 1996.

Table 2.4: Correlations

Variables	lpenetr	lgdppc	ninfl	ldep_y	welfare	edusec	llifexp	lpcrdbgdp	lm2gdp	ldbagdp	lstmktcap	lpubond	ruleoflaw
lpenetr	1.0000												
lgdppc	0.5360	1.0000											
	(0.0000)												
ninfl	-0.4282	-0.5629	1.0000										
	(0.0000)	(0.0000)											
ldep_y	-0.4106	-0.6341	0.3407	1.0000									
	(0.0000)	(0.0000)	(0.0000)										
welfare	0.3796	0.5090	-0.2677	-0.6836	1.0000								
	(0.0000)	(0.0000)	(0.0000)	(0.0000)									
edusec	0.4374	0.7462	-0.3996	-0.6975	0.6488	1.0000							
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)								
llifexp	0.3182	0.7195	-0.5664	-0.6646	0.4421	0.6594	1.0000						
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)							
lpcrdbgdp	0.6593	0.6440	-0.6252	-0.5224	0.3693	0.5074	0.6201	1.0000					
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)						
lm2gdp	0.6574	0.5491	-0.5159	-0.4304	0.3288	0.3752	0.4745	0.8223	1.0000				
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)					
ldbagdp	0.6373	0.6429	-0.6304	-0.5228	0.3642	0.5123	0.6388	0.9646	0.8510	1.0000			
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)				
lstmktcap	0.5624	0.5109	-0.4492	-0.2305	0.1234	0.3482	0.2510	0.5531	0.6079	0.5594	1.0000		
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0289)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)			
lpubond	0.1285	0.1569	-0.2242	-0.1521	0.1158	0.2483	0.1515	0.1407	0.0666	0.2174	0.0575	1.0000	
	(0.0437)	(0.0132)	(0.0005)	(0.0163)	(0.0949)	(0.0001)	(0.0168)	(0.0267)	(0.3045)	(0.0006)	(0.3661)		
ruleoflaw	0.6604	0.8499	-0.5784	-0.6146	0.5298	0.7029	0.6391	0.7259	0.6257	0.7032	0.5041	0.1894	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0027)	

Figure 2.3: Private Credit vs Life Insurance Penetration[a]



[a]Averages values are taken over the period of 1996-2010.

Table 2.5: Drivers of the Life Insurance Industry - Private Credit as a Measure of Banking Sector Development

	(1) Pooled OLS	(2) Fixed Effects	(3) One-step Difference GMM	(4) Two-step Difference GMM	(5) 2SLS	(6) Two-step System GMM
L.Penetration	0.925	0.221	0.140	0.106	0.044	0.874
	(0.0288)***	(0.0749)***	(0.199)	(0.0975)	(0.182)	(0.0096)***
				[0.170]		[0.0749]***
Private Credit	0.921	0.487	1.353	2.242	1.293	1.914
	(0.653)	(0.688)	(0.974)	(0.604)***	(0.764)*	(0.160)***
				[1.153]*		[0.933]**
(Private Credit)^2	-0.103	-0.0312	-0.113	-0.252	-0.148	-0.209
	(0.0771)	(0.0845)	(0.134)	(0.0789)***	(0.102)	(0.0207)***
				[0.158]		[0.115]*
GDP per capita	-0.334	5.255	3.863	1.761	3.848	0.739
	(0.337)	(2.359)**	(3.153)	(2.021)	(2.800)	(0.112)***
				[3.532]		[0.573]
(GDP per capita)^2	0.0158	-0.304	-0.310	-0.182	-0.273	-0.0493
	(0.0179)	(0.140)**	(0.186)*	(0.112)*	(0.154)*	(0.007)***
				[0.194]		[0.0346]
Inflation	-0.178	-0.135	-0.0273	0.0430	0.037	-0.387
	(0.102)*	(0.116)	(0.187)	(0.116)	(0.157)	(0.0364)***
				[0.193]		[0.217]*
Dependency ratio,y.	-0.00255	-0.717	-3.500	-2.832	-3.186	0.301
	(0.156)	(0.814)	(1.848)*	(0.931)***	(1.336)**	(0.0412)***
				[1.355]**		[0.318]
Life expectancy	0.235	-2.002	-1.016	5.416	1.561	0.110
	(0.422)	(3.463)	(6.317)	(3.842)	(5.108)	(0.309)
				[4.879]		[0.890]
Welfare	0.543	0.626	-3.241	-3.271	-0.187	0.951
	(0.461)	(1.338)	(3.040)	(1.342)**	(0.181)	(0.208)***
				[3.124]		[1.244]
Education	-0.0211	-0.416	-1.254	-1.029	-1.113	0.149
	(0.215)	(0.374)	(1.037)	(0.534)*	(0.648)*	(0.0995)
				[0.956]		[0.381]
Observations	249	249	167	167	167	249
F test	0.000	0.000	0.000	0.000	0.000	0.000
F test time dummies	0.2137	0.6526	0.7447	[0.8421]	0.7668	[0.3597]
Countries	79	79	66	66	66	79
N of instruments			30	30	30	66
Hausman test[a]		0.000				
AR(1) test[b]			0.729	0.433[0.564]		0.019[0.030]
AR(2) test[c]			0.725	0.417[0.454]		0.609[0.613]
Hansen test[d]			0.590	0.590	0.4590	0.528
K-P rk LM test[e]					0.1952	
Difference-in-Hansen [f]						0.550

Dependent variable is the logarithm of life insurance penetration. The sample consists of three-year averaged data for the period 1996-2010. Robust Standard errors in parentheses. For all tests p-values are reported. Two-step GMM estimation results with Windmeijer small-sample correction are reported in brackets.
* $p < .10$, **$p < .05$, *** $p < .01$
a The null hypothesis is that the fixed effect estimator is consistent and the random effect estimator efficient and consistent.
b The null hypothesis is that the errors in the difference equation do not exhibit first-order correlation.
c The null hypothesis is that the errors in the difference equation do not exhibit second-order correlation.
d Test of overidentifying restrictions. The null hypothesis is that the instruments are not correlated with the residuals.
e Underidentification (Kleibergen-Paap rk LM) test. The null hypothesis is that the equation is not identified.
f Difference-in-Hansen test of exogeneity is under the null that instruments used for the equations in levels are exogenous.

Table 2.6: Drivers of Life Insurance Industry - Alternative Measures of Financial Development

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L.Penetration	0.874	0.860	0.823	0.885	0.896	0.891	0.853
	(0.00955)***	(0.00988)***	(0.0122)***	(0.0158)***	(0.0125)***	(0.00940)***	(0.00977)***
	[0.0749]***	[0.0727]***	[0.0740]***	[0.0627]***	[0.0714]***	[0.0652]***	[0.0821]***
GDP per capita	0.739	0.743	0.105	-0.0885	1.071	0.931	0.909
	(0.112)***	(0.182)***	(0.178)	(0.221)	(0.228)***	(0.158)***	(0.162)***
	[0.573]	[0.679]	[0.583]	[0.476]	[0.769]	[0.603]	[0.596]
(GDP per capita)^2	-0.0493	-0.0508	-0.00707	0.00379	-0.0756	-0.0623	-0.0617
	(0.00696)***	(0.0110)***	(0.0104)	(0.0130)	(0.0137)***	(0.00986)***	(0.00900)***
	[0.0346]	[0.0406]	[0.0347]	[0.0274]	[0.0472]	[0.0375]*	[0.0355]*
Inflation	-0.387	-0.388	-0.368	-0.235	-0.550	-0.466	-0.416
	(0.0364)***	(0.0405)***	(0.0402)***	(0.0525)***	(0.0387)***	(0.0355)***	(0.0315)***
	[0.217]*	[0.198]**	[0.195]*	[0.172]	[0.226]**	[0.233]**	[0.224]*
Dependency ratio, y.	0.301	0.171	0.0692	0.0205	0.317	0.290	0.344
	(0.0412)***	(0.0582)***	(0.0572)	(0.0692)	(0.0559)***	(0.0484)***	(0.0615)***
	[0.318]	[0.293]	[0.284]	[0.208]	[0.346]	[0.242]	[0.367]
Welfare	0.951	0.644	0.693	1.075	2.258	2.328	1.299
	(0.208)***	(0.269)**	(0.254)***	(0.286)***	(0.324)***	(0.281)***	(0.233)***
	[1.244]	[1.275]	[1.239]	[0.930]	[1.491]	[1.425]	[1.301]
Education	0.149	0.285	0.244		-0.148	-0.319	
	(0.0969)	(0.0825)***	(0.117)**		(0.112)	(0.0935)***	
	[0.371]	[0.365]	[0.368]		[0.461]	[0.465]	
Life expectancy	0.110	0.356	-0.648	-0.261	1.473	1.293	0.995
	(0.309)	(0.269)	(0.304)**	(0.288)**	(0.360)***	(0.304)***	(0.340)***
	[0.890]	[1.117]	[0.875]	[0.714]	[1.515]	[1.469]	[1.934]
Private Credit	1.914						1.241
	(0.160)***						(0.147)***
	[0.933]**						[0.877]
(Private Credit)^2	-0.209						-0.145
	(0.0207)***						(0.0201)***
	[0.115]*						[0.108]
Bank Assets		2.123					
		(0.134)***					
		[1.000]**					
(Bank Assets)^2		-0.218					
		(0.0162)***					
		[0.119]*					
M2/GDP			1.925	2.283			
			(0.247)***	(0.294)***			
			[1.237]	[1.277]*			
(M2/GDP)^2			-0.190	-0.244			
			(0.0264)***	(0.0327)***			
			[0.140]	[0.145]*			
Stock Market Capitalization					0.220	0.324	0.186
					(0.0162)***	(0.0362)***	(0.0158)***
					[0.0980]**	[0.310]	[0.100]*
(Stock Market Capitalization)^2						-0.0273	
						(0.00714)***	
						[0.0474]	
Observations	249	249	251	263	238	238	248
Countries	79	79	80	81	74	74	75
Wald test	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N of instruments	66	66	66	59	60	66	65
AR(1) test[a]	0.0189	0.0185	0.0109	0.00923	0.0236	0.0192	0.0227
	[0.0295]	[0.0278]	[0.0175]	[0.0127]	[0.0263]	[0.0234]	[0.0320]
AR(2) test[b]	0.609	0.615	0.626	0.506	0.552	0.650	0.524
	[0.613]	[0.618]	[0.631]	[0.510]	[0.553]	[0.654]	[0.527]
Hansen test[c]	0.528	0.343	0.282	0.309	0.362	0.359	0.285
Difference-in-Hansen[d]	0.550	0.594	0.244	0.149	0.261	0.178	0.148

Two-Step System GMM estimation is performed. Robust Standard errors in parentheses. The estimation results with Windmeijer small-sample correction are reported in brackets. * $p < .05$, ** $p < .01$, *** $p < .001$
The sample consists of three-year averaged data for the period 1996-2010. A constant was estimated but not reported.
a The null hypothesis is that the errors in the difference equation do not exhibit first-order correlation.
b The null hypothesis is that the errors in the difference equation do not exhibit second-order correlation.
c Test of overidentifying restrictions. The null hypothesis is that the instruments are not correlated with the residuals.
d Difference-in-Hansen test of exogeneity is under the null that instruments used for the equations in levels are exogenous.
The variables ROA(Return on Assets), ROE(Return on Equity), bank-z-score, private and public bond market capitalization (Beck and Kunt (2009)) were tested as well. No significant relationships between them and life insurance consumption were found, due to the small sample size of the correponding variables mostly.

Chapter 3

The Impact of the Federal Reserve's Mortgage-Backed Securities Purchase Program on Mortgage Spreads

3.1 Abstract

In 2016 more than half of the U.S. total family mortgage credit was securitized into Agency Mortgage-Backed Securities (MBS) and sold to investors on the secondary mortgage market. Over the last few years the Federal Reserve became the largest provider of the U.S. home mortgage credit through the secondary market. This paper examines the quantitative impact of the Federal Reserve's Mortgage-Backed Securities (MBS) purchase program on the secondary mortgage market spreads. The results indicate that the MBS purchase program has effect on the mortgage spreads through both signaling and portfolio rebalancing channels. I find that not only the announcements of the first and the third rounds of "quantitative easing", QE1 and QE3, but also the increase in the size of the Federal Reserve's MBS holdings have negative impact on MBS spreads. This chapter employs a triangular structural VAR model to reveal the forecasting ability of the changes in the Federal Reserve's MBS holdings variable and to generate the forecast of MBS spreads, conditional on tapering of Federal Reserve's reinvestments in its MBS portfolio.

3.2 Introduction

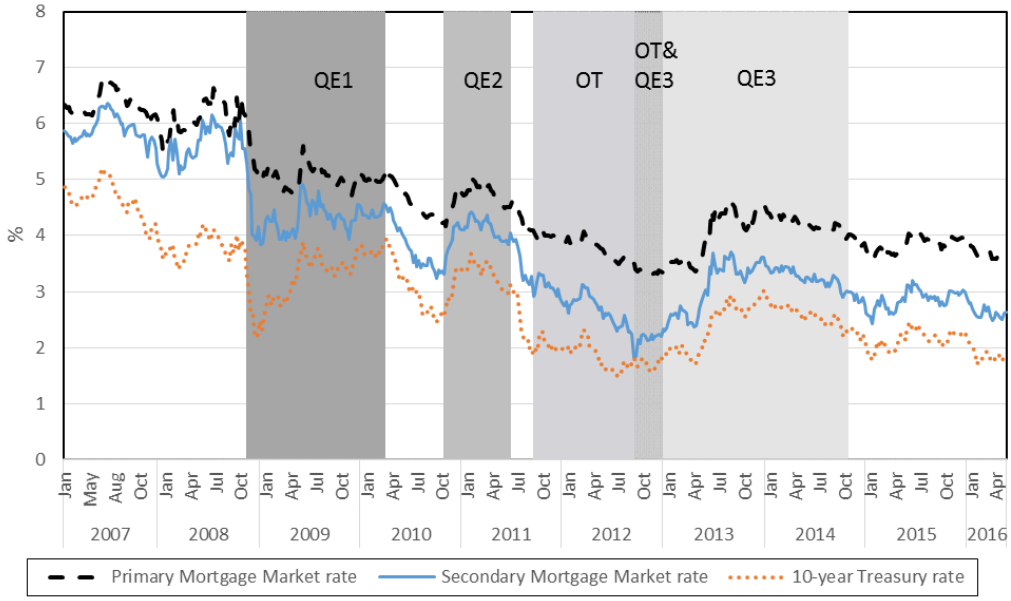
In response to the recent financial crisis, when the federal funds rate was pushed all the way down to virtually zero by December 16, 2008, the Federal Reserve Board (the "Fed") adopted a new monetary policy strategy: large-scale asset purchases (LSAP), commonly known as "quantitative easing" (QE) programs, to lower long-term interest rates and help to stimulate economic recovery. Quantitative easing refers to the changes in the composition and/or size of the central bank's balance sheet with objective to ease liquidity and/or credit conditions when the short-term interest rate is constrained by zero lower bound. The idea is that central bank can use unconventional monetary policy instruments to reduce interest rate spreads - term premiums and/or risk premiums over the risk-free rate - by purchasing safe and liquid long-term government debt and risky and less-liquid debt, either private or government (Blinder, 2010; Krishnamurthy and Vissing-Jorgensen, 2013). This paper examines the quantitative impact of the Federal Reserve's mortgage-backed securities (MBS) purchase program on agency MBS spreads. The goal of the MBS purchase program as a part of LSAP was "to reduce the cost and increase the availability of credit for the purchase of houses, which in turn should support housing markets and foster improved conditions in financial markets more generally"[1]. As of the second quarter of 2016, of the $10 trillion one- to four- family residences mortgage credit outstanding, approximately $5.9 trillion is Agency MBS, that is, more than half of the total family mortgage credit in the U.S. is eventually securitized into Agency MBS in the secondary market[2]. In the same period, with the Fed's MBS holding of $1.7 trillion, representing 30% of Agency MBS market, the Fed is the largest provider of the home mortgage credit through the secondary market. The demand for MBS by the Federal Reserve reduces secondary mortgage rates, which pass through to borrowers who may be able to purchase or refinance home mortgages at attractive rates

[1]Monetary Policy Press Release as of November 25, 2008 `http://www.federalreserve.gov/newsevents/press/monetary/20081125b.htm`

[2]Source: `https://www.federalreserve.gov/econresdata/releases/mortoutstand/current.htm`, Sifma

in the primary mortgage market. Figure 3.1 shows both primary and secondary mortgage market interest rates along with 10-year U.S. Treasury yield for the period from January 2007 to May 2016. The chart is separated into four sections displaying the three rounds of QE as well as Operation Twist (OT).

Figure 3.1: Mortgage Rates and 10-Year U.S. Treasury Yield



Source: The Federal Reserve, Bloomberg

While it is a well-established fact that the LSAP achieved the FOMC's goal to "put downward pressure on longer-term interest rates" (Gagnon et al., 2010; Krishnamurthy & Vissing-Jorgensen, 2011; Patrabansh et al., 2014), there is a debate whether the central bank has the ability to affect the pricing of mortgage-backed securities, in particular, MBS spreads (Stroebel & Taylor, 2012). The existing view in the economics literature is that the large scale asset purchases by central banks should have no effect on asset prices.[3] Wallace (1981) uses a Modigliani-Miller argument to show that the size and the composition of the central bank balance sheet do not have effect on the asset prices under the assumption that the assets are perfectly substitutable in terms of liquidity. Eggertsson and Woodward (2003) argue that any effect of unconventional monetary policy is due to changing the expectations

[3]See Kocherlakota (2012) discussion on quantitative easing, based on Wallace (1981) and Eggertsson and Woodward (2003).

regarding future interest-rate policy and "the shifts in the portfolio of the central bank could be of some value in making credible to the private sector the central bank's own commitment to a particular kind of future policy". However, a number of economists argued that the Fed's LSAP programs can work through two transmission channels: (1) a signaling channel, (2) a portfolio rebalancing channel (Hancock & Passmore, 2011, 2014; Krishnamurthy and Vissing-Jorgensen, 2013; Patrabansh et al., 2014).

Through the signaling channel, LSAP provide an indirect impact on asset prices by changing the expectations held by market participants about future short-term interest rates. Central bank asset purchases are interpreted by investors as signals regarding the central bank's intentions over the path of the short-term interest rate. Long-term asset purchases increase the credibility of the Fed's commitment to keep interest rates low (Krishnamurthy and Vissing-Jorgensen, 2011; Krishnamurthy and Vissing-Jorgensen, 2013). In case of the mortgage-backed securities (MBS) purchase program, the Federal Reserve's announcement signaled a strong and credible government backing for mortgage markets. The announcement of MBS purchase program changed the expectations by market participants about the re-establishment by the Fed of a functioning secondary mortgage market in which primary mortgage market originators will be able to finance their mortgages with certainty (Hancock and Passmore, 2011). This paper attempts to estimate whether MBS purchases impact MBS spreads beyond simply by moving investor expectations.

A portfolio rebalancing channel posits a direct impact of the Fed's purchases on asset prices (Bernanke, Reinhart, and Sack, 2004; Krishnamurthy and Vissing-Jorgensen, 2013; Hancock and Passmore, 2014; Patrabansh et al., 2014) and works as follows: (1) through the open market purchases of the longer-term assets, the Federal Reserve reduces the amount of securities held by the private sector while increasing the amount of short-term, risk - free, bank deposits held by the private sector; (2) the private sector investors hold more deposits than they desire because of selling their assets to the Fed; (3) the private sector investors desire to reduce their holdings of deposits and bid up the prices of the remaining longer-term

securities while lowering the yields of those securities.

The portfolio rebalancing effects of MBS purchases work through two narrow channels: capital constraints and scarcity channels (Krishnamurthy and Vissing-Jorgensen, 2013). According to the capital constraints channel, MBS purchases lower MBS risk premiums. By purchasing risky MBS, the Fed removes risk from the balance sheet of specialized investors and frees scarce capital. With less tight capital constraints, MBS investors bid more aggressively for MBS to meet their demands for duration and convexity by willing to accept less compensation for hedging the interest rate risks (duration component) and for hedging the prepayment risk (convexity component). The scarcity channel arises because of the heterogeneity in the characteristics of mortgage loans underlying mortgage-backed securities. The Fed has purchased MBS in the to-be-announced market, or TBA. In TBA trade, buyer purchases a contract to take delivery of securitized mortgage loans with general parameters, such as issuer, maturity, coupon, at a future date, say one month from today. The actual parameters of underlying loans will be learned by the buyer 48 hours prior to the settlement. The TBA structure offers the seller a "cheapest-to-deliver" option, that is, to deliver MBS securities that prepay most quickly. As the Fed purchases MBS in TBA market, the cheapest-to-deliver securities become scarce and more expensive securities are delivered, driving up the prices of TBA contracts. Additionally, the Fed's purchases have concentrated in the current-coupon or production-coupon MBS, whose coupons are near those of new mortgage loan originations. The shortage of the current-coupon MBS drives the current-coupon MBS yields down and induces banks to make new mortgage loans to ease the shortage of the production coupon MBS.

A question to what degree the decline in 10-year Treasury yields, agency MBS yields (and, thereby, mortgage rates) and mortgage interest rates spreads can be contributed to the LSAP by the Federal Reserve is very important for determining the ability of the cetral bank to conduct price-keeping operations and deciding on future uses of such programs as a tool of monetary policy. This study is unique and enhances the existing literature on the

empirical analysis of quantitative easing in that: (1) it estimates the impact of MBS purchase program's announcements and the change in size of the Fed's MBS holdings on MBS spreads rather than on MBS yields or mortgage rates; (2) it employs a dynamic multivariate time series modeling, specifically, vector autoregressive model with exogenous regressors (VARX), to capture the dynamic relationship between the variables that affect the secondary mortgage market spreads as well as the impact of the exogenous shocks such as the announcements of the quantitative easings programs on the MBS spreads over the most recent period from January 2007 to May 2016; (3) it provides a scenario analysis to assess the effect Fed's "exit strategy" of the normalization of its balance sheet by applying Kalman filtering technique on the state-space form of VARX model for conditional forecasting.

While Hancock & Passmore (2014) find that increase in the market share of the Federal Reserve MBS holdings contributes to the decline in MBS yields, even after accounting for changes in expectations about future rates by market participant, Stroebel & Taylor (2012) find no separate effect of the volume of Fed's MBS purchases on the mortgage spreads over the mere announcement or existence of the program. Stroebel & Taylor (2012) attribute a sizable portion of the decline in MBS spreads to the changes in the prepayment and default risks and small and uncertain portion to the MBS purchase program. The estimation strategies in existing literature with the exception of Patrabansh et al. (2014) have captured only contemporaneous relationships between the time series variables. Stroebel & Taylor (2012) try to estimate the quantitative impact of the Fed's MBS purchase program on mortgage spreads after controlling for prepayment and default risks that actually represent the mortgage spreads movements and find no evidence that the increase in the MBS purchases led to a reduction in mortgage interest rate spreads once the Fed's MBS purchase program dummy[4] is introduced.

By employing the VAR model, this paper tests the hypothesis that the Fed's MBS purchases impact not only the drivers of MBS spreads such as credit (default), prepayment and

[4]The program dummy is set to 1 starting with announcement of the Federal Reserve's MBS purchase program on November 25, 2008 (Stroebel & Taylor, 2012)

liquidity risks, but also MBS spreads directly through both signaling and portfolio rebalancing channels. Contrary to the results of Stroebel & Taylor (2012), the estimation results of this paper indicate that the Federal Reserve's MBS purchase program has effect on the mortgage spreads through both signaling and portfolio rebalancing channels. The study finds that not only the announcements of the first and the third rounds of "quantitative easing", QE1 and QE3, but also the increase in the size of the Federal Reserve's MBS holdings have negative impact on MBS spreads. QE1 and QE3 announcements, representing a signaling channel, reduced mortgage spreads by about 45 bps and 50 bps, respectively. Also the current coupon spreads were on average 50 bps lower after the start of the program compare to the average level before the start of the program since January 2007. Through portfolio rebalancing channel, the reduction in the public supply of the riskier long-term assets via the Fed's MBS purchases reduces the risk premium (MBS spreads) required to hold them. The Fed's MBS purchases reduces the amount of prepayment risk that investors have to hold in the aggregate, leading to the reduction in extra return (MBS spread) that investors typically demand to bear the negative convexity risk. By providing an ongoing source of demand for agency MBS, the Fed's MBS purchase program allows dealers and other investors to take larger positions in these securities, knowing that they could sell them if needed to the Federal Reserve and to accept lower liquidity risk premium embedded in MBS spreads. Using impulse response analysis for VAR model the paper finds that a one standard deviation ($20 billions of dollars) shock to the change in Fed's MBS holdings results in decline of the current coupon MBS spread by 2.5 bps in 6 months. Based on the estimation results this study concludes that the Federal Reserve's MBS purchase program was successful at lowering mortgage-backed securities spreads, supporting mortgage markets and financial markets, more generally. However, to assess whether unconventional monetary policy actions such as the Federal Reserve's MBS purchases are reaching economy and stimulating economic activity, a research on the business cycle implications of mortgage spreads would be a next step.

Now that QE is completed, the attention has turned to the Fed's "exit strategy". While it is not clear when the Fed will let the MBS holdings run-off or will liquidate them if it decides to do so, this paper discusses the effects of "tapering" of Fed's reinvestments on the mortgage spreads by running a scenario analysis using the conditional forecasting based on Kalman filtering technique applied to the state-space form of VARX model. The "tapering" of the Fed's MBS purchase program can be viewed as 1) reduction in the pace of purchases resulting in an end to the program at the future date, 2) liquidation of the Fed's holdings. Since the QE purchases ended in October 31, 2014, the scenario of the "tapering" of the Fed's MBS purchase program is run by liquidation of the Fed's holdings via ceasing the Fed's reinvestments of principal payments in agency mortgage-backed securities[5]. The paper finds that the unanticipated announcement about tapering in May 2013 had only small effect on mortgage spreads and the tapering announcement of December 2013 had no effect on the mortgage spreads because, by that time, the market had already adjusted in responses to earlier unanticipated announcement about tapering in May 2013. It is expected that future tapering announcements are unlikely to significantly affect mortgage spreads unless such announcements are highly unanticipated and the "exit strategy" for the MBS purchase program will impact MBS spreads via portfolio rebalancing channel. The scenario analysis results suggest that by letting the Fed's MBS portfolio holdings to decline by $40 billions per month for the next 12 months starting June 2016, the current coupon MBS spread will increase by 10 bps in 12 months. The conclusion that the winding down of LSAPs need not cause a large rise in MBS spreads as long as the completion of reinvestments is announced well in advance is consistent with conclusion in Gagnon et al. (2010).

The remainder of the paper is organized as follows. Section 3 gives a literature review. Section 4 describes the five main phases of the LSAP program. Section 5 discusses the drivers of the mortgage-backed securities spreads. Section 6 describes the data used in this

[5] "Each month, the System Open Market Account (SOMA) portfolio receives sizable principal payments on its securities holdings, which, if not reinvested, would decrease the size of the SOMA portfolio. Reinvestment, by keeping the Committees holdings of longer-term securities at sizable levels, should help maintain accommodative financial conditions". `https://www.newyorkfed.org/markets/ambs-treasury-faq.html`

study. Section 7 gives the description of the empirical methodology including structural VARX analysis and conditional forecasting using Kalman filtering technique in the state-space model framework and presents the main results. Section 8 provides a number of robustness checks. Section 9 concludes the paper with final remarks and discussion on the future research.

3.3 Literature Review

A sizable and growing literature has empirically studied the effects of unconventional monetary policy on the long-term interest rates or other asset prices. This literature review is based on and supplements many previous surveys of the empirical literature on the effects of U.S. unconventional monetary policy on the financial markets including Williams (2014), Fischer (2015), Gagnon (2016), Bhattarai and Neely (2016), Borio and Zabai (2016).

The two most common approaches to assess the impact of unconventional monetary policy on the interest rates are event studies using high-frequency data and time series models of interest rate risk premiums. A typical event study examines changes in bond yields over a one- or two-day window around which the policies are announced. The estimated effects are heavily influenced by the individual observations/dates included as well as the length of the event window. The time series method uses the entire time path of interest rates and asset quantities, rather than relying on certain dates, and makes possible to estimate the yield change for a given $100 billion in asset purchases.

Event studies

Bernanke, Reinhart, and Sack (2004) examine specific news events concerning future Treasury issuance or purchases of longer-term securities and find that longer-term yields declined on days in which the Federal Reserve announced the future declines in the net supply of longer-term Treasury securities. The paper provides an evidence that the changes in the relative supplies of securities matter for yields in the United States. Gagnon et al.

(2011) use an event study analysis of Federal Reserve communications to derive estimates of the effects of LSAPs during QE1 period on the two-year and ten-year Treasury yields, the ten-year agency debt yield, the current-coupon thirty-year agency MBS yield. The authors also include in the study the ten-year swap rate and the Baa corporate bond index yield to understand the extent to which news about LSAPs affected yields on assets that were not purchased by the Federal reserve. QE1 was announced in November 2008. The program entailed the purchase of $172 billion of Agency debt, $1,250 billion of Agency MBSs and $300 billion of longer-term Treasury securities. The paper concludes that the Fed's purchases caused economically meaningful and long-lasting reduction in longer-term private borrowing rates, with the most pronounced impact in the mortgage market. After LSAP announcement on November 25, 2008, the ten-year Treasury yield, ten-year agency debt yield, and current-coupon agency MBS yield declined 22, 58, and 44 basis points, respectively. Cumulatively, the ten-year Treasury yield, ten-year agency debt yield, and current-coupon agency MBS yield declined 91, 156, and 113 basis points, respectively, during QE1 period. Gagnon et al. (2011) show that these reductions in interest rates reflect lower risk premiums rather than lower expectations of future short-term interest rates. In other words, the primary channel through which QE1 impacted the interest rate rates is the risk premium on the asset being purchased, by bidding up the price of the asset being purchased and thus lowering its yield, so called "portfolio balance" channel. (Tobin, 1958, 1969).

Krishnamurthy and Vissing-Jorgensen (2011) using an event-study methodology evaluate the effect of QE1 and QE2 on the interest rates. Their analysis shows that it is inappropriate to focus only on Treasury rates as a policy target because QE works through several channels to affect specific asset differently, and effects on the assets depend on which assets are purchased. One of their main findings is that the large reductions in mortgage rates after QE1 can be attributed to the large purchases of agency MBS, hence, reduced price of mortgage-specific risk. For QE2, which involved only Treasury purchases, they find a substantial impact on Treasury rates, but almost no impact on MBS rates. Krishnamurthy and Vissing-

Jorgensen (2011) find that the QE1 announcement had cumulative negative effect on long-term interest rates: approximately 100 basis points for the ten-year Treasury yield, 200 basis points for agency issues and 90 basis points for agency MBS yield. The estimated two-day effects of QE2 announcements are approximately 30 basis points for Treasuries and agency issues and 10 basis points for MBS yields.

The event study in Patrabansh et al. (2014) suggests that on days when a major LSPA announcement was unexpected, it had a dramatic effect on the 10-year U.S. Treasury yield. After LSAP announcement on November 25, 2008, the ten-year Treasury yield declined by 22 bps. The effect of a LSAP announcement on the 10-year Treasury yield was smaller in QE2 and QE3 compare to QE1 due to the fact that after "unprecedented" QE1 policies the market became more adept at anticipating Fed's decisions and with the introduction of forward guidance policy market has become better at using macroeconomic data to anticipate Fed's actions.

Time Series Studies

While the event studies on the impact of unconventional monetary policies on the financial markets including mortgage markets are vast, the time series studies concentrate mostly on the long-term interest rates or term premium with a few papers focusing on the mortgage markets. Williams (2014) and Gagnon (2016) provide the summary of the estimated LSAP effects on long-term interest rates and/or term premium from the literature. Based on the median of the estimates from the literature, QE programs reduced the 10-year yield by about 120 bps. Only a few papers, by Hancock and Passmore (2011, 2014), Stroebel & Taylor (2012) and Patrabansh (2014), employed regression and time series approach to examine the impact of the Fed's MBS purchase program on the mortgage market variables.

Stroebel & Taylor (2012) examine the effect of the MBS purchase program using weekly data between 2007 and June 2010 on the following mortgage interest rate spreads: swap - OAS, spread of MBS yield over swap rates, Treasury OAS, and a spread of MBS yield over Treasury yield. The option-adjusted spread (OAS) is the additional yield over the LIBOR

yield curve that an MBS investor would receive, after adjusting for the prepayment risk to which the MBS investor is subject to. The OAS spread is the compensation for bearing normal duration risk and the default risk associated with the MBS. Stroebel & Taylor (2012) use the linear regression approach with contemporaneous relationships between the variables. The authors regressed OAS on the bond-spread variables to control for default risk and on the MBS purchasing program variables such as the cumulative total MBS purchases and dummy variables for the announcement or start of the program. Stroebel & Taylor (2012) find that a sizable portion of the decline in mortgage spreads attributable to the decline in factors which were responsible for the rise of spreads between 2007 and late 2008, prepayment and default risks, with small and uncertain portion attributable to the MBS purchase program. In the specifications, where program announcements appear to lower spreads, they find no separate effect of the stock of MBS purchased by the Federal Reserve. Given that the authors interpret the positive or insignificant coefficients on the total MBS Purchases held by the Federal Reserve variable, which is very persistent and can lead to the spurious results, as indicating that program has no effect on OAS, the results of their research should be considered with caution. In addition, the authors do not take into account the lagged impact of the MBS purchases on the risk drivers of the mortgage spreads. In this research, we show that the Federal Reserve's MBS Purchase program has effect on the mortgage spreads through both signaling and portfolio rebalancing channels using time series approach.

Hancock and Passmore (2011) examine whether the MBS purchase program lowered mortgage rates, and conclude that the Federal Reserve's MBS purchase program over the course of 16 months reestablished normal market pricing in the MBS market and resulted in lower mortgage rates of approximately 100 to 150 basis points. Using time series regression approach the authors show that around half of the declines were associated with improved market functioning and about half with the portfolio rebalancing effect, that is declines in risk premiums that were associated with changes in the compensation for holding fixed-rate financial assets over a long period.

Hancock and Passmore (2014) continue to investigate the role of the portfolio rebalancing channel by adding the Fed's market share of agency MBS variable and the dummy variables on the QE announcements to the MBS Yield regression using weekly data from July, 2000 to June, 2013. The Fed's market share variable was significant determinant of MBS yields even after accounting for the changes in the expectations about future rates by market participants representing the signaling channel. Their estimates also suggest that the Federal Reserve must hold a substantial market share of Agency MBS or of Treasury securities to significantly lower MBS yields and mortgage rates.

Patrabansh et al. (2014) estimate the effects of the Fed's monetary policy approach first on long-term interest rates and then on mortgage rates. The dynamic approach - specifically vector autoregression - enhances the existing literature as the dynamic relationship between long-term interest rates, mortgage rates and cumulative LSAP purchase amounts provides the insights how the LSAP program can impact current and future markets. Patrabansh et al. (2014) find a 10 basis point shock to the 10-year Treasury yield could increase the 30-year fixed rate mortgage rate by approximately 75 basis points over a quarter. The results from their event study were used to inform the ranges of shocks on the 10-year Treasury note from the LSAP program.

This chapter enhances the existing time series studies of the impact of the Fed's MBS purchase program on the mortgage market variables. The study is unique as it estimates the impact of MBS purchase program's announcements and the change in size of the Fed's MBS holdings on MBS spreads rather than on MBS yields or mortgage rates and it employs a dynamic multivariate time series modeling, specifically, vector autoregressive model with exogenous regressors VARX to capture the dynamic relationship between the variables that drive the secondary mortgage market spreads as well as the impact of the exogenous shocks such as the announcement of the quantitative easing programs on the MBS spreads.

3.4 Mortgage-Backed Securities Purchase Program as a Part of Large-Scale Asset Purchases Program

Over eight years, the LSAP program has undergone several phases. Between 2008 and 2014, the Fed performed three rounds of QE, buying long-term U.S. Treasury securities, agency debt from Fannie Mae (FNMA), Freddie Mac (FHLMC) and the Federal Home Loan Banks (FHLB) and agency mortgage-backed securities (MBS) backed by government-sponsored enterprises (GSE) and Ginnie Mae.

QE1

The first round of "quantitative easing", QE1, was announced on November 25, 2008. Federal Reserve Board announces its intention to purchase up to $100 billion in GSE (Fannie Mae, Freddie Mac) direct obligations and up to $500 billion in GSE-issued MBS. The goal of the QE1 was " to reduce the cost and increase the availability of credit for the purchase of houses, which in turn should support housing markets and foster improved conditions in financial markets more generally"[6]. On March 18, 2009 FOMC (Federal Open Market Committee) expands its asset purchases to a total of $1.25 trillion in purchases of agency MBS, $200 billion in GSE debt, and up to $300 billion of longer-term Treasury securities[7]. Through the signaling and the portfolio rebalancing effect, the QE1 program was expected to reduce long-term interest rates and, particularly, mortgage rates. The purchases on agency debt and MBS were completed on March 31, 2010.

On August 10, 2010 FOMC states that "to help support the economic recovery in a context of price stability, the Committee will keep constant the Federal Reserve's holdings of securities at their current level by reinvesting principal payments from agency debt and agency mortgage-backed securities in longer-term Treasury securities" and " will continue to

[6]Monetary Policy Press Release as of November 25, 2008 `http://www.federalreserve.gov/newsevents/press/monetary/20081125b.htm`

[7]See Patrabansh, Doerner, Asin (2014) for details of QE phases.

roll over the Federal Reserve's holdings of Treasury securities as they mature"[8].

QE2

The second round of "quantitative easing", QE2, was announced on November 3, 2010 and ended on June 30, 2011. During this period, the Fed purchased only U.S. Treasury securities, a total of $600 billion of U.S. Treasury securities. The goal of QE2 was "to promote a stronger pace of economic recovery and to help ensure that inflation, over time, is at levels consistent with its mandate[9]". Also the Fed continued the existing policy of reinvesting principal payments from its securities holdings in the longer-term Treasury securities and let the MBS portfolio run-off.

Operation Twist

Operation Twist ("OT"), also called the Maturity Extension Program ("MEP"), was announced on September 21, 2011 and ended in December 30, 2012. During this phase "to support a stronger economic recovery and to help ensure that inflation, over time, is at levels consistent with the dual mandate, the Committee decided . . . to extend the average maturity of its holdings of securities[10]". FOMC also announced that "to help support conditions in mortgage markets, the Committee will now reinvest principal payments from its holdings of agency debt and agency mortgage-backed securities in agency mortgage-backed securities", rather than into longer-term Treasury securities, and "will maintain its existing policy of rolling over maturing Treasury securities at auction". During the OT, the Fed purchased $667 billion of U.S. Treasury securities with maturities of 6 to 30 years and sold $667 billion of U.S. Treasury securities with maturities of three months to three years.

[8]Minutes of the FOMC as of August 10, 2010 `http://www.federalreserve.gov/monetarypolicy/fomcminutes20100810.htm`

[9]Monetary Policy Press Release as of November 3, 2010 `http://www.federalreserve.gov/newsevents/press/monetary/20101103a.htm`

[10]Monetary Policy Press Release as of September 21, 2011 `http://www.federalreserve.gov/newsevents/press/monetary/20110921a.htm`

QE3

The third round of "quantitative easing", QE3, was announced on September 13, 2012 and ended in October 31, 2014. Concerned with weak economic growth and anticipated midterm inflation running below 2 percent objective, the Committee agreed "to increase policy accommodation by purchasing additional agency mortgage-backed securities at a pace of $40 billion per month"[11]. Also the Committee continued through the end of the year "to extend the average maturity of its holdings of securities" as announced before and maintained "its existing policy of reinvesting principal payments from its holdings of agency debt and agency mortgage-backed securities in agency mortgage-backed securities". With the goal of supporting a stronger economic recovery and ensuring that inflation, over time, is at the rate most consistent with its dual mandate, the Fed's actions should have put the downward pressure on longer-term interest rates, supported mortgage markets, and helped to make broader financial conditions more accommodative. During QE3, the Fed purchased $823 billion of agency MBS and $790 billion of U.S. Treasury securities.

Tapering and Exit Strategy

During QE3, the Fed was reducing the pace of its asset purchases until it concluded them on October 31, 2014. On May 1, 2013 during FOMC meeting, the Committee mentioned that it "is prepared to increase or reduce the pace of its purchases to maintain appropriate policy accommodation as the outlook for the labor market or inflation changes"[12]. From May 1, 2013 until December 18, 2013, after the FOMC's announcement, the financial markets were in the period of, so called, "taper tantrum", which was driven by fears of the Fed's tapering. The panic spread in bond markets all over the world with the 10-year U.S. Treasury yield gained 120 basis points between May and December of 2013, which led to the increase

[11]Monetary Policy Press Release as of September 13, 2012 http://www.federalreserve.gov/newsevents/press/monetary/20120913a.htm

[12]Monetary Policy Press Release as of May 1, 2013 http://www.federalreserve.gov/newsevents/press/monetary/20130501a.htm

in government bond yields in Germany and Japan after the global bond market selloff. On December 18, 2013, the Fed announced it would reduce its monthly rate of purchase of agency MBS from $40 billion to $35 billion and its monthly rate of purchase of U.S. Treasury securities from $45 billion to $40 billion in January 2014. In the next few months in 2014, the Fed continued to taper its purchases gradually over time as economic conditions improved, particularly in labor market.

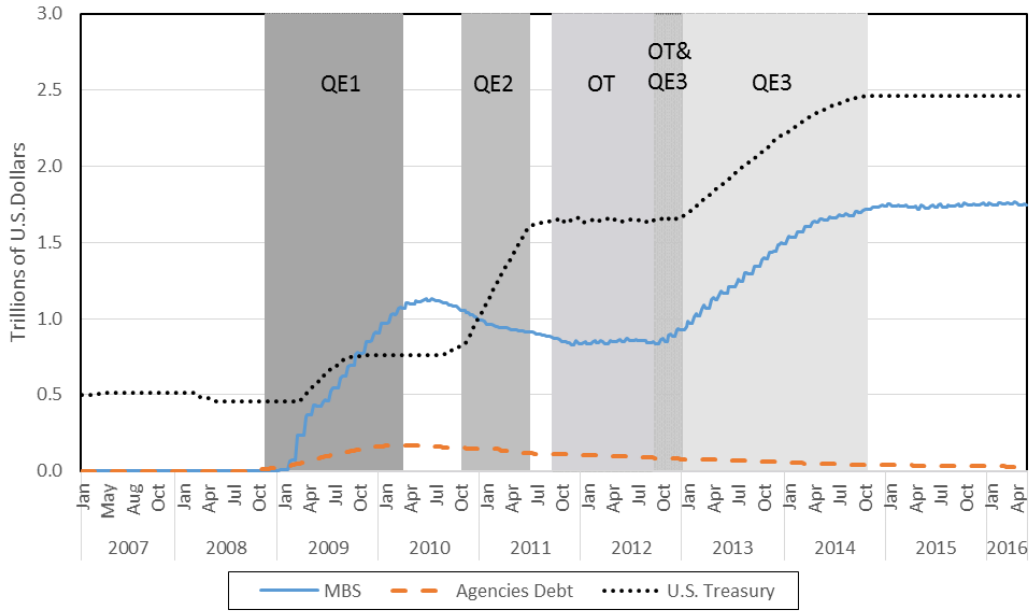
Figure 3.2 presents the Fed's holdings of dollar-denominated assets acquired via open market operations since the beginning of LSAP program on a weekly basis. The Fed's balance sheet increased over three phases of "quantitative easing", QE1, QE2 and QE3 and stayed relatively stable ('flat') during the "Operation Twist" and after the end of QE3 phase. Since the end of QE3 phase, the FOMC Committee maintains "its existing policy of reinvesting principal payments from its holdings of agency debt and agency mortgage-backed securities in agency mortgage-backed securities and of rolling over maturing Treasury securities at auction" and it "anticipates doing so until normalization of the level of the federal funds rate is well under way"[13]. "This policy, by keeping the Committee's holdings of longer-term securities at sizable levels, should help maintain accommodative financial conditions". As of May 25, 2015 the Fed held $2.46 trillion in U.S. Treasury securities, $1.7 trillion in agency MBS and $25.1 billion in agency debt.

Now that QE is completed, the attention has turned to the Fed's "exit strategy". In September 17, 2014 the Fed issues FOMC statement on policy normalization principles and plan. "The Committee intends to reduce the Federal Reserve's securities holdings in a gradual and predictable manner primarily by ceasing to reinvest repayments of principal on securities held in the SOMA" after it begins increasing the target range for the federal funds rate [14]. In its statement, the Fed ruled out MBS sales as a part of normalization process, although "limited sales might be warranted in the longer run to reduce or eliminate residual

[13]Monetary Policy Press Release as of July 27, 2016 `http://www.federalreserve.gov/newsevents/press/monetary/20160727a.htm`

[14]Monetary Policy Press Release as of September 17, 2014 `http://www.federalreserve.gov/newsevents/press/monetary/20140917c.htm`

Figure 3.2: The Federal Reserve's Cumulative Asset Holdings from LSAP Program



Source: The Federal Reserve of New York, SOMA

holdings". The Fed promised to communicate in advance to the public the timing and pace of any sales. While it is not clear when the Fed will let the MBS and other asset holdings run-off or will liquidate them if it decides to do so, this paper discusses the effects of possible reduction in the Fed's MBS holdings on the mortgage spread.

3.5 Mortgage-Backed Securities Spreads Drivers

In the primary mortgage market, lenders make loans to borrowers at a certain interest rate, called mortgage rate, whereas in the secondary market, lenders securitize these loans into MBS and sell them to investors. The principal and interest payments on Agency MBS are passed through to investors and are guaranteed by the GSEs Fannie Mae or Freddie Mac or by the government organization Ginnie Mae, which charge a fee to provide this credit wrap. This paper examines the impact of MBS purchase program on the secondary mortgage market spreads. The secondary mortgage market is the important source of U.S. home mortgage credit. With banks being the only source of funds for mortgage borrowers, primary

mortgage rates would have been much higher. With a goal of lowering mortgage rates, while U.S. Treasury securities purchases are expected to put downward pressure on long-term U.S. Treasury rates, MBS purchase program intended to reduce secondary mortgage market spreads. If the MBS Purchase program also lowered Treasury rates, then the effects of the program on mortgage rates could be larger. However, the goal of the paper is to investigate the primary channel through which MBS Purchase program effects mortgage rates by narrowing the risk premiums on the assets being purchased. The estimation of the spillover effects of the program to the other assets that are similar in nature is beyond the scope of the paper.

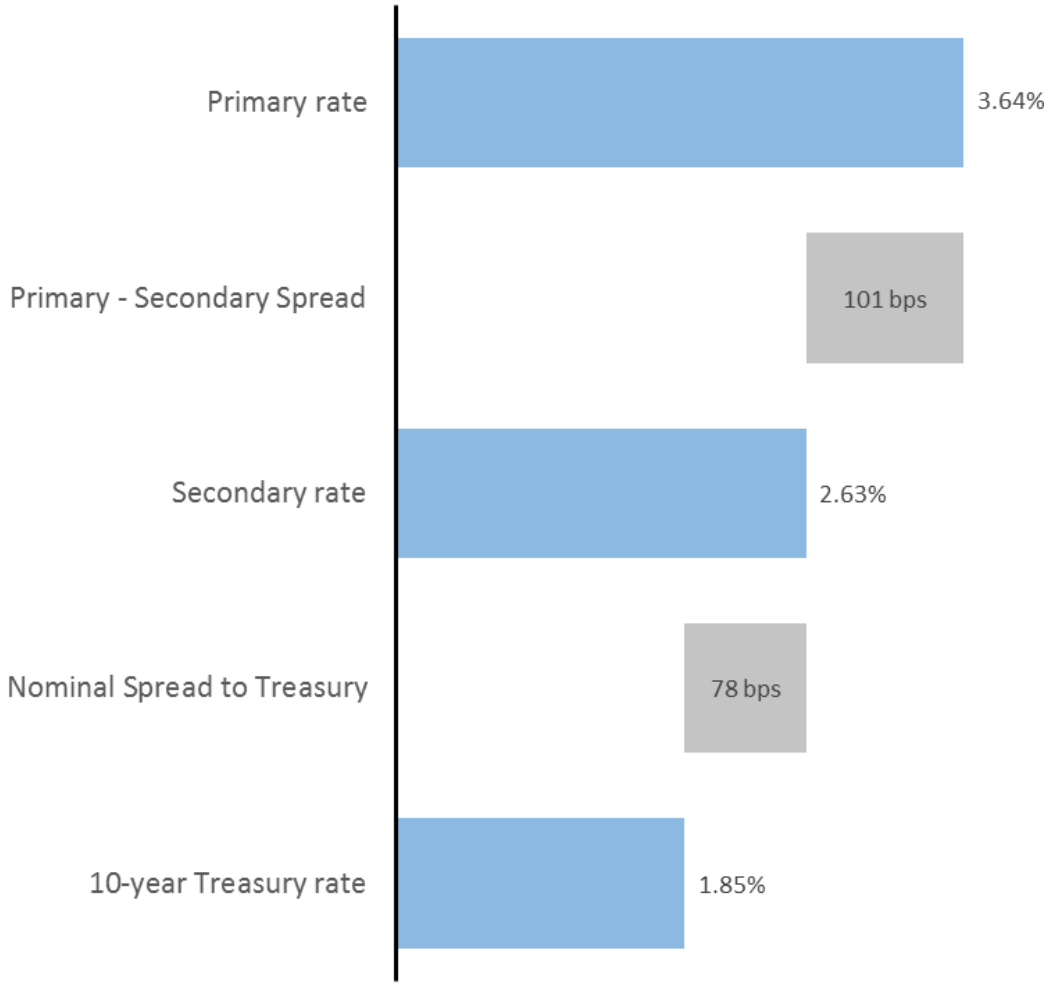
Figure 3.3 shows the composition of primary mortgage rates. The primary-secondary mortgage rate spread is calculated as a difference between 30-year primary mortgage market rate and 30-year FNMA current-coupon yield. This spread is a measure of the pass-through between secondary-market valuations and primary-borrowing costs. It is useful to assess whether unconventional monetary policy actions are reaching the real economy. A widening primary-secondary spread suggests that MBS purchases are not fully reaching borrowers. The pre-crisis level of primary-secondary spread averages around 50 basis points. Since the start of MBS purchase program this spread is averaged at about 90 basis points reaching the level of 101 basis points on May 25, 2016. The primary-secondary spread reflects the GSEs' guarantee fees ("g-fees") and mortgage originator's margins which both recently increased. In this paper we do not study what drives the changes in evolution of "g-fees" and originator margin but rather focus on studying the drivers of secondary mortgage market spreads.

The nominal spread, or secondary mortgage market spreads, is calculated as a difference between the MBS cash flow yield[15] and the yield on the comparable Treasury security[16]. "Comparable" is a Treasury security with the same maturity as the average life of the

[15]The MBS cash flow yield is the interest rate that makes the present value of the expected cash flow (under the certain assumption on the prepayment speed) equal to its market price plus accrued interest. It is converted to a semi-annual bond equivalent yield since MBS pay monthly.

[16]The average life of MBS is the average time to receipt of principal payments (scheduled principal payments and projected prepayments), weighted by the amount of principal expected.

Figure 3.3: Primary Rate Components as of May 25, 2016



mortgage-backed security. As a MBS cash flow yield, the current coupon yield on 30-year Fannie is used. This is the hypothetical coupon associated with an MBS pool that trades at par value[17]. Typically, the current coupon is calculated by interpolating between the coupons that trade above and below par. However, the past downward general trend in interest rates led to the many periods when there were no MBS securities traded below par. In past periods of low rate, the practice would be to extrapolate to par from the existing coupons.

The nominal spread measures the compensation for the credit risk, option (prepayment) risk, and liquidity risk an investor is exposed to by investing in a non-Treasury security rather than a Treasury security with the same maturity (Fabozzi, 2004). Thus, the option (prepayment) risk, credit (default) risk and liquidity risk are the key determinants of the secondary mortgage market spreads over the risk-free rate.

Stroebel & Taylor (2012) try to estimate the quantitative impact of the Fed's MBS purchase program on mortgage spreads after controlling for prepayment and default risk that actually represent the mortgage spreads movements and find no evidence that the increase in the MBS purchases led to a reduction in mortgage interest rate spreads once the Fed's MBS purchase program dummy[18] is introduced. On the contrast, this paper directly estimates the quantitative impact of the Fed's MBS purchase program on the determinants of the mortgage interest rate spreads and finds the additional impact of the actual volume of purchases which operates through portfolio rebalancing effect. The paper also finds the separate effect of the program's announcements on the mortgage spreads which operates through signaling channel.

[17]The MBS trades at a price of $100 dollars for $100 of mortgages in the pool.

[18]The program dummy is set to 1 starting with announcement of the Federal Reserve's MBS purchase program on November 25, 2008 (Stroebel& Taylor, 2012).

Credit (Default) Risk

In agency MBS, the risk of default of the underlying mortgages is not borne by investors but by the agencies that guarantee timely repayment of principal and interest. Hence, the default risk of agency MBS is related to the potential of insuring agency being unable to meet its guarantee obligations when borrower defaults on its mortgage obligation by stopping the monthly payments due on the underlying mortgage. While Ginnie Mae securities are backed by the full faith and credit of the US federal government and are generally perceived as being free of credit risk, Fannie Mae and Freddie Mac securities have only implicit U.S. government guarantees and more complex assessment of their credit risk. Besides the actions of the government to explicitly guarantee the timely payments on agency MBS, the ability to fulfill the insurance pledge by the agencies can be measured by the health of the housing market (Stroebel & Taylor, 2012). We use the growth in the S&P/Case-Shiller U.S. National Home Price Index as a proxy for the credit risk. A large decline in the home price index should indicate a higher degree of mortgage default risk. Depending on the original loan-to-value ratio, falling home prices can push borrowers into negative home equity increasing the risk of default on their mortgage obligations[19].

Liquidity Risk

The US agency MBS market is one of the most liquid fixed-income markets in the world, behind only the US Treasury market, with approximately $5.9 trillion in securities outstanding as of the second quarter of 2016[20]. More than 90 percent of agency MBS trading volume occurs in the to-be-announced (TBA) market (Vickery and Wright, 2013). The TBA market is a forward-settling market. Sellers and buyers agree to a sale price, par amount, coupon, agency, term and settlement date without identifying the specific pool numbers on the trade

[19] "Negative equity is a necessary but not sufficient condition for default. A borrower might continue making payments even with negative equity if they did not want to lose their homes, or held the view that in the long term home prices would begin increasing again, or out of fear of bad credit rating"(Hayre, 2001).

[20] Sifma

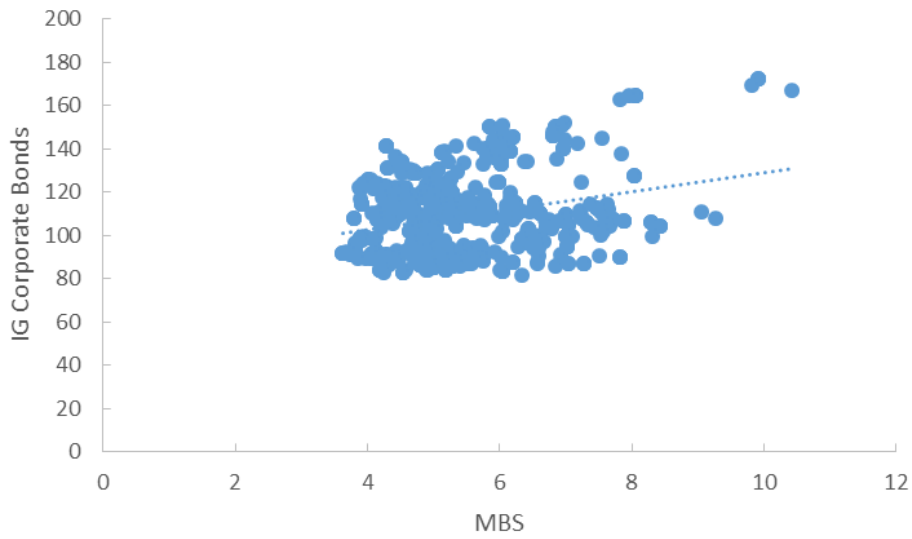
date. The detailed pool characteristics are not known until two days prior to settlement date. The TBA market enhances the liquidity by homogenizing mortgage pools. The presence of implicit or explicit government credit guarantee, the sheer aggregate size and the homogenous nature of agency MBS market contribute significantly to liquidity. Many MBS investors hold MBS as a liquid investment which can be quickly converted to cash at low transaction costs when the need arises while earning a positive rate of return. The MBS market was historically very liquid because participants were able to trade large volumes of securities relatively easily and quickly without incurring large transaction costs. Two common measures of market liquidity that are used by practitioners are transaction volume and bid-ask spread[21] (Campbell, Li and Im, 2014). Typically, the higher transaction volume of the asset is, the more liquid asset is. The higher bid-ask spread represents a less liquid market. Unfortunately, the data on the size and price of MBS transactions have become available from the TRACE reporting system[22] only in May 2011. Because of the lack of data availability, we will use the spread for Aaa-rated corporate bonds as a proxy for liquidity on the investment grade fixed income market. Longstaff, Mithal, and Neis (2005) estimate that "non-default component" accounts for about 50% of the spread between the yields of Aaa/Aa-rated corporate bonds and Treasuries. Furthermore, Longstaff, Mithal, and Neis (2005) find that "non-default component"of credit spreads are strongly related to measures of bond liquidity such as the size of the bid-ask spread and the principal amount outstanding[23]. Morever, we find a positive relationship between the bid-ask spread for a typical investment grade U.S. Corporate bond and the average bid-ask spread on MBS using data since 2011 which is depicted in Figure 3.4. Hence, we expect the Aaa corporate spread to pick some liquidity risk for MBS.

[21]Transaction volume measures the total value of purchases (or sales) over a given point in time. The bid-ask spread measures the round trip transaction cost of buying and selling an asset. The difference between the ask price (price to buyers) and the bid price (paid to sellers) is called the bid-ask spread.

[22]The Financial Industry Regulatory Authority's (FINRA) TRACE system was developed in 2002 to provide data on the size and price of corporate bond transactions that are conducted by FINRA registered securities dealers.

[23]Longstaff, Mithal, and Neis (2005) did not have access to the transaction volume data.

Figure 3.4: Scatter Plot of Daily Bid-Ask Spreads (bps) for Investment Grade (IG) Corporate Bonds and MBS for the Period from May 2011 to January 2014.



Source: TRACE, Federal Reserve. MBS - daily weighted averages of closest-in-execution effective bid-ask spread of 3.0%, 3.5% and 4.0% coupon, 30-year, TBA MBS issued by FNMA; IG Corporate Bonds - daily effective bid-ask spread of all investment grade corporate bonds.

Prepayment Risk

A distinct feature of MBS is the embedded prepayment option: individual borrowers can prepay their loan balance in full or in part at any time prior its maturity, without paying a fee. The investor does not know what the monthly prepayments will be when purchasing a mortgage-backed security. Actual prepayments will usually differ from prepayments that were assumed at the time of purchase. A fall in interest rates will give the borrower an incentive to prepay the loan and refinance the debt at a lower rate. This causes investors to have their principal returned sooner and requires them to reinvest the cash flow at a lower rate, hence, terminates the investors' source of above-market returns. This adverse consequence of declining interest rates is referred to as contraction risk. A rise in interest rates will tend to slow down the rate of prepayment. This causes investors to have their principal returned later than expected and to be not able to reinvest the prepayments at a

higher rate. This adverse consequence of rising interest rates is referred as extension risk. Therefore, the prepayment risk of holding MBS encompasses contraction risk and extension risk.

Since nominal spreads on MBS compensates for the embedded prepayment optionality, we include the factor that represents the option value in MBS spreads. The volatility of interest rates should be considered, as their volatility will affect the possibility of the option being exercised. CBOE/CBOT 10-year U.S. Treasury Note Volatility Index, the TYVIX index [24] measures the expected volatility of the interest rate market. "The more uncertainty there is around changes to interest rates, the higher the TYVIX index tends to be"[25]. The TYVIX exhibits upward spikes when 10-year Treasury note and futures prices experience large swings, especially on large downswings[26]. "TYVIX surges when yields experience large falls, possibly driven by a common fear that a fall in long-term yields might reflect bad times to come, which policy makers may have to handle in future cuts" (Mele and Obayashi, 2015). As a proxy for interest rate volatility we use again the Moody's Aaa-rated corporate bond spread. By referring to Figure 3.5 there is a positive correlation between the TYVIX index and Aaa-rated corporate bond spread. Hence, we expect the Aaa corporate spread to pick some prepayment risk for MBS spreads.

3.6 Data

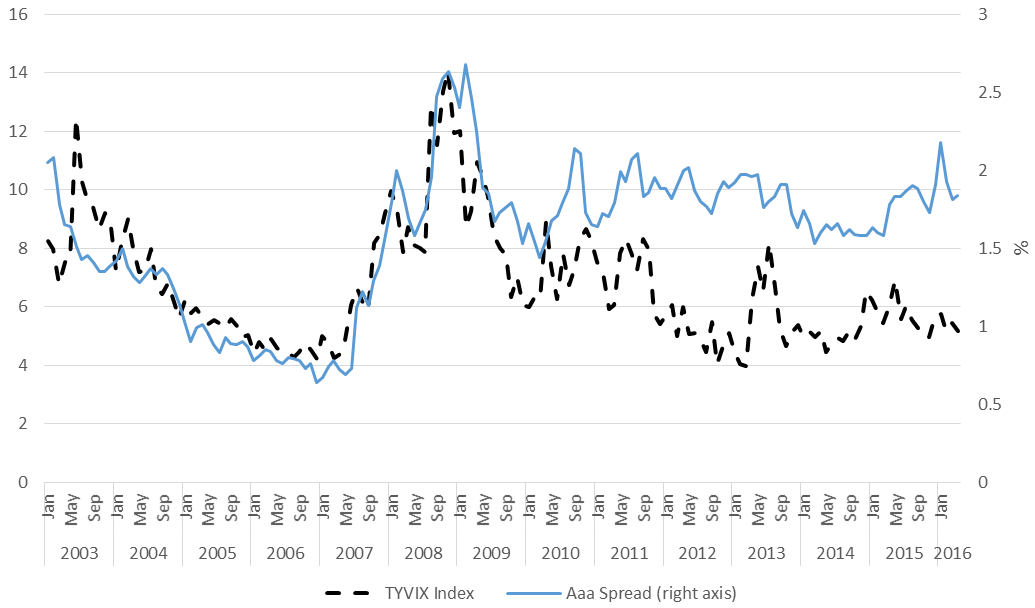
The current study concentrates on the period from January 2007 to May 2016. The weekly Fed's Agency MBS holdings are obtained from System Open Market Account, managed by the Federal Reserve Bank of New York, which contains dollar-denominated assets ac-

[24]The TYVIX index measures a 30-day expected volatility of 10-year Treasury Note futures prices, and is calculated based on transparent pricing from CBOT's actively traded options on the T-Note futures.

[25]The TYVIX Index: Navigating through interest rate volatility, Hedge week Special Report, September 2015.

[26]Due to this dynamic, futures on the TYVIX could provide a hedging mechanism for core instruments of the U.S. fixed income market such as mortgage backed securities, and corporate, municipal and government bonds. http://www.cboe.com/micro/volatility/tyvix/default.aspx

Figure 3.5: TYVIX and Aaa-rated Corporate Spread.



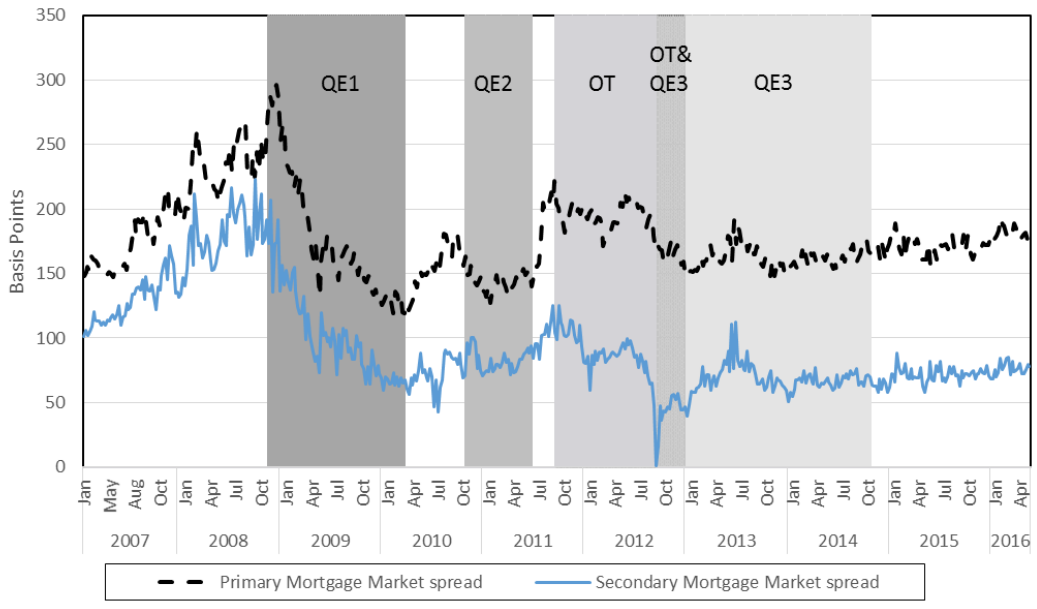
Source: CBOE, Moody's.

quired via open market operations[27]. Figure 3.2 displays SOMA holdings including Agency MBS. The average 30-year primary mortgage market rate series come from Freddie Mac's Primary Mortgage Market Survey, which surveys weekly about 125 lenders with the mix of lender types roughly proportional to the level of mortgage business that each type commands nationwide[28]. The secondary mortgage market rate which is obtained from Bloomberg at weekly frequency is a representative yield on newly issued Fannie Mae 30-year MBS - the "current-coupon yield"[29]. The primary and secondary mortgage market spreads are calculated by subtracting the yield on 10-year U.S. Treasury note from the corresponding mortgage market rates. The maturity difference between U.S. Treasury rate and mortgage rates is explained by the fact that the most of mortgages are prepaid before their maturity. Figure 3.6 shows both primary and secondary mortgage market rate spreads. Once can observe, that mortgage spreads over U.S. Treasury yield sharply declined after announcement of QE1 and

[27] `https://www.newyorkfed.org/markets/soma/sysopen_accholdings.html`
[28] `http://www.freddiemac.com/pmms/pmms_archives.html`
[29] `Source:BloombergIndexMTGEFNCL`

QE3 programs in November 2008 and in September 2012, respectively, and sharply increased to the level of 111 basis points after Federal Reserve Chairman Ben Bernanke discusses the tapering of bond-buying program in June 2013 in the news conference after the FOMC meeting. By the end of QE3 program in October 2014 the secondary spreads normalized around 70 basis points, the level that is lower than the pre-crisis level of 125 basis points. Since late 2014, the primary mortgage spreads averaged around 170 basis points, the level that is higher than the pre-crisis level of 150 basis points. This paper examines the impact of MBS purchase program on the secondary mortgage market spreads. The monthly time series for the 10-year Treasury yield, S&P/Case-Shiller U.S. National Home Price Index and Moody's Seasoned Aaa corporate bond spreads over 10-year Treasury yield come from Federal Reserve Bank of St.Louis website. The analysis is performed on the data at monthly frequency due to the absence data on home prices at higher frequency.

Figure 3.6: Mortgage Spreads



Source: Bloomberg

3.7 Empirical Methodology and Results

The goal of this section is to develop an empirical approach to estimate the impact the Federal Reserve's MBS purchasing program may have on mortgage spreads. This section presents a dynamic time series model of how mortgage rate spreads change with the changes in Federal Reserve's MBS holdings. A vector autogression (VAR) model has proven to be especially useful for describing complex dynamics and interrelationships between several time series. First, we summarize the dynamic properties of VAR model using the structural analysis. Then, we employ conditional forecasting technique for VAR model to generate the scenario-based forecasts of mortgage spreads.

3.7.1 Structural VAR

This subsection investigates how shocks to one series can have dynamic short-run or long-run effects on one or more other series by employing structural analysis. The aim is to quantify the effects of innovation to the changes in Fed's MBS holdings on the secondary mortgage spreads. We estimate the following triangular structural VARX(1) model[30] with a time-lag of order one[31]:

$$Beta * Y_t = c + \Gamma_1 Y_{t-1} + \Phi Z_t + \eta_t, \tag{3.1}$$

where

$$Beta = \begin{pmatrix} 1 & 0 & 0 & 0 \\ -\beta_{21} & 1 & 0 & 0 \\ -\beta_{31} & -\beta_{32} & 1 & 0 \\ -\beta_{41} & -\beta_{42} & -\beta_{43} & 1 \end{pmatrix};$$

[30] VARX model is a VAR model with exogenous variables.

[31] The lag length for the VAR(p) model is determined using AIC and BIC information criteria. Keeping in mind, that the AIC penalizes the number of parameters less strongly than the BIC does, we chose the lag length p = 1 based on BIC.

Y_t represents a multivariate vector of dimension $n = 4$ monthly stationary time series[32]; Z_t is k-dimensional vector of exogenous regressors with $k = 7$; c is a n-dimensional vector; Γ_1 is $n \times n$ matrix of coefficients; Φ is $n \times k$ matrix of coefficients; η_t is a n-dimensional vector of orthogonal errors with diagonal covariance matrix[33]. Based on which variables could plausibly drive the secondary mortgage market spreads, the VAR includes in vector Y_t the following variables: the changes in the Fed's MBS holdings ($\Delta MBS\_holdings_t$), the AAA-rated corporate spread (AAA_spread_t), the Case-Shiller U.S. national home price index growth rate ($HPI_{g,t}$) and the secondary mortgage market spread (MBS_spread_t). The order of the variables reflects identifying assumptions on impact restrictions. The identification treats the unconventional monetary policy variable, the change in the cumulative Fed's MBS holdings, as predetermined for the rest of the system, reflecting the view that FOMC's decision to expand or reduce MBS purchases does not respond immediately to shocks in the credit, housing and mortgage markets. Besides the changes in the Fed's MBS purchases, the AAA-rated corporate spread and home price growth are allowed to contemporaneously (within the month) affect the secondary mortgage market spreads as they represent the mortgage spreads drivers desribed in Section 5. Alternative identifying restrictions are explored in the robustness section. The k-dimensional vector of exogenous regressors Z_t includes the dummy variables which are specified only for the mortgage spread equation representing a signaling channel through which the MBS purchases program announcements affect mortgage spreads. The following dummy variables are included and set to one on the corresponding dates:

- QE1 Announcement - November 2008
- QE2 Announcement - November 2010
- OT Announcement - September 2011
- QE3 Announcement - September 2012

[32]The appropriate transformation of time series is applied to satisfy a stationarity assumption.

[33]A theoretical description of VAR models is presented in Chapter 11 of Zivot (2006). The book covers VAR estimations, impulse response functions, and projections.

- Taper tantrum - May 2013
- Tapering Announcement - December 2013
- LSAP Program - December 2008 - present

The data, which Section 6 describes, are monthly from January 2007 to May 2016. We estimate the VARX model with one lag using Kalman filter and maximum likelihood. Table 3.1 presents the estimation results on the drivers of secondary mortgage market spreads using different model specifications: (1) AR(1) model; (2) VAR(1) model; (3) VARX(1) model from equation (4.1). The outcomes of the estimation for mortgage spreads show that VARX(1) model and VAR(1) provide a better fit than the simple benchmark model, namely AR(1) model, does and VARX(1) model is superior to VAR(1) model based on R^2. By comparing the estimation results for VAR(1) and VARX(1) models, one can see in VARX(1) model a separate effect of the volume of Fed's MBS purchases on the mortgage spreads over the mere announcements or existence of the LSAP program. The estimation results for superior model VARX(1) are discussed further in this section.

The current mortgage spreads depend on the previous month value with positive, statistically significant coefficient. The estimated coefficient on the first lag of changes in the Federal Reserve's MBS holdings have the expected sign and is statistically significant at 1% significance level. The negative coefficient on the changes in the Federal Reserve's MBS holdings of -0.011 indicates that $100 billion decline in change in size of Fed's MBS holdings will result in the increase in mortgage spread by 11 bps. The coefficients on QE1, QE3 Announcements and LSAP Program dummy variables are negative and statistically significant at 1% significance level. QE1 and QE3 announcements reduced mortgage spreads by about 45 bps and 50 bps, respectively. The current coupon MBS spreads were on average 50 bps lower after the start of the LSAP program compare to the average level before the start of the program since January 2007. The coefficient on the dummy variable for the taper tantrum (unanticipated tapering announcement) indicates positive effect of about 12

bps on the secondary spreads, although it is not statistically significant. The anticipated announcement of Operation Twist in September 2011 and tapering announcement in December 2013 did not have a statistically significant impact on MBS spreads. The results confirm the hypothesis that the Federal Reserve's MBS purchase program has effect on the mortgage spreads through both signaling and portfolio rebalancing channels.

The triangular structural model (3.1) imposes the recursive causal ordering

$$y_1 \to y_2 \to y_3 \to y_4. \tag{3.2}$$

The ordering (3.2) means the following restrictions: y_{1t} affects $y_{2t}, \cdots, y_{4t}$ contemporaneously, but $y_{2t}, \cdots, y_{4t}$ do not affect y_{1t}; y_{2t} affects y_{3t}, y_{4t}, but y_{3t}, y_{4t} do not affect y_{2t}; and so on. After the assumptions about the causal structure of the data are imposed, the causal impacts of unexpected shocks on the variables in the model can be summarized with impulse response functions[34]. Figure 3.7 displays the impulse response functions for a change in Fed's MBS holdings innovation. All impulse response function (IRF) plots include 68 percent confidence interval in addition to the median response. A positive shock to the change in Fed's MBS holdings yields a sharp fall in the current coupon MBS spread, which is consistent with the hypothesis that the increase in MBS holdings should decrease the mortgage spreads via the portfolio rebalancing channel. The responses of Aaa-rated corporate bonds spread and home price growth on the shock to the change in MBS holdings are gradual, reaching the maximum impact approximately in 6-7 months. The estimated IRFs indicate very weak responses in the short run. The change in Fed's MBS holdings is the only variable where the 68 percent probability band does not include zero for the first 2 months. In terms of magnitutes, a one standard deviation ($20 billions of dollars) shock to the change in Fed's MBS holdings results in decline of the current coupon spread by 2.5 bps in 6 months.

The impulse response functions for the Aaa corporate spread, Case-Shiller home price index growth and mortgage spread innovation are presented in Figure 3.8, Figure 3.9 and

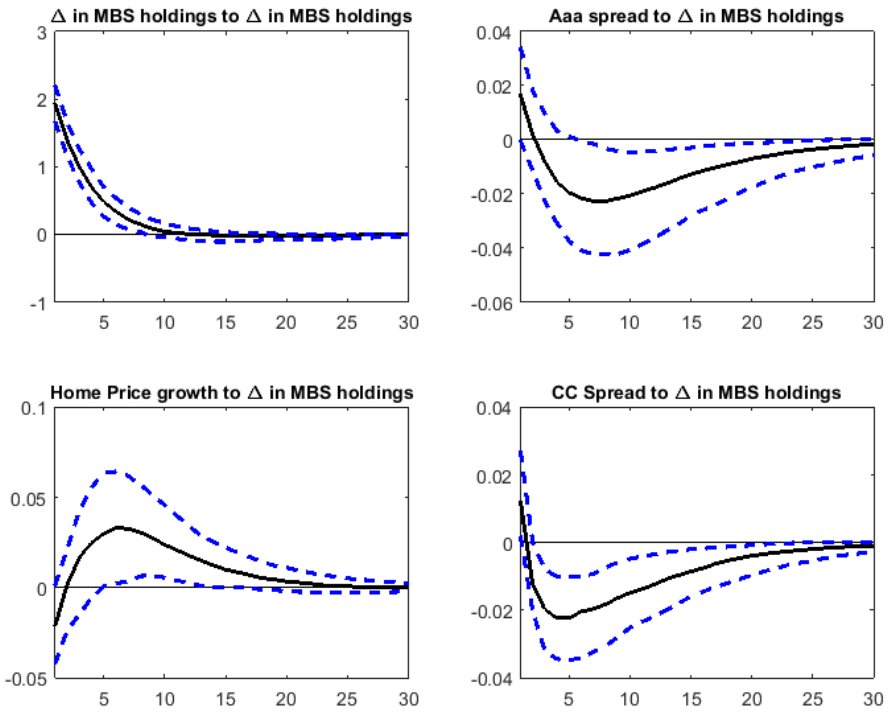
[34]Appendix B gives the definition of impulse response functions.

Table 3.1: Drivers of the Secondary Mortgage Market Spreads

	(1)	(2)	(3)
Intercept	0.080***	0.256***	0.479***
	(0.035)	(0.084)	(0.079)
Secondary mortgage market spreads	0.911***	0.853***	0.457***
	(0.030)	(0.057)	(0.077)
Change in Fed's MBS holdings		-0.008*	-0.011***
		(0.005)	(0.004)
AAA Spread		-0.064*	0.257***
		(0.039)	(0.055)
Case-Shiller HPI growth		-0.039	-0.050*
		(0.034)	(0.027)
QE1 Announcement			-0.445***
			(0.122)
QE2 Announcement			0.100
			(0.118)
OT Announcement			-0.061
			(0.113)
QE3 Announcement			-0.543***
			(0.113)
Tapering Unanticipated Announcement			0.119
			(0.115)
Tapering Anticipated Announcement			-0.061
			(0.113)
LSAP Program Indicator			-0.507***
			(0.074)
Observations	112	112	112
R^2	0.829	0.842	0.903

Column 1 presents the estimation results for the secondary mortgage market spreads using the simple benchmark model, AR(1). Columns 2 and 3 present the estimation results for the secondary mortgage market spreads equation from VAR(1) model without exogenous regressors and VARX(1) model (4.1), respectively. Dependent variable is the spread of Fannie Mae thirty-year current coupon MBS over ten-year U.S. Treasury yields. The estimates for the coefficients on the regressors excluding dummy variables are reported for lag one. Dummy variables as exogenous regressors affect spreads contemporaneously.
The sample consists of monthly data for the period January 2007 - May 2016.
Standard errors are reported in parentheses.
Significance levels: * $p < .10$, ** $p < .05$, *** $p < .01$

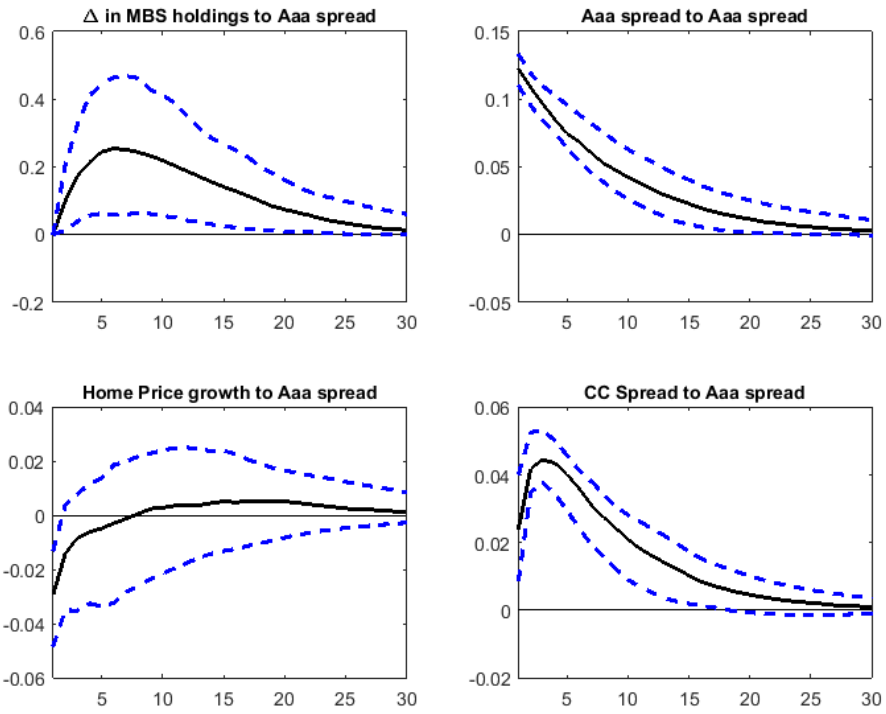
Figure 3.7: Impulse Response Functions to Changes in MBS Holdings



Notes: All units are in percent, except the change in Fed's MBS holdings which is measured in $10 billions of dollars. The number of steps: 30 months.

Figure 3.10, respectively. Consistent with the hypothesis which was presented in Section 5, a shock to the Aaa-rated corporate bond spread has a positive impact on the secondary mortgage spread and a shock to the home price growth has a negative impact on the secondary mortgage spread. Also while the MBS spread shock does not effect the change in the Fed's MBS holdings and Aaa corporate spread, one standard deviation shock (11 bps) to the mortgage spread results in a decline of monthly home price growth by 0.03 percent in 3 months horizon. The higher the mortgage spreads, the higher mortgage rates and the lower housing demand, hence, home prices.

Figure 3.8: Impulse Response Functions to Aaa Corporate Spread Shock

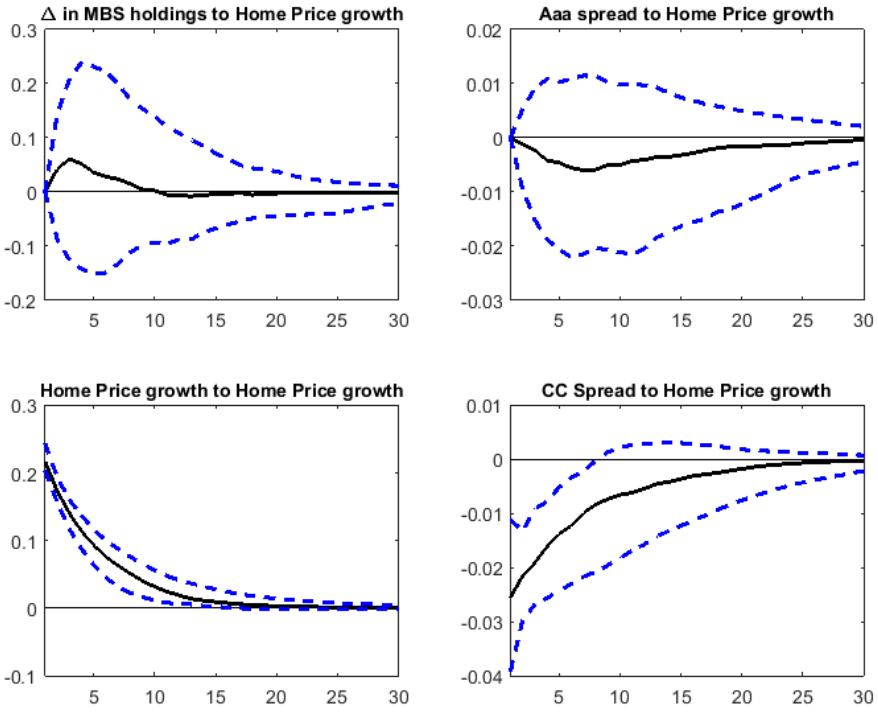


Notes: All units are in percent, except the change in Fed's MBS holdings which is measured in $10 billions of dollars. The number of steps: 30 months.

3.7.2 Conditional Forecasting

While it is not clear when the Fed will let the MBS holdings run-off or will liquidate them if it decides to do so, this section discusses the effects of possible reduction in the Fed's MBS holdings on the mortgage spreads by employing the conditional forecasting method. Conditional forecasts are projections of a set of variables of interest on future paths of some other variables. On the contrast, for the unconditional forecasts no knowledge of the future path of any variables is assumed. For VAR models, the conditional forecasts are typically computed by using the algorithm developed by Waggoner and Zha (1999), where they draw (the entire) paths of reduced form shocks which are compatible with the conditioning path on the observables. This paper uses an algorithm based on Kalman filtering techniques (Durbin

Figure 3.9: Impulse Response Functions to Home Price Growth Shock



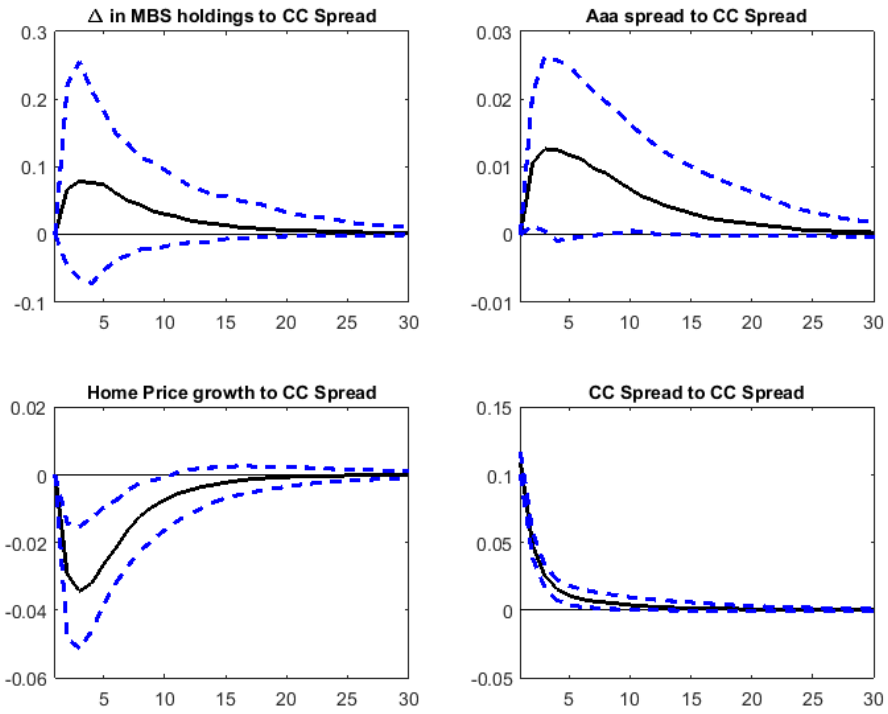
and Koopman, 2002) to compute conditional forecasts. Kalman filter based methods offer substantial computational gains when the number of conditioning variables and the forecast horizon are large (Bańbura, Giannone, Lenza, 2014). The algorithm applies to any model which can be cast in a linear state space representation. A state-space model is one in which an *observed* variable is the sum of a linear function of the *state* variable plus an error. The state variable evolves according to a stochastic difference equation that depends on the parameters that along with the path of state variable are to be inferred from the data (Kim and Nelson, 1999).

The linear state-space representation of the VAR model with exogenous regressors from equation (3.1) is defined as:

Transition Equation

$$X_t = A_t X_{t-1} + B_t u_t \tag{3.3}$$

Figure 3.10: Impulse Response Functions to Mortgage Spread Shock



Measurement Equation

$$Y_t = C_t X_t + D_t e_t \tag{3.4}$$

where $Y_t = [\Delta MBS\_holdings_t, AAA\_spread_t, HPI_g, MBS\_spread]'$ is a n-dimensional *observation vector* describing how the states are measured by the observations at period t with $n = 4$; $X_t = [S_t, \Phi_t']'$ is a m-dimensional *state vector* describing the dynamics of the potentially unobserved states with $m = n+k$ and including Φ', a k-dimensional vector of coefficients of the exogenous regressors for the MBS_spread variable from model (4.1); u_t and e_t are n-dimensional, Gaussian White noise, unit-variance vectors with $E[u_t e_s'] = 0 \; \forall t, s$. Finally, the potentially time-varying coefficient matrices A_t, B_t, C_t, D_t are the $(n+k) \times (n+k)$ state-transition matrix, the $(n+k) \times n$ state-disturbance-loading matrix, the $n \times (n+k)$ observation-sensitivity matrix and the $n \times n$ observation-innovation matrix, respectively,

which are defined as follows:

$$A_t = \begin{pmatrix} \Pi_{n\times n} & Z_{t,n\times k} \\ 0_{k\times n} & I_k \end{pmatrix}, B_t = \begin{pmatrix} \Sigma_{n\times n} \\ 0_{k\times n} \end{pmatrix}, C_t = (I_n, 0_k), D_t = 0_n,$$

where $Z_{t,n\times k} = \begin{pmatrix} 0_{(n-1)\times k} \\ z_{t,1\times k} \end{pmatrix}$ is matrix of exogenous regressors at time t, which is loaded only on the MBS_spread at time t and $\Sigma_{n\times n}$ is the lower triangular matrix, which is obtained from Cholevsky decomposition of the Q-covariance matrix of the residuals from the reduced-form VAR(p) such that $Q = \Sigma\Sigma'$. The state-space model was written in such way that it includes the exogenous regressors Z_t and the regression coefficient Φ in equation (3.1) in time-varying transition matrix A_t and in the state vector X_t in equation (3.3), respectively.

A basic tool that deals with state-space models is the Kalman filter. The Kalman filter is a recursive procedure for computing the estimate of the state vector X_t at time t, based on available information at time t, $X_{t|t}$. The filter consists of two steps as decribed in Kim and Nelson (1999) by the following six equations:

Prediction

$$X_{t|t-1} = A_t X_{t-1|t-1} \tag{3.5}$$

$$P_{t|t-1} = A_t P_{t-1|t-1} A_t' + B_t B_t' \tag{3.6}$$

$$\epsilon_t = Y_t - Y_{t|t-1} = Y_t - C_t X_{t|t-1} \tag{3.7}$$

$$V_{t|t-1} = C_t P_{t|t-1} C_t' + D_t D_t' \tag{3.8}$$

Updating

$$X_{t|t} = X_{t|t-1} + K_t \epsilon_t \tag{3.9}$$

$$P_{t|t} = P_{t|t-1} - K_t C_t P'_{t|t-1}, \tag{3.10}$$

where $X_{t|t-1}$ is the estimate of X_t conditional on information up $t-1$; $P_{t|t-1}$ is the covariance matrix of X_t conditional on information up to $t-1$; $P_{t|t}$ is the covariance matrix of X_t conditional on information up to t; ϵ_t is the prediction error; $V_{t|t-1}$ is the covariance matrix of the forecasted observations ; $K_t = P_{t|t-1} C'_t V^{-1}_{t|t-1}$ is a Kalman gain, which determines the weight assigned to new information about X_t contained in the prediction error. In the *prediction* step, at the beginning of period t, the optimal estimate of the 1-step ahead vector of observation forecasts for period t, $Y_{t|t-1}$, and its variance-covariance matrix, $V_{t|t-1}$, are obtained using all information up to time $t-1$, the estimate of the 1-step ahead vector of state forecasts for period t, $X_{t|t-1}$ and its variance-covariance matrix, $P_{t|t-1}$. In the *updating* step, once Y_t is observed at the end of time t, the prediction error ϵ_t can be calculated and a more accurate inference can be made of state vector X_t, $X_{t|t}$, an inference about X_t based on the information up to time t. $X_{t|t}$ is updated estimate of X_t based on the weight K_t assigned to the new information about X_t contained in the prediction error ϵ_t. This weight, K_t, called as a Kalman gain, is a portion of the conditional variance of the prediction error, $V_{t|t-1}$, explained by the variance of the prediction error due to error in making an inference about X_t (i.e., $X_t - X_{t|t-1}$), $P_{t|t-1}$, scaled by the measurement-sensitivity matrix C_t. If the uncertainty associated with $X_{t|t-1}$ is relatively small, the Kalman gain assigns a relatively smaller weight on the observations and, consequently, the updated (filtered) states $X_{t|t}$ at period t are close to the initial state forecasts $X_{t|t-1}$.

The derivation of prediction equations (3.5) - (3.8) is straightforward. Under the assumption of normality, the updating equations (3.9) - (3.10) are obtained by simple applications of the standard results of the multivariate normal regression theory in Lemma C.0.1 in Ap-

pendix C. Lemma C.0.1 states if X and Y are jointly normally distributed random vectors, the conditional distribution of X given Y is also normal. Lemma C.0.1 represents the regression of X on Y in a multivariate normal distribution. In the context of Kalman filter, during the estimation of the state vector X when X is unknown and the observation vector Y is known, we take as an estimate of X at time t, based on the available information at time t, the conditional expectation $X_{t|t} = E(X|Y)$, that is,

$$X_{t|t} = X_{t|t-1} + P_{t|t-1}C_t'V_{t|t-1}^{-1}(Y_t - Y_{t|t-1}). \tag{3.11}$$

The unconditional variance of estimation error $X_{t|t} - X_t$ is

$$P_{t|t} = P_{t|t-1} - P_{t|t-1}C_t'V_{t|t-1}^{-1}C_tP_{t|t-1}'. \tag{3.12}$$

The equations (3.11) and (3.12) are simply the updating equations from Kalman filter.

Given the assumptions on the distribution of uncertainty, the Kalman filter also estimates model parameters by maximum likelihood method. The Kalman filter feeds the forecasted estimates into the log likelihood function

$$L(\theta|Y_T, ...Y_1) = \sum_{t=1}^{T} \ln \phi(Y_t; Y_{t|t-1}, V_{t|t-1}),$$

where $\phi(Y_t; Y_{t|t-1}, V_{t|t-1})$ is the multivariate normal probability density function with mean $Y_{t|t-1}$ and variance $V_{t|t-1}$.

Another application of Kalman filtering technique on the state space model is the forecasting. The minimum mean square error forecasts of observation and state can be obtained simply by treating future observations Y_t as missing values.

Let $Y_1, ..., Y_n$ be a vector observations which follow the state-space model (3.3)-(3.4). The forecasts Y_{n+j} for $j = 1, ..., J$ together with their forecast error variance matrices can be obtained by treating Y_t for $t > n$ as missing observations and by continuing the Kalman

filter $t = n$ with $C_t = 0$ for $t > n$[35]. The Kalman recursion in case of missing observations consists of the updating and prediction equations (3.13)-(3.16):

Updating

$$X_{t|t} = E(X_t|Y_t) = E(X_t|Y_{t-1}) = X_{t|t-1} \tag{3.13}$$

$$P_{t|t} = Var(X_t|Y_t) = Var(X_t|Y_{t-1}) = P_{t|t-1} \tag{3.14}$$

Prediction

$$X_{t|t-1} = E(X_t|Y_{t-1}) = A_t X_{t-1|t-2} \tag{3.15}$$

$$P_{t|t-1} = Var(X_t|Y_{t-1}) = A_t P_{t-1|t-2} A_t' + B_t B_t' \tag{3.16}$$

Equations (3.13)-(3.14) are obtained from equations (3.9)-(3.10) by having Kalman gain equal to zero, since there is no new information from observations for $t > n$. For the computation of the minimum mean square error forecast of Y_{n+j} give Y_n, $Y_{n+j|n} = E(Y_{n+j}|Y_n)$ and its conditional mean square error matrix $V_{n+j|n} = Var(Y_{n+j} - Y_{n+j|n}|Y_n) = E[(Y_{n+j|n} - Y_{n+j})(Y_{n+j|n} - Y_{n+j})'|Y_n]$, C_{n+j} are taken as their actual values for $j = 1, ..., J$. The j-step-ahead forecasted observation vector $Y_{n+j|n} = C_{n+j} X_{n+j|n}$, where $X_{n+j|n} = \left(\prod_{i=n+1}^{n+j} A_i \right) X_{n|n}$.

The unconditional forecast for horizon h of Y_{T+h} based on the information available at time T are obtained by treating all elements of the observation vector Y_t as missing for $t > T$ and applying the technique described above. Conditional forecasting can be performed by treating some but not all of the elements of observation vector Y_t for $t > T$ as missing observations. The conditional forecasts are obtained for the subset of variables in Y_t for $t > T$, conditional on their own past and on the past and future observations of the remaining variables. Let Y_t^* be the vector of variables for which we actually assume the knowledge of

[35]See pages 110 - 111 in Durbin and Koopman (2012)

a future path. Then $Y_t^* = W_t Y_t$ where W_t is a known matrix whose rows are a subset of the rows of identity matrix I. Consequently, at time points where not all elements of Y_t are assumed to be known, Kalman filter is applied to a modified state space representation with equation (3.4) being replaced by equation

$$Y_t^* = C_t^* X_t + D_t^* e_t,$$

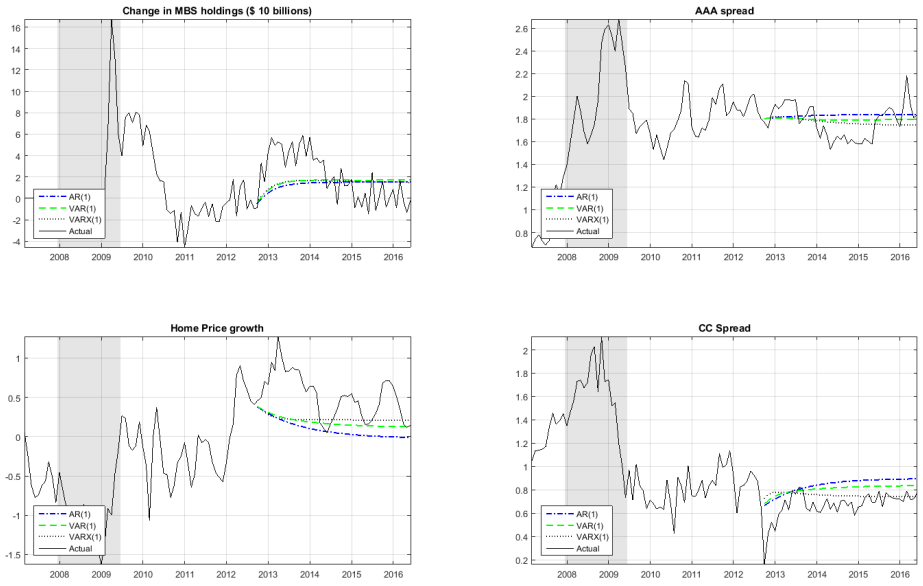
where $C_t^* = W_t C_t$, $D_t^* = W_t D_t$. The forecasts for the subset of variables for which we do not assume the knowledge of a future path can be estimated by appropriate elements of $C_t X_{t|t-1}$.

Figure 3.11 shows the unconditional forecasts generated over the period from September 2012 to May 2016 for the different model specifications: (1) AR(1) model; (2) VAR(1) model; (3) VARX(1) model from equation (4.1). Since the parameters are estimated over the period from January 2007 to May 2016, the forecast for 2012 to 2016 period is considered as "in-sample". The unconditional forecasts from VARX(1) model indicate a better in-sample fit by comparing the forecasted values with actual historical values in line with the conclusion in the previous section.

Figure 3.12 shows the unconditional and conditional forecasts generated over the period from September 2012 to May 2016 for VARX(1) model from equation (4.1) estimated over the period from January 2007 to May 2016. The aim of this exercise (see Banbura, Giannone, Lenza (2014) for similar exercises) is two-fold. First, Figure 3.12 shows that by incorporating the knowledge of the future path of the changes in Fed's MBS holdings, a more reliable forecast of other variables in the system compare to the unconditional forecast of the variables in the system is obtained. Second, the "in-sample" part of the conditional forecasts is compared with the observed developments to confirm the goodness of fit of the model.

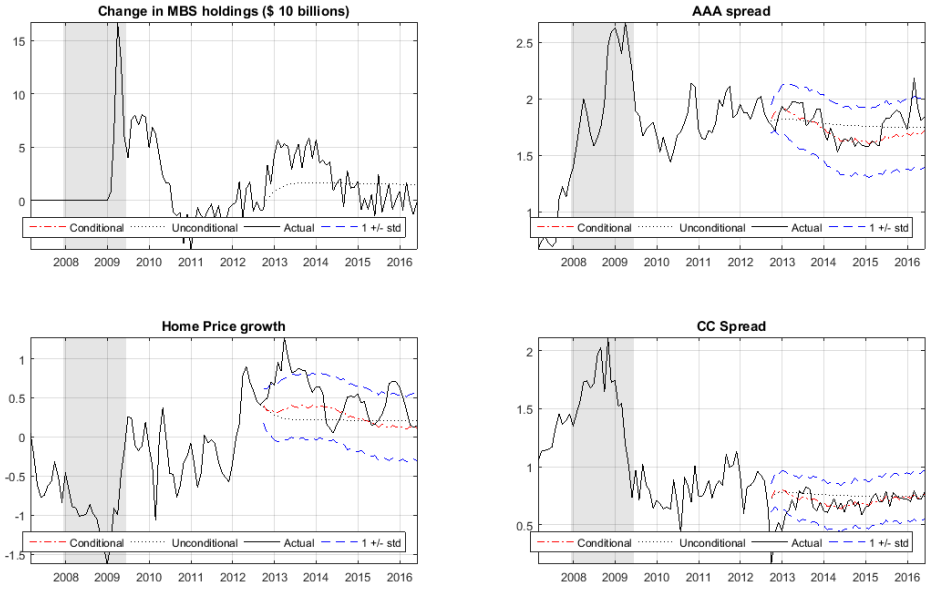
In the next step the conditional forecasting technique is used to perform scenario analysis to assess the effect associated with the possible Fed's "exit strategy" on the normalization of its balance sheet. According to the Fed's June 2016 Survey of Primary Dealers, during the

Figure 3.11: Unconditional Forecasting: In-sample Projections



Notes: The shaded area represents the U.S. Recession defined by NBER. All units of measurement are in percent, except the change in Fed's MBS holdings which is measured in $10 billions.

Figure 3.12: Conditional vs Unconditional Forecasting: In-sample Projections



Notes: The shaded area represents the U.S. Recession defined by NBER. All units of measurement are in percent, except the change in Fed's MBS holdings which is measured in $10 billions.

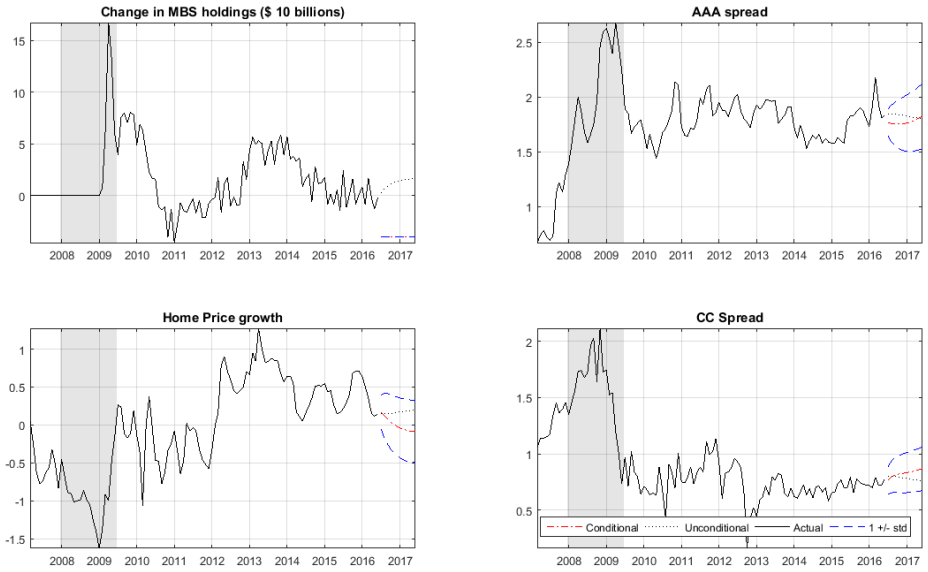
process of policy normalization by the FOMC Committee 67% of dealers expect Agency debt and MBS reinvestments to be phased out over time, 15% of dealers expect reinvestments to be ceased all at once and 18% of dealers expect no changes to reinvestments.[36] The worst case scenario under which the Committee cease the reinvestments all at once is considered here. The impact of the change of the reinvestment policy is evaluated for the next 12 months. In the second quarter of 2016, the Fed reinvested roughly $40 billion a month in MBS.[37] To obtain hard conditional forecasts[38], the fixed values of the future values of

[36] `https://www.newyorkfed.org/medialibrary/media/markets/survey/2016/jun-2016-results.pdf`//List of all surveys can be found at `https://www.newyorkfed.org/markets/primarydealer_survey_questions.html`

[37] "Each month, the System Open Market Account (SOMA) portfolio receives sizable principal payments on its securities holdings, which, if not reinvested, would decrease the size of the SOMA portfolio. Reinvestment, by keeping the Committees holdings of longer-term securities at sizable levels, should help maintain accommodative financial conditions". `https://www.newyorkfed.org/markets/ambs-treasury-faq.html`. The Fed's tentative outright agency MBS operation schedule can be found at `https://www.newyorkfed.org/markets/ambs_operation_schedule.html#tabs-2`

[38] The hard conditions restrict future values of certain variabes at fixed values. See Waggoner and Zha

Figure 3.13: Conditional vs Unconditional Forecasting: Out-sample Projections



Notes: The shaded area represents the U.S. Recession defined by NBER.

the change in Fed's MBS holdings variable are used for the next 12 months. Under the assumption that prepayments on MBS continue to be made at the rate $40 billions per month, letting the Fed's MBS portfolio holdings to decline by $40 billions per month for the next 12 months starting June 2016 would increase the current coupon MBS spread by 10 bps in 12 months as shown in Figure 3.13. The projected increase in the secondary mortgage market spread reflects the impact of the decrease of the size of the Fed's MBS portfolio solely through portfolio-rebalancing channel. The results of Table 3.1 show that the anticipated announcements of the changes to the quantitative easing program such as QE2, OT and Tapering do not have significant impact on the mortgage spreads. The conclusion of the performed scenario analysis is that the winding down of LSAPs need not cause a large rise in MBS spreads as long as the completion of reinvestments is announced well in advance and is consistent with conclusion in Gagnon et al. (2010).

(1998) for the details.

3.8 Robustness Check

The robustness of the results of the previous analysis is checked by altering the VAR specification in the following two ways: (1) the change of the ordering of variables so that mortgage spreads are allow to affect some of the variables contemporaneously; (2) the sample period is shortened to January 2007 to June 2010. In the first robustness check, alternative identifying restrictions are explored. The order of the variables in the recursive VAR is rearranged such that the mortgage spreads affect either AAA corporate spread or Case-Shiller home price growth contemporaneously. The results of previous analysis are robust to these variations in VAR specification and available from the author upon request. In the second robustness check, the VARX(1) model (3.1) is estimated for the shorter sample period from January 2007 to June 2010 as in Stroebel & Taylor (2012). One can see in Table 3.2 the estimation results are consistent with the previous findings. The LSAP Program and QE1 Announcement dummies are negative and statistically significant. The QE1 program announcement reduced mortgage spreads by about 45 basis points in the month following the announcement. Since the start of the LSAP program the secondary mortgage market spreads decreased by roughly 50 basis points. The significant coefficient on the first lag of changes in the Federal Reserve's MBS holdings enters negatively as expected as well.

The potential robustness exercise would be the use of the alternative measure of mortgage spread that accounts for the prepayment option in 30-year fixed rate mortgage. This is so called option-adjusted spread (OAS), which is computed as the yield on current coupon agency MBS over the corresponding Treasury yield after controlling for the value of the prepayment option. Unfortunately, there was no available access to the history of current-coupon OAS at the time of this research.

In general, the results are robust to the variations in both VAR specification and the sample period.

Table 3.2: Drivers of the Secondary Mortgage Market Spreads: Alternative Estimation Period

	(1)
Intercept	0.571***
	(0.125)
Secondary mortgage market spreads	0.293**
	(0.141)
Changes in Fed's MBS holdings	-0.029***
	(0.008)
AAA Spread	0.369***
	(0.091)
Case-Shiller HPI growth	-0.053
	(0.068)
QE1 Announcement	-0.460***
	(0.138)
LSAP Program Indicator	-0.517***
	(0.109)
Observations	41
R^2	0.908

This table shows the estimation results for the secondary mortgage market spreads equation from VARX(1) model (4.1). Dependent variable is the spread of Fannie Mae thirty-year current coupon MBS over ten-year U.S. Treasury yields. The estimates for the coefficients on the regressors excluding dummy variables are reported for lag one. Dummy variables as exogenous regressors affect spreads contemporaneously.
The sample consists of monthly data for the period January 2007 - June 2010.
Standard errors are reported in parentheses.
Significance levels: * $p < .10$, ** $p < .05$, *** $p < .01$

3.9 Conclusion

This paper has examined the quantitative impact of the Federal Reserve's Mortgage-Backed Securities (MBS) purchase program on the secondary mortgage market spreads. The paper employed vector autoregression model with exogenous regressors, specifically, VARX model to capture the dynamic relationship between the variables that affect the secondary mortgage market spreads as well as the impact of the exogenous shocks such as the announcements of the quantitative easings programs on the MBS spreads. The paper challenges the results of Stroebel & Taylor (2012), where the authors find no evidence that the increase in the MBS purchases led to a reduction in MBS spreads once the dummy for the existence of Fed's MBS purchase program is introduced. The paper's results indicate that the Federal Reserve's MBS purchase program has effect on the mortgage spreads through both signaling and portfolio rebalancing channels. The results are robust to variations in VAR specification. QE1 and QE3 announcements, representing a signaling channel, reduced mortgage spreads by about 45 bps and 50 bps, respectively. Also the current coupon spreads were on average 50 bps lower after the start of the program compare to the average level before the start of the program since January 2007. $100 billion decline in change in size of Fed's MBS holdings will result in the increase in mortgage spread by 11 bps, supporting the hypothesis of portfolio-rebalancing channel.

By casting VARX model into state-space form and applying Kalman filtering technique for conditional forecasting, the paper provides scenario analysis to assess the effect associated with the Fed's "exit strategy" of the normalization of its balance sheet. Under the scenario of ceasing the reinvestments by FOMC and letting the Fed's MBS portfolio holdings to decline by $40 billions per month for the next 12 months starting June 2016 the current coupon MBS spread will increase by 10 bps in 12 months. The conclusion of the performed scenario analysis is that the winding down of LSAPs need not cause a large rise in MBS spreads as long as the completion of reinvestments is announced well in advance.

Based on the paper's results we conclude that the Federal Reserve's MBS purchase pro-

gram was successful at lowering mortgage-backed securities spreads, supporting mortgage markets and financial markets, more generally. An interesting avenue for the future research is to assess whether unconventional monetary policy actions such as the Federal Reserve's MBS purchases reach economy and stimulate economic activity. A widening primary-secondary spread since the introduction of LSAP program might suggest that the Fed's MBS purchases are not fully reaching borrowers.

Chapter 4

The Macroeconomic Impact of the Federal Reserve's Mortgage-Backed Securities Purchase Program

4.1 Abstract

While there is substantial evidence that the Federal Reserve's Mortgage-Backed Securities (MBS) purchases have lowered mortgage spreads and eased broader financial conditions, there is not enough research on the effects of the Federal Reserve's MBS purchases on the broader economy. This chapter examines the quantitative impact of mortgage spreads on aggregate economic variables. I find that mortgage spread shocks reduce consumption, residential investments and GDP by both economical and statistically significant magnitudes. The results indicate that the reduction in mortgage spreads from the Federal Reserve's MBS purchase program has only partially passed through to borrowers due to widening of the primary-secondary mortgage market spread, the spread between mortgage rates and MBS yields, explaining the slow recovery of consumption in post-crisis period. The decline in mortgage rates did not keep pace with it in the secondary rates as the transmission of lower mortgage spreads in the secondary mortgage market to lower borrowing costs in the primary mortgage market has not happened due to a rise in originators' costs and profitability, as well as increases in g-fees.

4.2 Introduction

In response to the 2008 financial crisis, the Federal Reserve has undertaken unconventional monetary policy to stimulate its economy, through long-duration large-scale asset purchase program (LSAP), commonly known as "Quantitative easing" (QE) program. Quantitative easing refers to the changes in the composition and/or size of the central bank's balance sheet with objective to ease liquidity and/or credit conditions when the short-term interest rate is constrained by zero lower bound. Using monetary policy to support housing market was a particular focus of the Federal Reserve during the Great Recession as housing is a critical channel for the transmission on monetary policy to the real economy. The Federal Reserve announced on November 25, 2018 that "it will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises (GSEs) - Fannie Mae, Freddie Mac, and the Federal Home Loan Banks - and mortgage-backed securities (MBS) backed by Fannie Mae, Freddie Mac, and Ginnie Mae". The goal of quantitative easing and MBS purchase program as a part of LSAP was to lower mortgage rates by reducing financing costs for mortgage lenders (Bernanke, 2009, 2012) and "increase the availability of credit for the purchase of houses, which in turn should support housing markets and foster improved conditions in financial markets more generally"[1]. Between 2008 and 2014, the Fed performed three rounds of QE. While there is a large amount of literature that studies the impact of the LSAP on the interest rates including mortgage rates (Gagnon, et al., 2010; Hancock & Passmore, 2011, 2014; Krishnamurthy and Vissing-Jorgensen, 2011; Patrabansh et al., 2014; Stroebel & Taylor, 2012; Kasymova, 2017), there is a lack of empirical evidence on whether LSAP affects the housing market and the real economy.

Housing is an important channel for the transmission of monetary policy to the real economy. Monetary policy can affect the real economy through housing directly or indirectly. Residential investment is the component of GDP that responds to the monetary shocks immediately (Bernanke and Gertler, 1995). Monetary policy through housing can affect

[1] https://www.federalreserve.gov/newsevents/pressreleases/monetary20081125b.htm

consumption. An easing of monetary policy can decrease mortgage rates, increase refinancing of mortgages at lower rates, reduce households' monthly payments and, as a consequence, boost aggregate consumption.

This paper's research question on the impact of the unconventional monetary on the business cycle through the mortgage spread is important in deciding whether to use the Fed's QE in a future recession or financial crisis. Kasymova (2017) shows that the Federal Reserve's Mortgage-Backed Securities (MBS) purchases have lowered mortgage spreads. This study of the impact of the shocks to the mortgage spread between residential mortgage rates and U.S. Treasury rate on the housing market and aggregate economic variables takes a deep dive into the efficacy of the Federal Reserve's Mortgage-backed securities purchase program. Our work is inspired by Walentin's (2014) paper, only one paper, to our knowledge, which explores the business cycle effects of innovations to the residential mortgage spreads. Walentin (2014) performs a structural vector autoregression (SVAR) analysis with the following seven variables, where the ordering reflects identifying assumptions on impact restrictions: consumption, residential investment, GDP, the consumer price level, the primary mortgage market spread, the nominal policy interest rate and house prices. Walentin (2014) finds that aggregate quantities decrease following a positive shock to the mortgage spread consistent with an interpretation of mortgage spread shocks as credit supply shocks. In addition, Walentin (2014) concludes that if the unconventional monetary policy is successful in affecting the mortgage spreads, then it has sizable effects on aggregate quantities. This paper extends Walentin's (2014) work on the macroeconomic effects of mortgage spreads and explores whether the Federal Reserve's MBS purchase program has fully reached real economy through impact on borrowing costs.

Contrary to Walentin's (2014) study this paper looks at the impact of both primary mortgage market and secondary mortgage market spreads on the aggregate economic and housing variables. The primary mortgage spread is the difference between the rate charged for a newly issues good quality mortgage at a given maturity (primary mortgage market rate)

and the yield on the government bond of corresponding maturity. The secondary mortgage market spread is the difference between a yield on newly issued par-priced agency MBS (secondary mortgage market rate, or "current coupon rate") and the yield on government bond of corresponding maturity. Hence, the primary-secondary spread is calculated as the difference between average mortgage interest rate paid by borrowers and the secondary mortgage market rate paid to investors.

This study is performed by estimating a structural VAR model with the following eight variables: household wealth (financial or housing wealth), consumption, residential investment, GDP, inflation, mortgage spread (primary or secondary mortgage market spreads), policy interest rate and housing specific variable (home prices, existing home sales ad housing starts). The order of the variables reflects identifying assumptions on impact restrictions. Several variations in both the SVAR specification and the sample period allowed to document the robustness of our results and to reveal the efficacy of the unconventional monetary policy. The model is estimated over the small sample from 1986Q1 to 2008Q4 before the introduction of QE and over the full sample from 1986Q1 to 2017Q4 which includes QE period. The results show that the mortgage spread shocks impact the real economy by both economically and statistically significant magnitudes. The Granger-causality tests and impulse response functions run over the full sample reveal that the main channel through which monetary policy affects the aggregate quantities is residential investment, while the impact of the mortgage spreads on consumption is less significant due to their insignificant effect on the housing wealth, the main driver of the consumption (Kishor, 2007; Iacoviello, 2011; Case et al., 2013). Consistent with Walentin's (2014) findings that the shocks to the secondary mortgage spread rather to the primary-secondary mortgage spread affect the macroeconomy, the impact of the secondary mortgage market spreads on the aggregate quantities and housing starts in the model is larger than it is in the VAR model with the primary mortgage market spread as a mortgage spread measure. The same conclusion holds for the estimation results for the small sample. For the full sample, a 100 basis points (bps) shock to the pri-

mary mortgage market spread yields a decrease of 1.3 percent in consumption, 8.3 percent in residential investment, 1.9 percent in GDP and 30.4 percent in housing starts. At the same time, a 100 basis points (bps) shock to the secondary mortgage market spread yields a decrease of 1.4 percent in consumption, 12.7 percent in residential investment, 2.3 percent in GDP and 42.5 percent in housing starts. The largest effect on the aggregate quantities occurs after 3 quarters and on the housing starts after 2 quarters. However, the transmission of monetary policy directly to the real economy and to the housing or through housing to the real economy was impeded over the recent period including QE period since the magnitude of impact of the mortgage spreads estimated over the full sample was smaller compared with the magnitude for the smaller sample. In addition, the difference between the impacts of secondary mortgage spreads on the aggregate variables estimated over the full sample and over the small sample is larger than this difference between the impacts of primary mortgage market spreads on the aggregate variables, indicating the decay in the transmission of the impact of the Feds MBS purchases on the secondary mortgage market to the primary mortage market. That means that the shocks to secondary mortgage market spreads are not one-to-one transmitted to the primary mortgage market spreads explained by the widening of the primary-secondary spread over the recent period. The primary-secondary spread is higher since 2008 due to a rise in originators' profits and unmeasured costs, as well as increases in g-fees.

The takeaways from this paper are the following: (i) business cycle fluctuations are affected by financial frictions in the residential mortgage market; (ii) the reduction in mortgage spreads from the Federal Reserve's MBS purchase program has only partially passed through to borrowers due to widening of the primary-secondary spread, the spread between mortgage rates and MBS yields, explaining the slow recovery of consumption in post-crisis period; (iii) the transmission of monetary policy indirectly to the real economy through housing was impeded by the partial transmission of lower interest rates to young, lower FICO score, and, presumably, lower income individuals, who represent the key group of consumers; (iv) un-

conventional monetary policy in the form of the mortgage-backed securities purchases can have sizable effects on the aggregate quantities and housing market if the transmission of its impact from the secondary to the primary mortgage market, or in other words, from lenders to borrowers, is part of its focus.

The remainder of the paper is organized as follows. Section 3 gives the background on the relations between mortgage spreads, housing market and macroeconomy as well as literature review. Section 4 discusses what drives the dynamics of the primary-secondary spread in details. Section 5 describes the data on the mortgage spreads, housing market and economy. Section 6 gives the description of the empirical methodology and presents the initial results. Section 7 provides a number of robustness checks and additional findings. Section 8 concludes the paper with final remarks and discussion on the future research.

4.3 Mortgage Spreads, Housing Market and Macroeconomy: Literature Review

While the literature on the impact of unconventional monetary policies on interest rates on Treasury bonds and mortgage-backed securities is vast, that on their effect on real activity and inflation is much more limited. This largely reflects the difficulties of estimating their effect involved. The effects of lower longer-term interest rates take place over the longer horizons. In addition, standard macroeconomic models do not allow for imperfect substitutability of assets and are needed to be developed. Several authors tried to investigate the impact of unconventional monetary policy on macro variables with conventional empirical macro modeling tools: dynamic stochastic general equilibrium (DSGE) and vector autoregressions (VAR) models.

Gertler and Karadi (2013) use the dynamic stochastic equilibrium model that incorporates the financial frictions in the form of limits to arbitrage in private financial intermediation. In their model, LSAPs are seen as central bank intermediation. Gertler and Karadi

(2013) find that LSAPs can affect real activity only to the extent there exists limits to the arbitrage in the private financial intermediation, that is private intermediaries are constrained in their ability to fund the same long-term securities by issuing liabilities of same (short term) maturity as the central bank. Like private intermediaries, the central bank finances its asset purchases by interest bearing liabilities. However, the advantage the central bank has is that it can obtain funds elastically by issuing riskless short-term government debt. Hence, quantitative easing is modeled as a policy in which the central bank steps in, performs intermediation between different assets that private financial institutions are unable to do and reduces excess returns. Authors interpret QE1 as the Fed's increasing central bank intermediation to offset the disruption of private intermediation during the demise of the shadow banking system. Gertler and Karadi (2013) find that during QE1 the output drop is roughly 3.5 percent lower relative to the case without central bank intervention and QE2 increased GDP by 1 percent within a year.

Another way to estimate the macroeconomic implications is to translate the decline in interest rates into an equivalent reduction in the federal funds rate. Engen, Laubach, and Reifschneider (2015) find that the Fed's cumulative QE programs with equivalent effect of a cut in the federal funds rate reduced the unemployment rate by 1.2 percentage point as of early 2015 while raising the inflation rate by nearly half a percentage point. This approach to estimate the macroeconomic effects of QE was enhanced by computing a "shadow" short-rate that is consistent with the observed behavior of the term structure of interest rates. When the actual short-rate is zero or near-zero given the existence of the option to hold currency, the shadow rate is negative in the zero lower bound period, reflecting the stance of unconventional monetary policy (Krippner (2013), Wu and Xia (2016)). Using factor-augmented vector autoregression to assess the impact of shocks to the shadow short rate, Wu and Xia (2016) found that the reduction in the shadow rate reduced the unemployment rate by a full percentage point from July 2009 to December 2013, relative to a counterfactual with no quantitative easing.

Other authors use other unconventional monetary policy instrument in the VAR analysis. Given the substantial evidence on the effects of QE on the interest rate spreads, researchers study the effects of a spread shocks on the business cycle to assess indirectly the macroeconomic effects of QE. Walentin (2014) performs a structural vector autoregression (SVAR) analysis with the following seven variables, where the ordering reflects identifying assumptions on impact restrictions: consumption, residential investment, GDP, the consumer price level, the primary mortgage market spread, the nominal policy interest rate and house prices. Walentin (2014) finds that aggregate quantities decrease following a positive shock to the mortgage spread consistent with an interpretation of mortgage spread shocks as credit supply shocks. A mortgage shock of 100 basis points (bps) yields a decrease of 1.6 percent in consumption, 6.2 percent in residential investment, and 1.9 percent in GDP. Walentin (2014) concludes that if the unconventional monetary policy is successful in affecting the mortgage spreads, then it has sizable effects on aggregate quantities. This chapter extends Walentin's (2014) work on the impact of the unconventional monetary policy on the business cycle through the mortgage spread and explores whether the Federal Reserve's MBS purchase program has fully reached real economy through impact on borrowing costs.

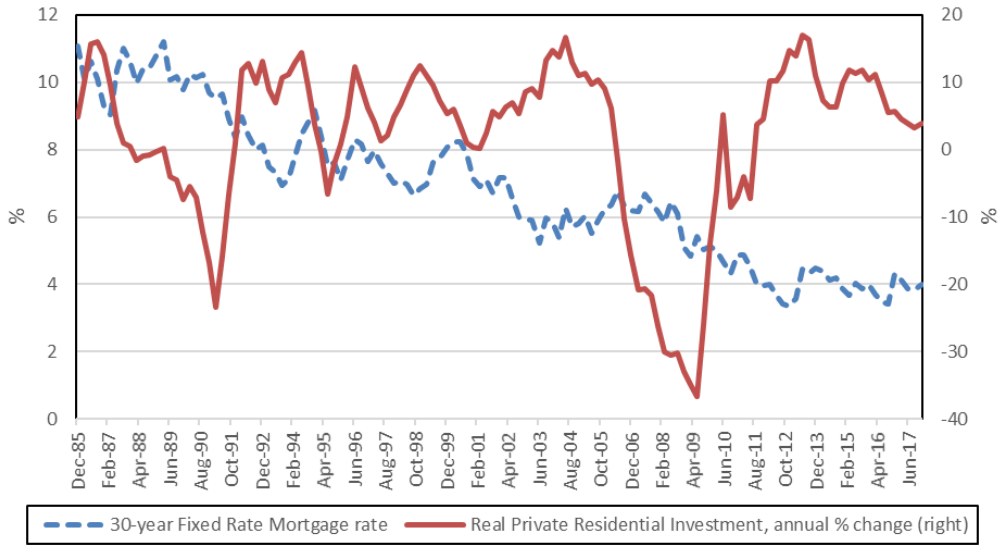
The mortgage spreads, hence, mortgage rates and housing market, can potentially impact the aggregate economic variables through direct channel - residential investment via the cost of housing, and indirect channel - consumption via housing and financial wealth effects[2]. The broadest measure of economic activity, gross domestic product, can be decomposed into four broad categories: investment, consumption, government spending and net exports.

Housing directly contributes to the investment component of GDP through residential fixed investment. Residential fixed investment includes construction of new single-family and multifamily structures, residential remodeling, production of manufactured homes, and brokers' commission on sales. The construction of single-family houses contributes over half

[2]According to Case et al. (2005), a rise in consumption due to an increase in housing prices is called the housing wealth effect, whereas a rise in consumption due to an increase in prices of financial assets, such as stocks and bonds, is called the financial wealth effect.

of the value of residential fixed investment and is usually highly volatile over the business cycles. At the peak of the housing cycle, construction of new single-unit housing was valued at $434 billion, or 3.4% of GDP. It declined to $109 billion in 2009, following the collapse of the housing market, and contributed 0.8% to GDP[3]. Home improvements, refurbishment and remodeling of residential structures are the second largest component of residential fixed investment. It is typically less volatile and contributes around a quarter of residential fixed investments' value. Since residential investment spending requires financing, it is normally sensitive to interest rates. The rising mortgage rates may lead to weak housing sales, rising inventories of homes for sales, and falling housing prices. Those make building houses less profitable and home-builders are likely to construct few new houses, leading to the reduction of real residential investment. Figure 4.1 shows the negative relationship between the mortgage rates and the changes in the real residential investments.

Figure 4.1: Mortgage Rate and Annual Changes in Residential Investments



Source: FRED, Federal Reserve Bank of St. Louis

Housing indirectly affects GDP via consumption spending. The link between the housing market and consumption is important as consumer spending accounts for over 70% of U.S.

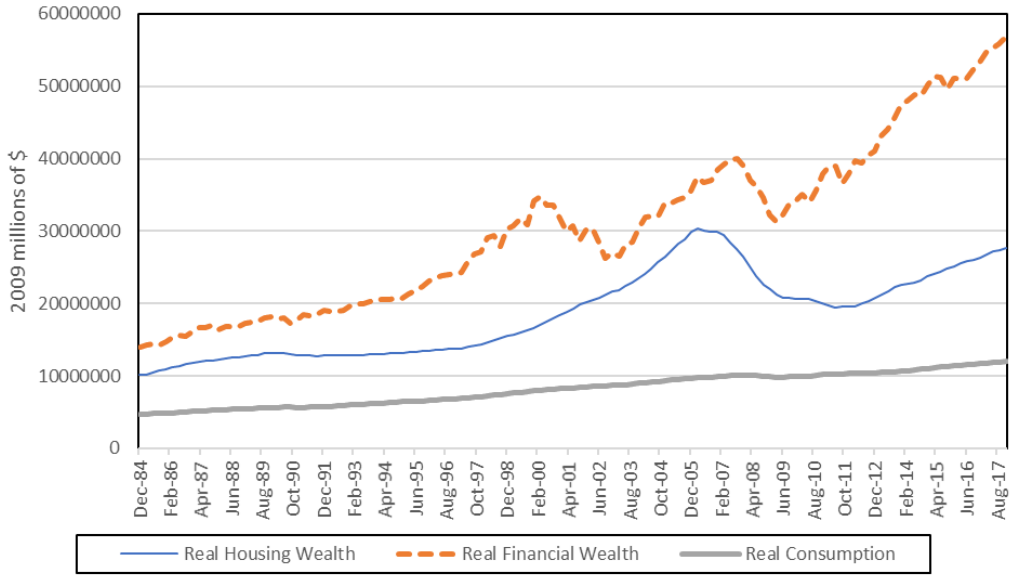
[3] https://www.nahb.org/en/research/housing-economics/special-studies/archives/housing-and-gdp-2010.aspx

economic output. There has been a consensus in economic literature that household wealth is one of the determinants of consumption expenditure. Many researchers have distinguished between two forms of wealth, the financial wealth (FW) and the housing wealth (HW), and studied their impact on consumption. The idea of the wealth effect is that if consumers are less wealthy because of decline in the value of their assets, whether stocks or homes, they will reduce their consumer spending. While researchers agreed that both HW and FW have significant effects on consumption, they have not agreed on the magnitude of the effects. Kishor (2007), Iacoviello (2011), Case et al. (2013) argued that the consumption response to HW movements is significantly higher than the response to FW movements. Other studies have argued that consumption is less sensitive to HW than to FW. Dvornak and Kohler (2007) see HW as less liquid wealth than FW, although the studies were conducted for Australian economy. In addition, there is another channel through which house prices can influence consumer spending decisions by affecting consumers' access to credit, so called collateral channel. Housing equity is the primary form of the collateral that households use for borrowing and as an important source of consumption funding[4].

Figure 4.2 plots the personal consumption expenditures in the United States along with wealth divided into housing wealth and financial wealth converted in 2009 millions of dollars. While the real housing wealth is very close to the pre-crisis level and the real financial wealth surpassed the pre-crisis peak, the consumption average annual growth has slowed after the Great Recession contributing to the sluggish recovery. Figure 4.3 shows that the post-crisis consumption average annual growth rate is lower than the pre-crisis growth rate. Tight credit standards and reduction in homeownership, especially for the young, have contributed to a shift in housing wealth toward older, higher FICO score, and presumably, higher income individuals. In 2017 more than 40% of housing wealth is concentrated in the hands of those aged 60 or more compare to 24% in 2006. People under the age of 45 hold only 14% of U.S. housing wealth - down from 24% in 2006 (Haughwout et al., 2018). Also, the top 10%

[4]http://libertystreeteconomics.newyorkfed.org/2017/02/houses-as-atms-no-longer.html

Figure 4.2: Housing Wealth, Financial Wealth and Consumption in the U.S. from 1984 to 2017

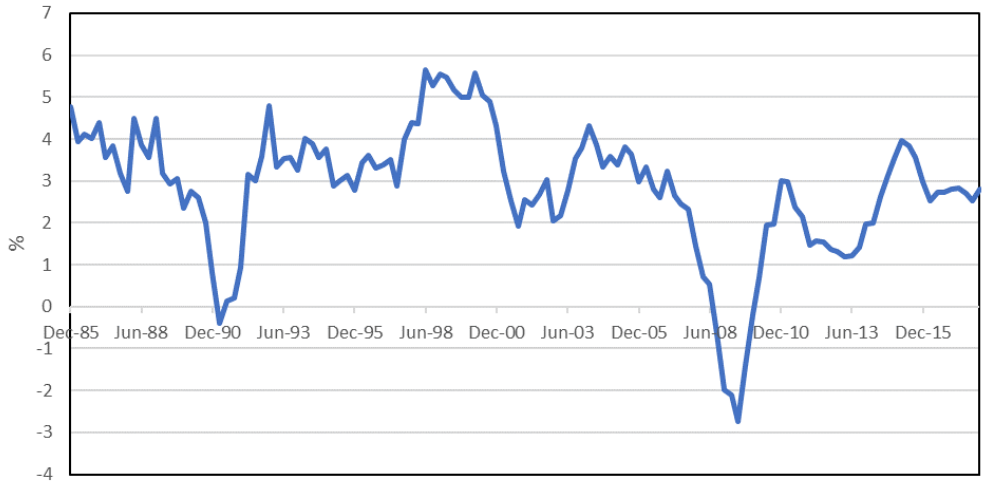


Source: FRED, Federal Reserve Bank of St. Louis

of households owns 84% of financial wealth. Considering that the lower and middle-income individuals between ages 35 and 55 are the key drivers of consumer spending and the overall economic output, the change in the composition of the housing wealth by age and income groups explains the slow recovery of consumption in post-crisis period.

Figure 4.4 plots annual changes in real household wealth and personal consumption expenditures in the United States from 1985 to 2017. The contemporaneous correlation between changes in housing wealth and consumption is 0.67. This correlation is larger than the correlation between changes in financial wealth and consumption, which is equal to 0.47. However, one can see that after Great Recession both the real housing wealth growth and the correlation between the changes in consumption and housing wealth are lower than those levels before Great Recession, presumably, for the reasons explained above. Also, despite the home prices are close to their pre-crisis level, people extract much less equity from their homes now. That is, because older and more creditworthy borrowers, the main owners of housing wealth after the Great Recession, have a lower appetite for equity withdrawal, as

Figure 4.3: Annual Changes in Consumption



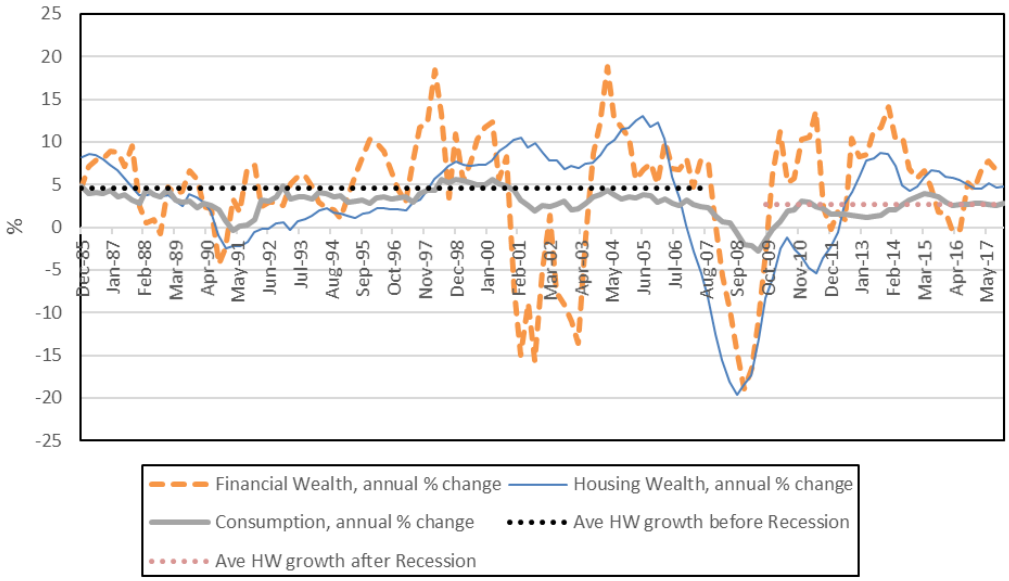
Source: FRED, Federal Reserve Bank of St. Louis

their demand for credit is lower in general[5]. Figure 4.5 shows total owner's equity in real home equity which has surpassed its pre-crisis peak and home equity withdrawals, as proxied by the changes in mortgage balances due to refinances or junior liens, which remains subdued (Aladangady and Feiveson, 2018).

In Figure 4.6 one can see that the changes in the housing wealth and primary mortgage market spread, which is defined as a difference between the average interest rate on newly issued mortgages at 30-year maturity and the government bond rate of the corresponding maturity, are less correlated compare to the changes in the financial wealth and the mortgage spread over the period from 1985 to 2017. While decrease in mortgage spreads did not lead to increase in home prices, hence, housing wealth, it did lead to increase in financial wealth. The lower yields on relatively less risky agency-guaranteed mortgages force investors, who need higher spreads and yields to achieve target returns, into riskier asset classes such as equities and corporate bonds leading to higher prices for those financial assets. The slowdown in consumption growth is explained by the slower housing wealth growth which is in turn explained by the tight credit standards and reduction in homeownership, especially for the young, and concentration of housing wealth in older and more wealthier generations who

[5] http://libertystreeteconomics.newyorkfed.org/2017/02/houses-as-atms-no-longer.html

Figure 4.4: Annual Changes in Household Wealth and Consumption in the U.S.



Source: FRED, Federal Reserve Bank of St. Louis, Author's Calculations

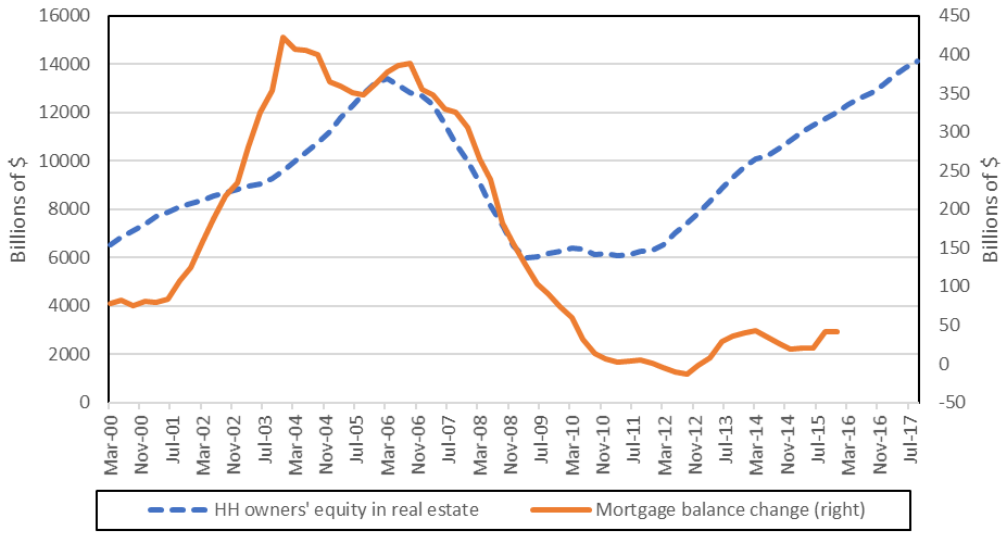
have lower appetite for equity extraction and consumption. The reduction in MBS spreads from quantitative easing has only been partially passed through to borrowers, leading to historically high values primary-secondary spread, the spread between mortgage rates and MBS yields, which impede the transmission of monetary policy to the housing sector.

4.4 Primary-Secondary Mortgage Spreads

As of the first quarter of 2018, of the slightly more of $10 trillion housing debt outstanding, approximately $6.0 trillion is Agency MBS, that is, more than half of the total family mortgage credit in the U.S. is eventually securitized into Agency MBS in the secondary market. Principal and interest payments on the mortgage loans are passed through to investors and are guaranteed by the government-sponsored enterprises (GSEs) Fannie Mae or Freddie Mac or by the government organization Ginnie Mae[6]. Hence, Fannie Mae, Freddie Mac, and Ginnie Mae improve the flow of funds to the mortgage market by bearing the credit risk of

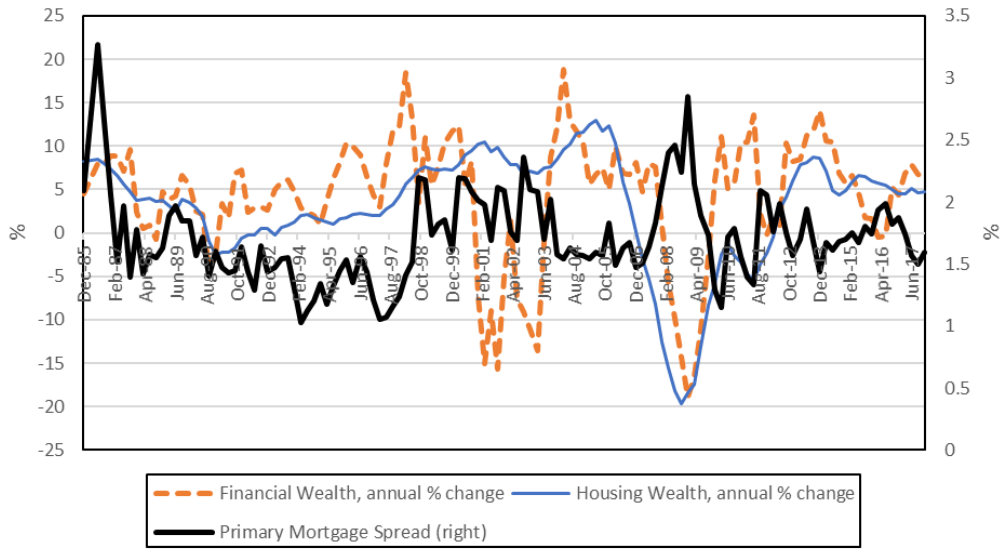
[6]Fannie Mae is the Federal National Mortgage Association (or FNMA); Freddie Mac is the Federal Home Loan Mortgage Corporation (FHLMC; also FGLMC); Ginnie Mae is the Government National Mortgage Association (GNMA).

Figure 4.5: Total Equity vs Equity Withdrawal



Source: Aladangady and Feiveson (2018), Financial Account of the United States

Figure 4.6: Annual Changes in Household Wealth and Mortgage Spread



Source: FRED, Federal Reserve Bank of St. Louis, Bloomberg Author's Calculations

the underlying loans. The investors in Agency MBS securities face only interest rate and prepayment risk - the risk that borrowers may refinance the loan when rates fall and may prepay at the lower-than-expected speeds when rates rise.

Fannie Mae and Freddie Mac focus on mortgages of a certain size originated through private-sector programs and are referred to as conventional conforming loans. Ginnie Mae

focuses on loans originated under programs of the Federal Housing Administration, a government organization devoted to improving of financing for low-cost housing, and under programs of the Veterans Administration, an organization devoted to helping former members of the U.S. military. The paper applies directly to conventional mortgage securitized by the GSEs Fannie Mae and Freddie Mac as the process of securitization through Ginnie Mae is similar.

Creating a mortgage-backed security involves the following steps:

1. Borrowers submit applications for new loans or for refinancing existing loans. The originator processes the loan application and work with the agency to ensure that the loans meet underwriting criteria such as loan amount and credit quality.

2. As loans close, the originator packages the loans into pools.

3. Once an originator chooses to securitize the loan in an agency MBS pool, it selects from different securitization coupons in the increments of 50 basis points. The originator delivers the pool of loans to the agency in exchange for MBS to fund the loans, while retaining 25-50 basis points of the pools' annual cash flows to cover the costs of servicing the loans. The GSEs require the servicer to collect at least 25 basis points in servicing the loan (collecting payments from the borrower), known a "base servicing" fees.

4. The agency creates MBS, which "passes through" to prospective investors all scheduled and prepaid principal and all scheduled interest reflected in the coupon rate from the underlying loans except the servicing fees and the agency guarantee fee, known as "g-fees". "G-fees" are intended to cover the credit risk and other costs that the Enterprises expect to incur in providing their guarantee on MBS. Until 2012, the g-fees averaged approximately 20 basis points per year. During 2012 they rose to approximated 40 basis points due to 10-basis-point increase to fund the 2012 payroll tax reduction and another 10-basis-point increase mandated by the Federal Housing Finance Agency (FHFA) (Fuster et al., 2013). In 2013-2015 g-fees averaged around 55 bps (FHFA,

2016). Also, since 2007 the GSEs charge a separate up-front insurance premium (UIP) due upon delivery of loan, known as the loan-level price adjustment (LLPA), which includes fixed charge for all loans plus additional loan-specific charges that depend on loan characteristics such as the term of the loan, the Loan-to-Value (LTV), and the borrower's FICO score.

5. The originator sells MBS pools "forward" in the TBA (to-be-announced) market at a TBA price per $100 par to be delivered on the contractual settlement day in the future (one, two or three months in the future) to the investor. In the TBA market, the buyer and the seller agree on a pool type, coupon, amount, settlement date and a price and trade on these terms. The detailed pool characteristics are not known until two days prior settlement date. While the originator is closing loans, packaging them into pools and securitizing them through the agency, selling the pools in the TBA market allows originators to eliminate the risk of the interest rate change and of the recovery less than par for the original pool.

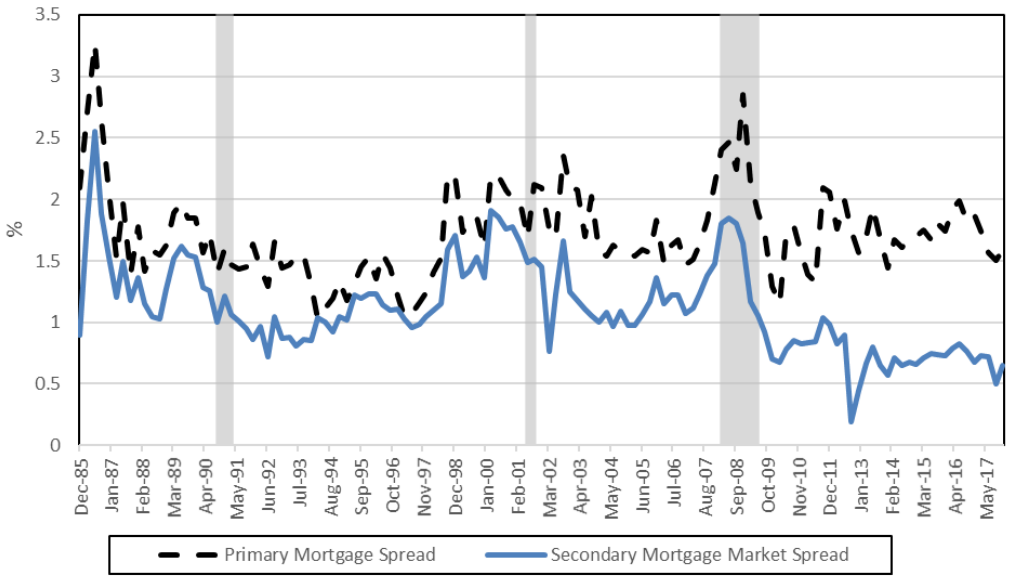
The steps of creating mortgage pass-through help to explain the components of the primary mortgage rate. The primary mortgage rate is the rate charged for a good quality mortgage. In the primary mortgage market, originators make loans to borrowers at the primary mortgage rate. To replenish the funds loaned to the borrowers, originators securitize these loans into MBS and sell to investors in the secondary mortgage market. Hence, the primary mortgage rate can be viewed as a combination of the primary-secondary spread[7] and secondary mortgage market rate, which, in turn, is a combination of secondary mortgage market spread[8] and the yield on the comparable Treasury security (Kasymova, 2017). The

[7]The primary-secondary spread is calculated as the difference between average mortgage interest rate (primary mortgage market rate) paid by borrowers and the secondary mortgage market rate, a representative yield on the newly issued MBS for conforming loans implied by TBA prices and guaranteed by the GSEs - "the current-coupon rate" - paid to the investors. Thus, the spread is a measure of the revenue going to mortgage originators and servicers.

[8]The secondary mortgage market spread is calculated as a difference between the secondary mortgage market rate, a representative yield on the newly issued agency MBS - "the current-coupon yield" - and the yield on the comparable Treasury security. "Comparable" is a Treasury security with the same maturity as

secondary mortgage spread measures the compensation for the credit risk, prepayment risk and liquidity risk to the investor for investing in a non-Treasury security rather than a Treasury security with the same maturity. Figure 4.7 shows the time series of the primary mortgage market spread, which is defined as a difference between the primary mortgage market rate and 10-year Treasury rate, and the secondary mortgage market spread. The gap

Figure 4.7: Mortgage Spreads

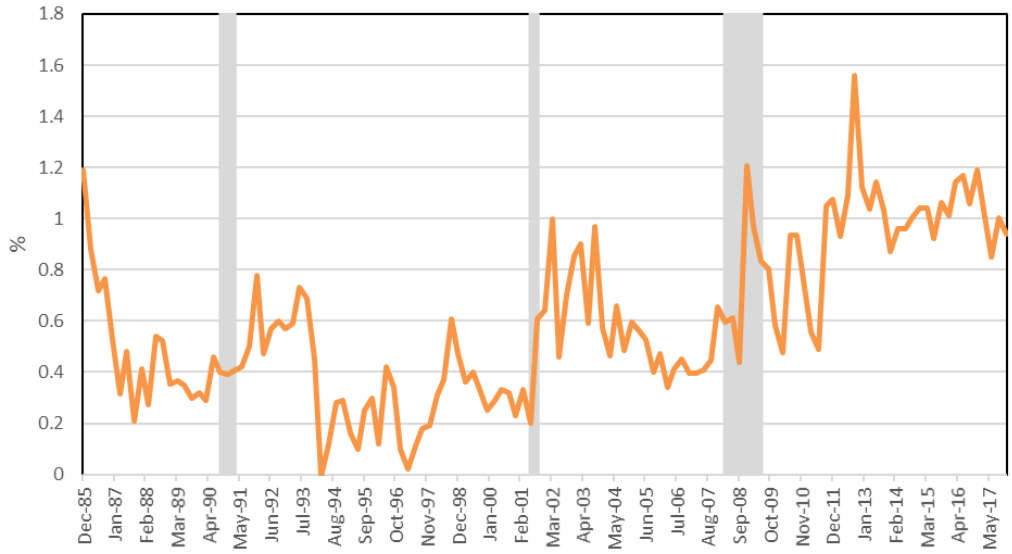


Source: Bloomberg. Shaded areas indicate recession periods as dated by the National Bureau of Economic Research (NBER)

between primary and secondary mortgage spreads, a primary-secondary mortgage spread, has widened considerably since the introduction of QE, suggesting that declines in primary mortgage rates did not keep pace with declines in secondary mortgage market rates driven by the MBS purchasing program of QE. In Figure 4.8 the primary-secondary mortgage spread was relatively stable from 1995 to 2000, at about 30 basis points; it widened to about 50 basis points through early 2008, but then reached more than 100 basis points during the QE1 announcement in November 2008 and rose more than 150 basis points during the QE3 announcement in September 2012.

the average life of the mortgage-backed security or with maturity 10 years often used by investors for the computing the measures of relative value.

Figure 4.8: Primary-Secondary Mortgage Spread



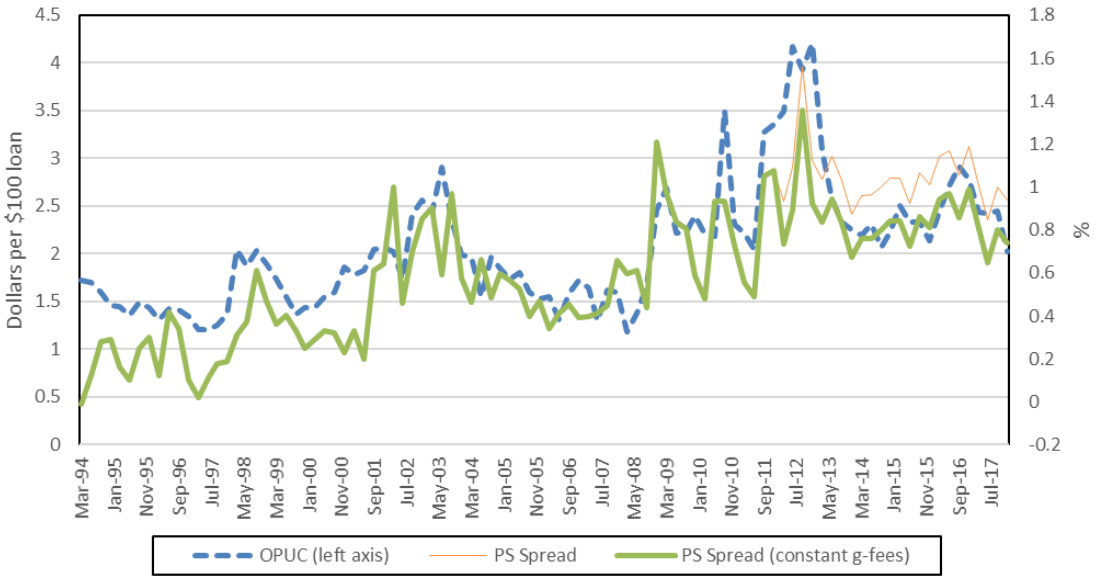
Source: Bloomberg, Author's calculations. Shaded areas indicate recession periods as dated by the National Bureau of Economic Research (NBER)

The primary-secondary spread reflects the GSEs' "g-fees" and the originator profits and unmeasured costs per loan (OPUCs). The originator profits and unmeasured costs per loan are equal the sum of profits at origination and the present value of the servicing cash flow to the originator where "unmeasured costs" are all marginal costs (other than the "g-fees") of originating and servicing the loan (Fuster et al., 2013). The purpose of the OPUCs is to track how many dollars per $100 loan get absorbed by the originator as originator profits and to cover costs other than "g-fees". Figure 4.9 shows the dynamics of the primary-secondary spread and the OPUCs as the measures of the mortgage market pass-through[9]. Since 2012, "g-fees" were increased by 20 basis points, the counterfactual path for the primary-secondary spread with constant "g-fees" as of 2011 reflects the dynamics of the primary-secondary spread due to the changes solely in originator profits and costs. The OPUC measure jumped dramatically to $3.50 in early 2009 and then again in 2010. During the 2012 refinance boom, OPUCs increased further leading to the continuing rise in primary-secondary spread,

[9]OPUC stands for "originator profits and unmeasured costs" as discussed in Fuster et al. (2013). Series is a monthly (4-week moving) average and available at `https://www.newyorkfed.org/research/epr/2013/1113fust.html`.

then as interest rates increased in the second half of 2013 and into 2014, when the Federal Reserve began to taper its purchases of Treasuries and MBS, refinance and origination volume dropped, OPUCs and the counterfactual primary-secondary spread returned to the levels prior to 2012. In Figure 4.10 the gap between the actual mortgage rate and the counterfactual mortgage rate with constant primary-secondary spread as of third quarter of 2008 is mainly driven by the rise of OPUCs as the difference between the counterfactual path of mortgage rate with constant primary-secondary spread is close to the counterfactual path of mortgage rate with constant OPUCs. Fuster et al. (2013) discuss the potential explanations for the rise in OPUCs since 2008.

Figure 4.9: Primary-Secondary Spread vs OPUC



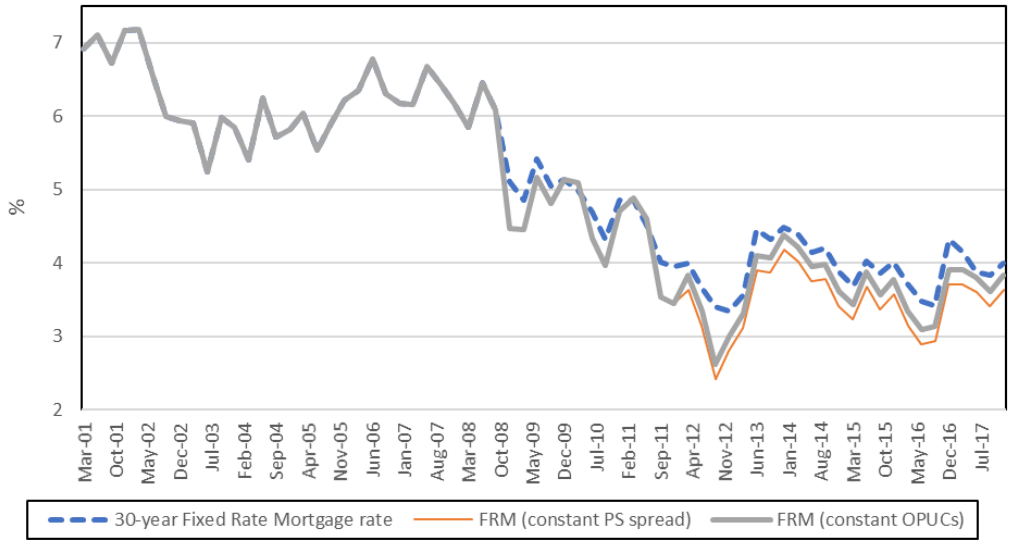
Source: Federal Reserve Bank of New York, Bloomberg, Author's calculations.

The potential explanations for the rise in costs are loan putback costs, pipeline hedging costs, only small declines in valuation of mortgage servicing rights and loan production expenses.

Loan Putback costs

As originators pay g-fees to the GSEs in exchange for the GSEs' ability to pay the principal and interest of the loan in full to the investors when the borrower is delinquent, the originators

Figure 4.10: Counterfactual Paths of Mortgage Rates since QE1 Announcement



Source: Federal Reserve Bank of New York, Bloomberg, Author's calculations.

face the risk of the loans being put back to them since they are obligated to repurchase nonperforming or defaulted loans if the loans did not meet their original underwriting or eligibility requirement. As Fuster et al. (2013) estimated a putback cost of 19 cents per $100 loan for the loans originated after 2008, they think the "true" costs of putback risk comes from originators trying to avoid putbacks at first place by spending more resources on underwriting new loans.

Mortgage Servicing Rights (MSR) Values

According to Fuster et al. (2013) a decline since 2008 in the mortgage servicing rights values, which are defined as the net present value of the servicing revenue components less expenses, adjusted for expected prepayment speeds, only partially offset the OPUCs increase over the past years. The prepayment speeds (on performing or new production) and the increased costs[10] associated with servicing performing loans (performing and non-performing loans[11]) are the key drivers behind decline in servicing rights values (on performing or new

[10] `https://www.mba.org/servicing-newslink/2017/july/servicing-newslink-tuesday-7-25-17/news-and-trends/mba-chart-of-the-week-servicing-costs-per-loan-(single-family)-performing-v-non-performing`

[11] Costs associated with servicing performing loans include the base direct costs to service any loan, regardless of default status: call center, technology, escrow, cashiering, quality assurance, investor reporting

production). As interest rates dropped, prepayment speeds rose, which decreased the life and value of the MSR.

Pipeline Hedging costs

Fuster et al. (2013) conclude that the slight increase in costs of hedging of risks while the loan is in the pipeline, a channel through which an originator's loan commitment is delivered into a security, had only small impact on OPUCs. Typically, originators face two sources of risks while the loan is in the pipeline: changes in the value of the loan due to interest rate fluctuations and movements in the number of "fallouts", the fraction of rate-locks that do not lead ultimately to the originations.

Other Loan Production Expenses

According to the MBA's Quarterly Mortgage Bankers Performance Report (Fratantoni, 2016), the loan production expenses such as costs related to the underwriting of loans and to finding borrowers (sales commissions, advertising) have increased only over the recent years and exhibited fairly stable pattern over the period of 2008-2012, hence, appeared unlikely to explain the more than doubling in OPUCs over this period.

Since the higher OPUCs over the period 2008-2012 were not driven by increases in costs, they should be driven by increases in profits. However, over the recent period the higher OPUCs reflect increases in loan production expenses according to MBA's Quarterly Mortgage Bankers Performance Report in Fratantoni (2016). Figure 4.11 shows the mortgage industry profitability trends since 2003. The profit margins were at their highest level in 2012 and at their lowest level in 2017 since 2008.

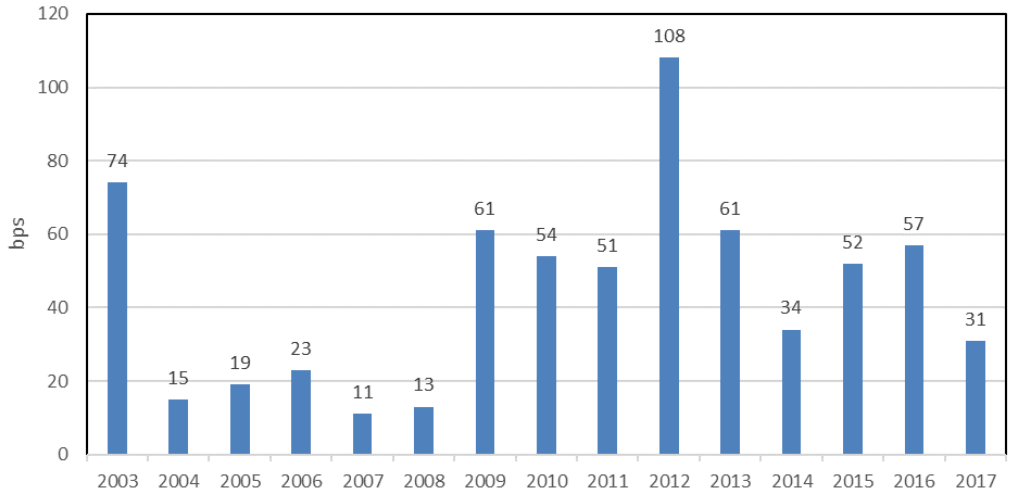
The potential explanations for the rise in profits are capacity constraints, market concentration, existence of HARP refinance loans.

Capacity Constraints

Figure 4.12 shows that the OPUC measure and MBA Refinance index are positively corre-

and executive management, among others including corporate overhead. Costs of servicing non-performing loans include the same base direct costs and corporate overhead as for performing loans, plus the following additional costs: collections, loss mitigation, bankruptcy, foreclosure and post-sale, unreimbursed foreclosure and real estate owned (REO) losses and other default-specific costs.

Figure 4.11: Pre-Tax Production Income Divided by Loan Volume (bps)



Source: MBA's Quarterly Mortgage Bankers Performance Report

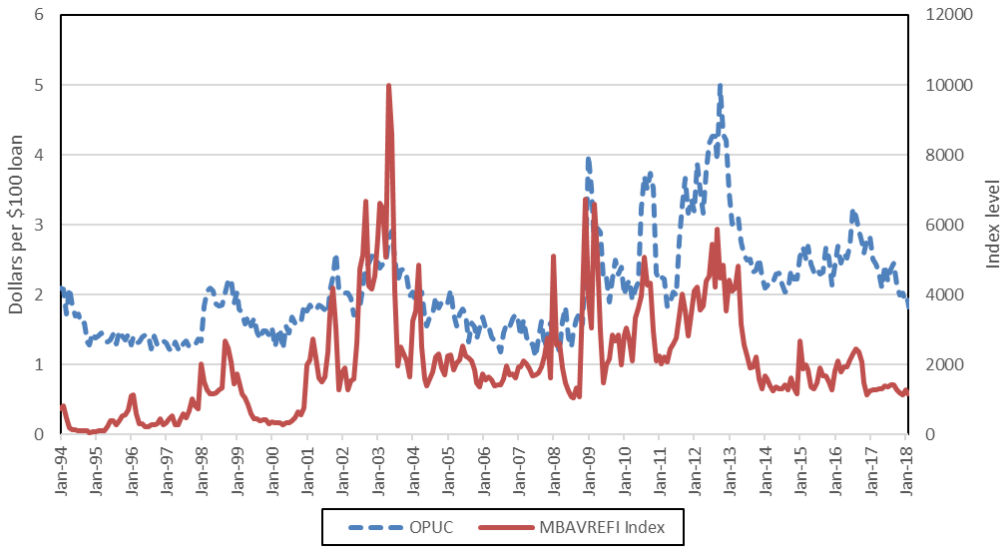
lated: whenever MBA Refinance index increases, OPUCs tend to increase, and vice-versa. When rates are lower, then refinancing volumes are increased significantly. When loan volumes are high (this includes refinances as well new purchases), the capacity constraints in the mortgage origination business become binding and originators do not lower rates as much as they would without these constraints in order to curb the excess flow of applications. Hence, the capacity constraints play an important role in generating the higher OPUCs. Consistent with this hypothesis that lenders ration the pace of production through their pricing during refinancing waves, Fratantoni (2016) shows a positive and statistically significant relationship between primary-secondary spreads and the refinance share. However, capacity constraints do not explain the full rise in the OPUCs, as in the past mortgage refinancing activity was at high levels without OPUCs being as high as they were in 2012.

Market Concentration

Another explanation for the higher profits in the mortgage origination business is the high market concentration. Scharfstein and Sunderam (2016) shows that high concentration[12] in local mortgage lending reduces the sensitivity of mortgage rates and refinancing activity to MBS yields. That is, increasing concentration by one standard deviation reduces the overall

[12]A share of the top 4 mortgage originators in the county is used as a concentration measure.

Figure 4.12: Originator Profits and Unmeasured Costs (OPUCs) and MBA Refinance Index



Source: Federal Reserve Bank of New York, Bloomberg

impact of a decline in MBS yields on mortgage rates by approximately 50%. Their conclusion is built on the literature in industrial organization that argues that when production costs fall, prices fall less in concentrated markets than they do in competitive markets because producers use their market power to capture larger profits (Rotemberg and Saloner, 1987). This suggests that when the Federal Reserve lowers MBS spreads/yields, mortgage rates will fall less in concentrated mortgage markets than in competitive mortgage markets, explained by increased OPUCs due to higher profits in the concentrated market. In other words, market power in mortgage lending explains a significant amount of the increase in the primary-secondary spread and impedes the transmission of monetary policy to the housing sector.

HARP Refinance Loans

Originators could make larger profits in the period 2008-2012 through enjoying the pricing power on some of their borrowers looking to refinance due to borrowers' switching costs. The pricing power could be exploited in the high-LTV segment, which was dominated by refinancing through HARP (Home Affordable Refinance Program), introduced in March 2009 to help underwater and near-underwater homeowners refinance their mortgages. The introduction of revised HARP rules in late 2011 such as relief from representations and

warranties for using the same servicer led to a significant increase in HARP refinancing activity. In addition, a new servicer with identical representations and warranties conditions did not want to consider high-LTV borrowers because of their high likelihood of delinquency. Hence, the current servicer has a significant pricing power over its own high-LTV borrowers looking to refinance. Fuster et al. (2013) show that lenders have been making larger profits on HARP loans than on regular loans. In addition, the originators were taking advantage of the pricing power over the streamline-eligible borrowers with non-HARP loans.

Thus, the widening gap between the primary and secondary mortgage market spreads in Figure 4.7 shows that the lower mortgage spreads in the secondary market from quantitative easing are not fully transmitted to the lower primary mortgage market spreads. The primary-secondary spread, the spread between mortgage rates and MBS yields, is higher since 2008 due to a rise in originators' profits and unmeasured costs, as well as increases in g-fees.

4.5 Data

This section documents the data, data source and sample periods used. The current study concentrates on two sample periods: small sample - the period from the first quarter of 1986 to the fourth quarter of 2008 and full sample - the period from the first quarter of 1986 to the fourth quarter of 2017, which includes QE period. The sample begins in 1986 after the Great Inflation period. Based on which aggregate variables could plausibly be affected by (or affect) the mortgage spread, the US economy is modeled using household wealth (financial or housing wealth), consumption, residential investment, GDP, price deflator, mortgage spread, policy interest rate and housing specific data. The frequency of the data is quarterly.

Financial Wealth

Financial wealth is defined as total financial asset-liabilities of households. The data are in real per capita terms. The data source is Flow of Funds Account of Federal Reserve Board.

Housing Wealth

Housing wealth is defined as the real estate wealth of households which is calculated as the sum of owner-occupied real estate, including vacant land and mobile homes and owners' equity in real estate. The data are in real per capita terms. The data source is Flow of Funds Account of Federal Reserve Board.

Consumption

The data on consumption are from national income and product accounts of U.S. Bureau of Economic Analysis and retrieved from FRED, Federal Reserve Bank of St. Louis. Consumption includes expenditure on non-durable goods and services. It is seasonally adjusted and deflated by chained weighted deflator. The data are in real per capita terms.

Residential Investment

The data on residential investment are from national income and product accounts of U.S. Bureau of Economic Analysis and retrieved from FRED, Federal Reserve Bank of St. Louis. Residential Investment includes investments in residential structures and equipment, new construction of single-family and multifamily units. It is seasonally adjusted and deflated by chained weighted deflator. The data are in real per capita terms.

Gross Domestic Product

The data on gross domestic product are from national income and product accounts of U.S. Bureau of Economic Analysis and retrieved from FRED, Federal Reserve Bank of St. Louis. Gross Domestic Product is the market value of the goods, services, and structures produced by the economy in a given period. It is seasonally adjusted and deflated by chained weighted deflator. The data are in real per capita terms.

Price Deflator

The data on gross domestic product implicit price deflator are from national income and product accounts of U.S. Bureau of Economic Analysis and retrieved from FRED, Federal Reserve Bank of St. Louis. Price Deflator is the ratio of the current-dollar value to the corresponding chained-dollar value, multiplied by 100.

Mortgage Spread

The primary mortgage market spread is defined as a difference between the average 30-year primary mortgage market rate coming from Freddie Mac's Primary Mortgage Market Survey and the yield on 10-year U.S. Treasury note. The secondary mortgage market spread (the current coupon spread) is defined as a difference between a representative yield on newly issued Fannie Mae 30-year MBS - the current-coupon yield, and the yield on 10-year U.S. Treasury note. The maturity difference between U.S. Treasury rate and mortgage rates is explained by the fact that the most of mortgages are prepaid before their maturity. The data source is Bloomberg.

Policy Interest Rate

The effective federal funds rate is the nominal interest rate at which depository institutions trade federal funds (balances held at Federal Reserve Banks) with each other overnight. The data are from Board of Governors of the Federal Reserve System and retrieved from retrieved from FRED, Federal Reserve Bank of St. Louis.

Housing Market Variable: Home Price Index

The home price index is S&P/Case-Shiller U.S. National Home Price Index from S&P Dow Jones Indices LLC and is retrieved from FRED, Federal Reserve Bank of St. Louis. It is a composite of single-family home price indices for the nine U.S. Census divisions. It measures the changes in housing market prices, given a constant level of quality in the homes. It is seasonally adjusted and deflated by chained weighted deflator.

Housing Market Variable: Existing Home Sales

The existing home sales index reflects the existing single-family home sales in number of units at seasonally adjusted annual rate. The data are from National Association of Realtors and are retrieved from FRED, Federal Reserve Bank of St. Louis.

Housing Market Variable: Housing Starts

The housing starts index reflects the new privately-owned housing units started in thousands of units at seasonally adjusted annual rate. The data are from U.S. Bureau of the Census, U.S. Department of Housing and Urban Development and are retrieved from FRED, Federal

Reserve Bank of St. Louis.

The household wealth, consumption, residential investment, GDP, price deflator and housing market variables are transformed into annualized growth rate.

Table 4.1: Descriptive Statistics

variable	min	max	mean	median	std
Housing Wealth	-0.245	0.132	0.021	0.034	0.068
Financial Wealth	-0.352	0.389	0.033	0.044	0.126
Consumption	-0.058	0.066	0.019	0.021	0.021
Resid Investment	-0.477	0.240	0.011	0.039	0.144
Real GDP	-0.095	0.065	0.016	0.020	0.023
GDP Deflator	-0.007	0.047	0.022	0.021	0.010
Primary Mortgage Spread	0.01	0.029	0.017	0.017	0.003
Secondary Mortgage Market Spread	0.002	0.02	0.01	0.01	0.004
Federal Funds Rate	0.00	0.099	0.037	0.04	0.029
Home Prices	-0.175	0.133	0.018	0.033	0.225
Existing Home Sales	-0.917	0.506	0.019	0.033	0.226
Housing Starts	-1.526	0.838	-0.007	0.022	0.363

All variables except spreads and federal funds rate are transformed in annualized rate of growth. Spreads and federal funds rate are in annual percentage rate. Units of measurement are decimal.

4.6 Empirical Methodology and Initial Results

The goal of this section is to determine whether mortgage spreads affect the macroeconomy and document the importance of mortgage spread innovations for aggregate quantities. The results of the section help to answer the question, whether unconventional monetary policy such as Federal Reserve's MBS purchase program has effect on the business cycle through mortgage spreads. A structural VAR provides a convenient and powerful framework for policy effectiveness analysis. The dynamic interactions between the variables in the model are summarized using the impulse response functions and the Granger causality tests. The following multivariate triangular structural VAR(2) model with a time lag of order two[13] is

[13]The lag length for the VAR(p) model is determined using AIC and BIC information criteria. Since the AIC penalizes the number of parameters less strongly than the BIC does, we chose the lag length p = 2 based on BIC.

estimated:

$$Beta * Y_t = c + \Gamma_1 Y_{t-1} + \Gamma_2 Y_{t-2} + \eta_t, \tag{4.1}$$

where

$$Beta = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ -\beta_{21} & 1 & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots \\ -\beta_{n1} & -\beta_{n2} & \cdots & 1 \end{pmatrix};$$

Y_t represents a multivariate vector of dimension $n = 8$ quarterly stationary time series[14]; c is a n-dimensional vector; Γ_1 is $n \times n$ matrix of coefficients; η_t is a n-dimensional vector of orthogonal errors with diagonal covariance matrix. Based on which agreggate variables could be potentially driven by the mortgage market spreads, the VAR includes in vector Y_t the following variables: household wealth (financial or housing wealth), consumption, residential investment, GDP, price deflator, mortgage spread (primary mortgage market spread or secondary mortgage market spread), policy interest rate and one housing specific variable. A housing specific variable is chosen from the following list of housing variables: housing price index, existing home sales and housing starts. The household wealth, consumption, residential investment, GDP are in real per capita terms. All variables except mortgage spread and federal funds rate are transformed into annualized growth rate. The frequency of the data is quarterly. The analysis starts with the estimation period for the full sample from the first quarter of 1986 to the fourth quarter of 2017. The triangular structural model (4.1) imposes the following recursive causal ordering:

$$y_1 \to y_2 \to \cdots \to y_n. \tag{4.2}$$

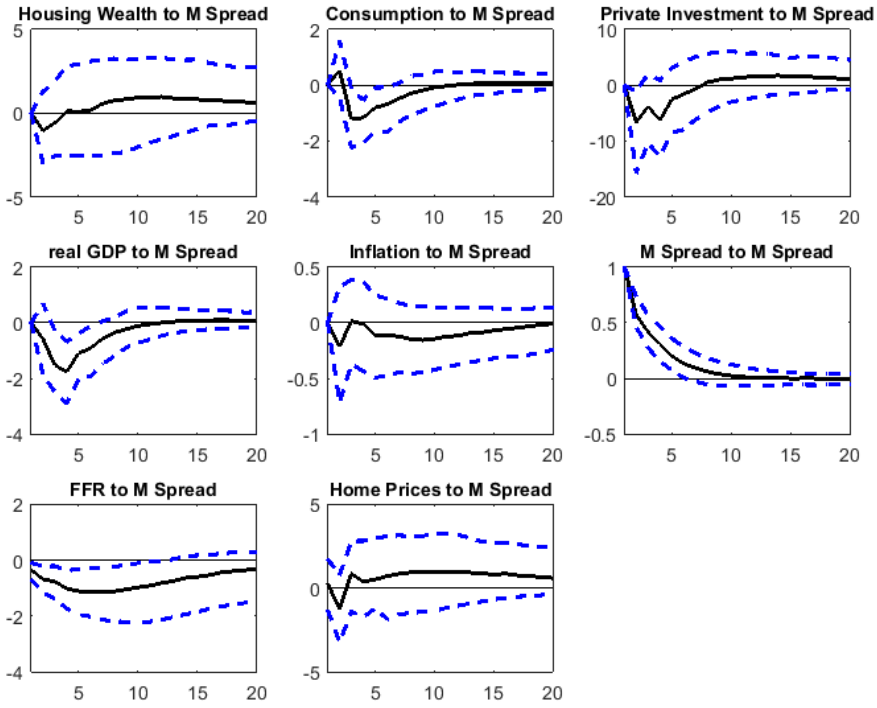
[14]The appropriate transformation of time series is applied to satisfy a stationarity assumption.

The ordering (4.2) means the following restrictions: y_{1t} affects $y_{2t}, \cdots, y_{nt}$ contemporaneously, but $y_{2t}, \cdots, y_{nt}$ do not affect y_{1t}; y_{2t} affects $y_{3t}, \cdots, y_{nt}$, but $y_{3t}, \cdots, y_{nt}$ do not affect y_{2t}; and so on. The order of the variables reflects identifying assumptions on impact restrictions. The identification restriction is that the mortgage spread shocks are allowed to impact the federal funds rate and housing variables contemporaneously (within the quarter) and do not affect the aggregate quantities and inflation contemporaneously following the order from Walentin (2014). Alternative identifying restrictions are explored in the robustness section.

After the assumptions about the causal structure of the data are imposed, the causal impacts of unexpected shocks on the variables in the model can be summarized with impulse response functions. See Appendix for the definition of impulse response functions. The impulse response function shows how one variable responses to an impulse in another variable in a system that involves a number of further variables. Impulse responses trace out the response of current and future values of each of the variables to a one unit increase in the current value of one of the VAR errors, assuming that this error is zero in subsequent periods and that all other errors are equal to zero.

Figure 4.13 displays the impulse response functions of Home Prices, Housing Wealth and Residential Investments to primary mortgage market spread unit shock for 20 quarters. A VAR(2) model with primary mortgage spread as a mortgage spread, housing wealth as a household wealth and housing prices as a housing variable is estimated for the full sample period. A 100 bps shock to the morgage spread reduces GDP growth by 1.9 percent and consumption growth by 1% at three quarters horizon. The federal funds rate falls by 1% the most at 5 quarters. A possible interpretation of the response of the policy rate in the later quarters is that policymakers are well aware of the contractionary effects of mortgage rates as pointed in Walentin (2014). The mortgage spread shock has no significant impact on the housing wealth, private investment, inflation and home prices as the entire 90 percent probability band of the responses includes zero. These results can be compared with the results from Walentin (2014). In Walentin's VAR model with identifying assumptions on

Figure 4.13: Impulse Response Functions of Home Prices, Housing Wealth and Residential Investments to Primary Mortgage Market Spread Shocks

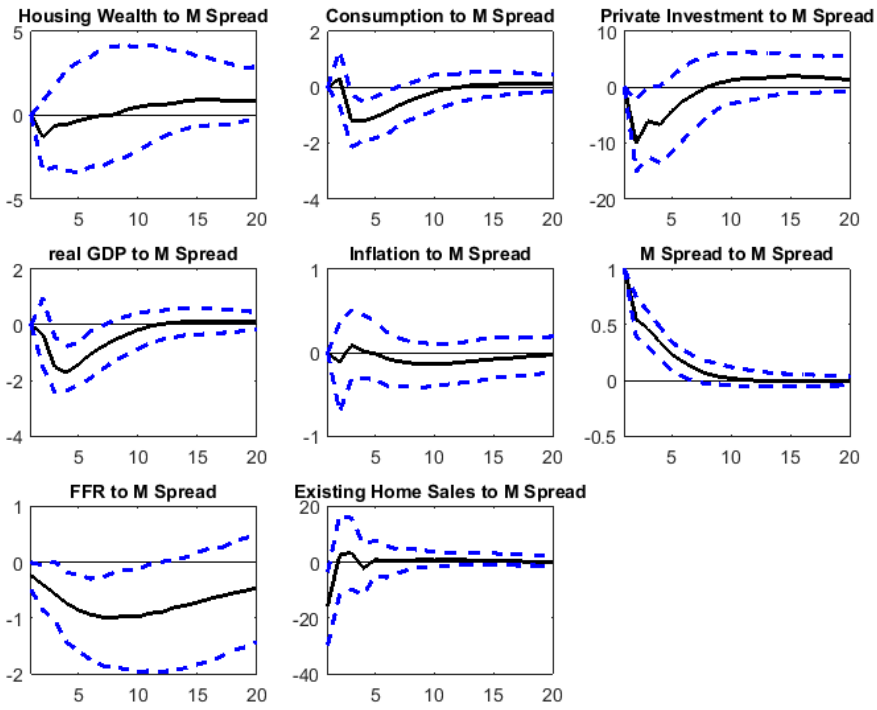


Notes: Estimation period: 1986Q1 - 2017Q4. The number of steps: 20 quarters. Mean and 90% probability bands.

impact restrictions: consumption, residential investment, GDP, consumper prices, mortgage spread, federal funds rate and home prices, mortgage spread shocks have significant impact on consumption, GDP and federal funds rate and small impact on residential investment and home prices. The insignificant relationship between mortgage spreads and home prices is in line with the historical observation that trends in house prices are not sensitive to movements in the mortgage rate (McManus and Yannopoulos, 2018).

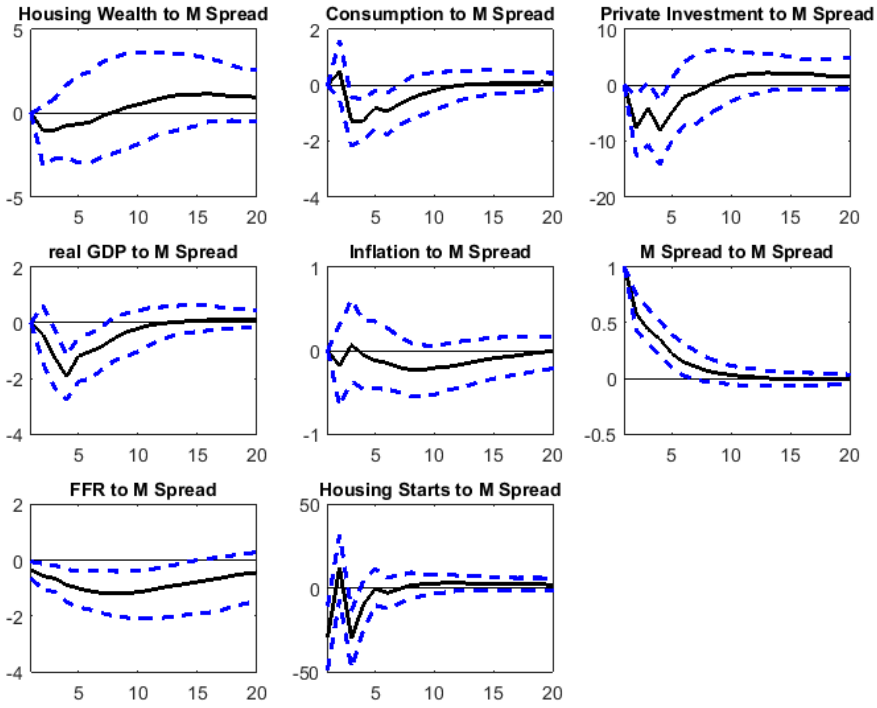
Figure 4.14 displays the impulse response functions of the same VAR(2) model as in previous figure, with the exception of existing home sales used as a housing variable. As before the maximum impact of the primary mortgage market spread on consumption and real GDP at three quarters horizon and on the federal funds rate at 5-6 quarters. The

Figure 4.14: Impulse Response Functions of Existing Home Sales, Housing Wealth and Residential Investments to Primary Mortgage Market Spread Shocks



Notes: Estimation period: 1986Q1 - 2017Q4. The number of steps: 20 quarters. Mean and 90% probability bands.

Figure 4.15: Impulse Response Functions of Housing Starts, Housing Wealth and Residential Investments to Primary Mortgage Market Spread Shocks



Notes: Estimation period: 1986Q1 - 2017Q4. The number of steps: 20 quarters. Mean and 90% probability bands.

primary mortgage market spread shock has the contractionary but not significant impact on the housing wealth, private investment, inflation and existing home sales.

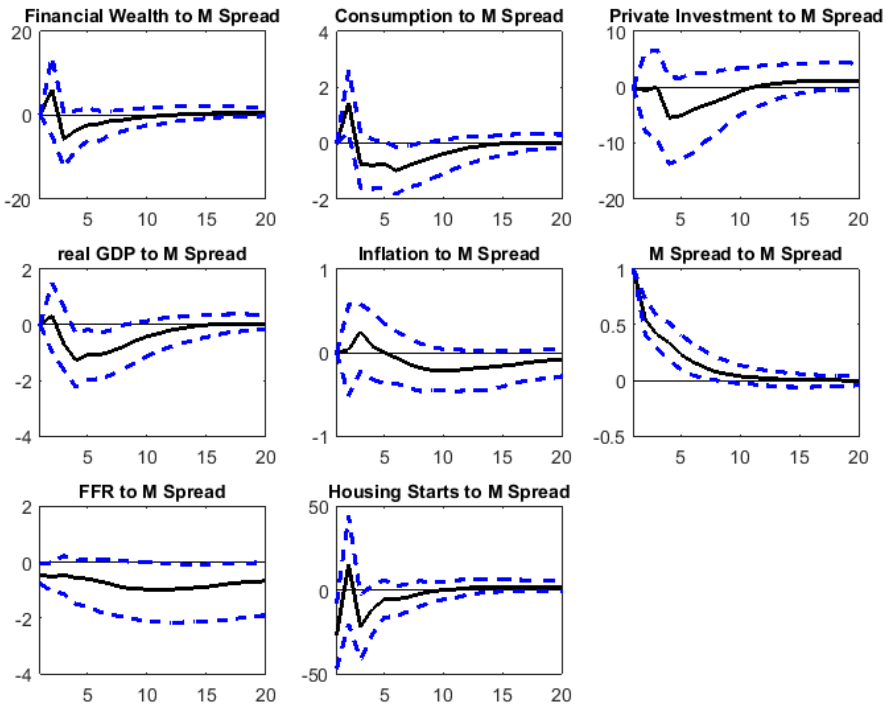
Figure 4.15 displays the impulse response function of the VAR(2) model with primary mortgage spread as a mortgage spread, housing wealth as a household wealth and housing starts as a housing variable. A shock to the primary mortgage market spread has a negative impact on the consumption, private investment, real GDP, federal funds rate and housing starts. The largest effect on the aggregate quantities occurs after 3 quarters. A 100 bps shock to the mortgage spread reduces GDP growth by 1.9 percent. Consumption growth responds slighly less with 1.3 percent decline, while residential investments growth responds more with 8.3 percent decline. A 100 bps shock to the morgage spread reduces the most the

housing starts annualized growth by 30 percent at the second quarter horizon. It is expected that housing specific variable reacts earlier than aggregate variables do as mortgage spread shocks should have direct effect on the housing market. The increasing mortgage rates has direct effect on the borrowers' decision to which home to buy, when to buy and how much to borrow. As mortgage rates rises, the monthly payments required to purchase a home rises. Some households may compensate for this by choosing a lower-priced home, while other may find that they can no longer afford to own a home and choose to rent. Fewer home sales lead to a reduction in the demand for construction of new homes. There is usually delay in this impact because of the lapse in time between the decision to build a house and the start of construction. Typically, new construction of single-family homes falls as mortgage rates increase, but usually three to six months after rates start to climb (Freddie Mac, 2018). As before the primary mortgage market spread shock has no significant impact on the inflation and housing wealth.

Figure 4.16 displays the impulse response functions of the VAR(2) model with primary mortgage spread as a mortgage spread, financial wealth as a household wealth variable and housing starts as a housing variable. Once the financial wealth variable is included in the system, the impact of the shock on primary mortgage market spread is insignificant for all variables in the system except real gdp. This could be explained by the positive correlation of financial wealth and 1-quarter lagged mortgage spread and identification restriction with contemporaneous relationship of financial wealth with aggregate variables in the economy. The negative impact of mortgage spread shock on aggregate variables is offset by the positive impact of rising financial wealth on the aggreate variables. The alternative identification restrictions are explored in the robustness check section.

Due to the complicated dynamics in the VAR, another form of structural analysis, Granger-causality tests, are employed. Granger-causality statistics examine whether lagged values of one variable helps to predict another variable. That is, one variable x fails to Granger-cause another variable y, if all of the coefficients on the lagged values of the variable

Figure 4.16: Impulse Response Functions of Housing Starts, Financial Wealth and Residential Investments to Primary Mortgage Market Spread Shocks



Notes: Estimation period: 1986Q1 - 2017Q4. The number of steps: 20 quarters. Mean and 90% probability bands.

x are zero in the equation for another variable y. Table 4.2 shows the results of Granger-causality testing in a VAR(2) model with primary mortgage market spread as a mortgage spread variable, financial wealth as a household wealth variable and housing starts as a housing variable. The p-values for the Granger non-causality tests indicate strong rejection of the null that mortgage spread does not Granger cause financial wealth, consumption or real gdp but only very weak rejection of the null that mortgage spread does not Granger cause the residential investment. Hence, the lagged values of the primary mortgage spread appear to be useful for forecasting future values of financial wealth, consumption or real gdp, but not very useful for forecasting future values of residential investment. The positive one-lag response of the financial wealth to the mortgage spread dampens the contractionary impact of mortgage spreads on the aggregate quantities. This contradicts the result of Walentin (2014) that shock to the mortgage spread results in a decline in residential investment. Table 4.3 shows the results of Granger-causality testing in a VAR(2) model with primary mortgage market spread as a mortgage spread variable, housing wealth as a household wealth variable and housing starts as housing variable. The p-values for the Granger non-causality tests indicate strong rejection of the null that mortgage spread does not Granger cause consumption, residential investment, real gdp and housing starts and no rejection of the null that mortgage spread does not Granger cause the housing wealth. The lagged values of the primary mortgage spread appear to be useful for forecasting future values of consumption, residential investment, real gdp and housing starts. This alligns with the result of Walentin (2014) and consistent with the hypothesis that mortgage spread innovations should be interpreted as credit supply shocks. Hence, for the further analysis, VAR(2) model with housing wealth as a household wealth variable is chosen.

Table 4.2: Primary Mortgage Market Spread, Financial Wealth and Macroeconomy: Granger Causality Tests (1986-2017 Sample)

FW → cons	FW → resinv	FW → GDP	FW → Infl	FW → MSpread	FW → FFR	FW → HS
0.04	**0.09**	**0.10**	**0.04**	0.33	0.08	0.94
cons → FW	cons → resinv	cons → GDP	cons → Infl	cons → MSpread	cons → FFR	cons → HS
0.65	0.24	0.01	0.70	0.88	0.00	0.09
resinv → FW	resinv → cons	resinv → GDP	resinv → Infl	resinv → MSpread	resinv→ FFR	resinv → HS
0.37	0.01	0.00	0.91	0.28	0.26	0.00
GDP → FW	GDP → cons	GDP → resinv	GDP → Infl	GDP → MSpread	GDP → FFR	GDP → HS
0.53	0.32	0.05	0.30	0.65	0.60	0.28
Infl → FW	Infl → cons	Infl → resinv	Infl → GDP	Infl → MSpread	Infl → FFR	Infl → HS
0.24	0.06	0.66	0.38	0.44	0.06	0.48
MSpread→ FW	MSpread→ cons	MSpread→ resinv	MSpread→ GDP	MSpread→ Infl	MSpread→ FFR	MSpread→ HS
0.05	**0.01**	**0.10**	**0.01**	0.73	0.24	**0.01**
FFR → FW	FFR → cons	FFR → resinv	FFR → GDP	FFR → Infl	FFR → MSpread	FFR → HS
0.13	0.04	0.38	0.01	0.41	0.67	0.37
HS → FW	HS → cons	HS → resinv	HS → GDP	HS → Infl	HS → MSpread	HS → FFR
0.29	0.07	0.00	0.20	0.49	0.22	0.05

Note: The table reports p-values for Granger non-causality tests. p-values in bold indicate the significant test statistics.

Table 4.3: Primary Mortgage Market Spread, Housing Wealth and Macroeconomy: Granger Causality Tests (1986-2017 Sample)

HW → cons	HW → resinv	HW → GDP	HW → Infl	HW → MSpread	HW → FFR	HW → HS
0.00	**0.00**	0.84	0.23	0.70	0.50	**0.09**
cons → HW	cons → resinv	cons → GDP	cons → Infl	cons → MSpread	cons → FFR	cons → HS
0.56	0.43	0.04	0.83	0.92	0.00	0.05
resinv → HW	resinv → cons	resinv → GDP	resinv → Infl	resinv → MSpread	resinv→ FFR	resinv → HS
0.10	0.70	0.09	0.45	0.77	0.4	0.00
GDP → HW	GDP → cons	GDP → resinv	GDP → Infl	GDP → MSpread	GDP → FFR	GDP → HS
0.55	0.01	0.09	0.28	0.72	0.45	0.23
Infl → HW	Infl → cons	Infl → resinv	Infl → GDP	Infl → MSpread	Infl → FFR	Infl → HS
0.06	0.03	0.54	0.23	0.37	0.07	0.17
MSpread→ HW	MSpread→ cons	MSpread→ resinv	MSpread→ GDP	MSpread→ Infl	MSpread→ FFR	MSpread→ HS
0.58	**0.03**	**0.02**	**0.02**	0.77	0.18	**0.01**
FFR → HW	FFR → cons	FFR → resinv	FFR → GDP	FFR → Infl	FFR → MSpread	FFR → HS
0.46	0.14	0.03	0.14	0.47	0.89	0.32
HS → HW	HS → cons	HS → resinv	HS → GDP	HS → Infl	HS → MSpread	HS → FFR
0.76	0.33	0.00	0.12	0.74	0.34	0.34

Note: The table reports p-values for Granger non-causality tests. p-values in bold indicate the significant test statistics.

4.7 Robustness

The VAR specification is altered in the following ways to document the robustness of the initial results and to investigate the effectivess of unconventional monetary policy: (i) the sample period is shortened to 1986Q1-2008Q4; (ii) the use of a secondary mortgage market spread, a spread measure that is directly impacted by the Fed's MBS purchase program; (iii) the change of the ordering of variables so that mortgage shocks affect fewer variables contemporaneously.

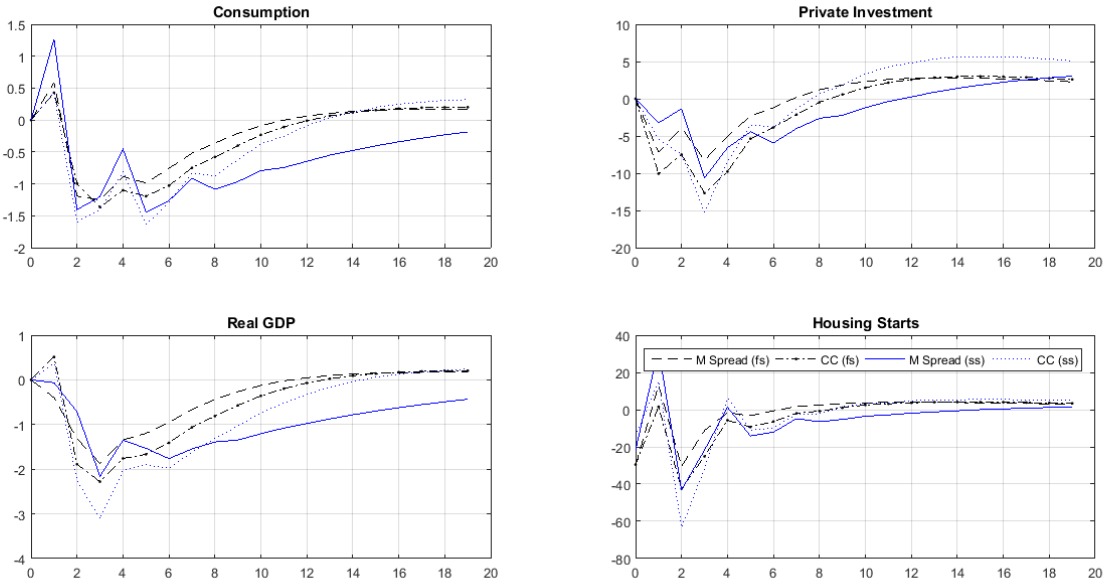
Figure 4.17 provides the comparison between the impulse response functions of four VAR(2) models estimated over the small sample period, from 1986Q1 to 2008Q4, and full sample period, from 1986Q1 to 2017Q4, with housing wealth as a household wealth, housing starts as a housing variable and primary mortgage market spread or secondary mortgage market spread as a mortgage spread. A 100 bps shock to the primary mortgage market spread has a larger negative effect on the aggregate quantities and housing starts in the model estimated over earlier period from 1986Q1 till 2008Q4 than it has in the model estimated over longer period including QE period. The estimated impact of primary mortgage spread shock on GDP growth is in the interval $(-1.9, -2.2)$ percent with the smaller sample yielding larger impact. The corresponding intervals for consumption are $(-1.3, -1.4)$, for residential investment $(-8.3, -10.6)$ and for housing starts $(-30.4, -43.2)$. The largest effect on the aggregate quantities occurs after 3 quarters and on the housing starts after 2 quarters. This confirms that the mortgage spread shocks impact the real economy by both economically and statistically significant magnitudes. In addition, we observed that the transmission of monetary policy directly to the real economy and to the housing or through housing to the real economy was impeded over the recent period including QE period since the magnitude of impact of the mortgage spreads was smaller over the recent longer sample. In order to investigate the transmission of unconventional monetary policy to the real economy, the VAR(2) model with secondary mortgage market spread, which is directly impacted by the Fed's MBS purchase program, is estimated for the full and small samples. The difference be-

tween the impacts of secondary mortgage spreads on the aggregate variables estimated over the full sample and over the small sample is larger than this difference between the impacts of primary mortgage market spreads on the aggregate variables. The larger decline in the impact of secondary mortgage market shocks on the aggregate variables indicates the decay in the transmission of the impact of the Feds MBS purchases from the secondary mortgage market to the primary mortage market. That means that the shocks to current coupon spreads (secondary mortgage market spreads) are not one-to-one transmitted to the primary mortgage market spreads explained by the widening of the primary-secondary spread over the recent period for the reasons mentioned in earlier section. Hence, the reduction in MBS spreads from quantitative easing has only partially passed through to borrowers and to the real economy. Consistent with Walentin's (2014) findings that the shocks to the secondary mortgage spread rather to the primary-secondary mortgage spread affect the macroeconomy, the impact of the secondary mortgage market spreads on the aggregate quantities and housing starts in the model estimated over the small and full sample periods is larger than it is in the VAR model with the primary mortgage market spread as a mortgage spread measure. The estimated impact of secondary mortgage spread shock on GDP growth is in the interval $(-2.3, -3.1)$ percent with the smaller sample again yielding larger impact. The corresponding intervals for consumption are $(-1.4, -1.6)$, for residential investment $(-12.7, -15.2)$ and for housing starts $(-42.5, -63.3)$. Again, the largest effect on the aggregate quantities occurs after 3 quarters and on the housing starts after 2 quarters. The differences between impacts of primary mortgage market spread and secondary mortgage market spreads on GDP, residential investments and housing starts are especially large. Thus, the monetary policy with the focus on the MBS yields and the secondary mortgage spreads would be more effective in impacting the economy and housing market, if the transmission from the secondary market to the primary market was part of the focus of the monetary policy.

Finally, the change in the ordering the ordering of variables so that mortgage shocks affect fewer variables contemporaneously produces the model with roughly similar results

(not reported).

Figure 4.17: Impulse Response Functions to Primary and Secondary Mortgage Market Spread Shocks estimated over Full and Small Samples



Notes: VAR(2) model with housing wealth variable. M Spread stands for primary mortgage market spread. CC stands for the current coupon mortgage spread or secondary mortgage market spread. Small Sample (ss): 1986Q1 - 2008Q4. Full Sample (fs): 1986Q1 - 2017Q4. The number of steps: 20 quarters. Mean and 90% probability bands.

4.8 Conclusion

This paper explored the macroeconomic effects of shocks to the residential mortgage spreads and whether the Federal Reserve's MBS purchase program has fully reached real economy through impact on borrowing costs. The structural VAR with recursive ordering was employed for the analysis. The main result is that mortgage spread shocks can have sizeable effects on the macroeconomy. The result is robust to variations in the VAR specification. The results indicate that the reduction in mortgage spreads from the Federal Reserve's MBS purchase program has only partially passed through to borrowers due to widening of the

primary-secondary mortgage market spread - the spread between mortgage rates and MBS yields - leading to the slow recovery of consumption in post-crisis period. Quantitatively, considering all reasonable VAR specification and data samples, a 100 bps decrease in the mortgage spread yields an increase in GDP between 1.9 percent and 3.1 percent.

There are several takeaways from this research. First, business cycle fluctuations are affected by mortgage spreads. Second, the reduction in mortgage spreads from the Federal Reserve's MBS purchase program has only partially passed through to borrowers due to widening of the primary-secondary spread, the spread between mortgage rates and MBS yields, explaining the slow recovery of consumption in post-crisis period. Third, the transmission of monetary policy indirectly to the real economy through housing was impeded by the partial transmission of lower interest rates to young, lower FICO score, and, presumably, lower income individuals, who represent the key group of consumers. Finally, unconventional monetary policy in the form of the mortgage-backed securities purchases can have sizable effects on the aggregate quantities and housing market if the transmission of its impact from the secondary to the primary mortgage market, or in other words, from lenders to borrowers is part of its focus. The shocks to secondary mortgage market spreads are not one-to-one transmitted to the primary mortgage market spreads explained by the widening of the primary-secondary spread over the recent period. The primary-secondary spread is higher since 2008 due to a rise in originators' profitability and g-fees. An interesting avenue for the future research is to study what public policy would be more effective in terms of impact on the housing market and economy or what measures should be taken by the Federal Reserve to ensure the transmission of lower mortgage spreads in the secondary market to lower borrower's costs in the primary lending market.

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Appendix A

Country list

92 countries included in the study are Algeria, Angola, Argentina, Australia, Austria, Bahamas, The Bangladesh, Barbados, Belgium, Botswana, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Finland, France, Germany, Greece, Guatemala, Hong Kong SAR, China, Hungary, Iceland, India, Indonesia, Iran, Islamic Rep., Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Latvia, Lebanon, Lithuania, Luxembourg, Malaysia, Malta, Mauritius, Mexico, Morocco, Namibia, Netherlands, New Zealand, Nigeria, Norway, Oman, Pakistan, Panama, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Saudi Arabia, Serbia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad and Tobago, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Zimbabwe.

Appendix B

Structural Analysis

Any covariance stationary VAR(p) process has a Wold representation as a linear combination of shocks. The coefficients on the error terms can be interpreted as impulse responses if the error terms are uncorrelated.

The Wold representation of Y_t based on the orthogonal errors η_t is given by

$$Y_t = \mu + \Theta_0 \eta_t + \Theta_1 \eta_{t-1} + \Theta_2 \eta_{t-2} + \cdots \tag{B.1}$$

where $\Theta_s = \Psi_s Beta^{-1}$ with Ψ_j are $(n \times n)$ moving average matrices from the reduced form MA representation of VAR(p) process and $Beta^{-1}$ is the inverse of a lower triangular $Beta$ matrix from model (3.1). The inverse of $Beta$ is obtained via Cholevsky decomposition of the Q-covariance matrix of the residuals from the reduced-form VAR(p).

The impulse responses to the orthogonal shocks η_{jt} are

$$\frac{\partial y_{i,t+s}}{\partial \eta_{j,t}} = \frac{\partial y_{i,t}}{\partial \eta_{j,t-s}} = \theta^s_{i,j}, \qquad i,j = 1,...,n; s > 0, \tag{B.2}$$

where $\theta^s_{i,j}$ is the (i,j)-th element of Θ_s. A plot of $\theta^s_{i,j}$ against s is called orthogonal impulse response functions of y_i with respect to η_j.

Appendix C

Multivariate Regression Theory

In this section some elementary results in mulivariate regression theory which provide the foundation for the Kalman filter are presented.

Suppose that x and y are jointly normally distributed random vectors with

$$E\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} \mu_x \\ \mu_y \end{pmatrix}, \qquad VaR\begin{pmatrix} x \\ y \end{pmatrix} = \begin{bmatrix} \Sigma_{xx} & \Sigma_{xy} \\ \Sigma'_{xy} & \Sigma_{yy} \end{bmatrix},$$

where Σ_{yy} is assumed to be a nonsingular matrix.

Lemma C.0.1. *The conditional distibution of x given y is normal with mean vector*

$$E(x|y) = \mu_x + \Sigma_{xy}\Sigma_{yy}^{-1}(y - \mu_y),$$

and variance matrix

$$Var(x|y) = \Sigma_{xx} - \Sigma_{xy}\Sigma_{yy}^{-1}\Sigma_{xy}^{'}$$

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