Unconventional Monetary Policy and U.S. Housing Markets Dynamics*

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Abstract

This study investigates whether the unprecedented liquidity injected in the economy by the U.S Fed through unconventional monetary policy measure, popularly known as quantitative easing (QE), is a systematic factor that can explain the abnormally low U.S. investments in new single family housing (housing starts) of recent years. We specify and estimate a model of new housing investments supply that incorporates constructed aggregate liquidity factors that capture QE liquidity injections. The results suggest that new housing investments liquidity betas, their sensitivities to liquidity shocks from QE transmitted through the constructed aggregate liquidity factors significantly influence the level of U.S. investments in new single family housing over the study period. Further, there is evidence of heterogeneity in the responsiveness of new housing investments to shocks from the aggregate liquidity factors in that housing markets constrained by excessive land use controls exhibit relatively muted sensitivities to fluctuations in the aggregate liquidity factors induced by QE. Remarkably, we also find that in the absence of GSE and FHA capital market activities induced by QE that channel credit into housing market, the contraction in new housing investments would have been worse. Additionally, the build-up in the inventory of single family homes-for-rent, a structural factor that emerged in housing markets during the recession, exerts a down-ward pressure on the supply of new single family housing investments.

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1.0 Introduction

In the throes of the recent global financial crisis triggered by the deterioration of housing and subprime mortgage markets, the U.S. Federal Reserve (the Fed) was compelled to adopt unconventional monetary policy measures never before used in its history to stabilize financial markets and stimulate real economic activity. Although there were several policy measures, the Fed's large scale asset purchase (LSAP), popularly known as quantitative easing (QE), was striking and unprecedented both in terms of its scale and the controversy it generated. Between 2009 and 2014 the Fed launched three waves of QE (QE1, QE2, Q3), purchasing a variety of high grade financial assets including agency mortgage backed securities (MBS), agency debt obligations, and coupon paying Treasury securities. The cumulative effect of these QE purchases caused the Fed's balance sheet to burgeon from about $850 billion around the start of the crisis in 2008 to more than $4.4 trillion as of September 2014 (see Exhibit 1). At the outset the striking impact of QE on the Fed's balance sheet generated continuing debates and diversity of opinions among economists, central bankers and policy makers regarding it's efficacy to stabilize financial markets and stimulate real economic activity. [1]

To date, the weight of the empirical evidence from macroeconomic models suggests that QE (in particular QE1) has significantly reduced the general level of interest rates or credit cost and stimulated aggregate economic activity by increasing GDP or aggregate output anywhere from 1 to 3 percent. [2], [3] While the extant literature has clearly enhanced our understanding of the effectiveness of QE at the macroeconomic level, the specific channel(s) of economic activity through which QE might have boosted the GDP is still subject to considerable debate. Dobbs et al (2013) suggest that the extremely low interest rates induced by QE permitted the financing of public expenditures at higher levels which propelled GDP growth rather than through classical channels of boosting corporate investments and consumer expenditures. In this contest it is important to stress the fact the Fed's unconventional monetary policy measures especially

[1] For example, Svensson *et al* (2011) suggests that quantitative easing in general is the wrong policy to follow for the U.S. because of a sluggish housing sector and fiscal policy problems. However, other researchers have arrived at favorable conclusions concerning the impact of QE on financial markets and real economic activity.

[2] See for example Baumeister and Benati (2010), Gertler and Karadi (2012), D'Amico and King (2013), Doh (2010), Gabriel and Lutz (2014), Gagnon, et al. (2011), Hamilton and Wu (2010), Hancock and Passmore (2011), Krishmamurthy and Vissing-Jorgensen (2011), Strobel and Taylor (2009), Williams (2011) and Wright (2011)

[3] QE1 which involved a $100 billion per month purchase of residential mortgage backed securities (RMBS) and other debt securities issued by government sponsored agencies (Fannie and Freddie) and Treasury securities has been the largest of all the QEs totaling about $17 trillion, lasted 17 months and is generally considered to be the most effective of all the QEs.

targeted a still ailing and contracting housing sector. Indeed the bulk of QE1 purchases was agency MBS and agency debt. As a consequence any analysis and characterization of the transmission channels of QE's stimulus effects must also take into account the special role of the agencies as liquidity providers to housing markets. Thus it is plausible that the series of QE liquidity injections may have stimulated new housing construction.

Against this backdrop, this paper contributes to the ongoing debate by investigating whether the aggregate liquidity injected in the economy by the U.S Fed through QE is a systematic factor for explaining the abnormally low investments in new single family housing of recent years. The massive infusion of liquidity into the system by the Fed coincided with the record contraction in new single family housing investments (housing starts) that began rather abruptly in early 2006. In fact as of 2009 the cumulative shortage of units built (relative to the long-run average) was around 3,800k units.[4] Although this phenomenon has also commanded the attention of policy makers, economists and industry professionals alike, it is still not well understood. The sharp decline in U.S. new single of family residential housing investments has been attributed to a number of factors including a lower preference for homeownership among the millennial generation, burdensome student loans carried by recent graduates, substantial decline in house prices and supply restrictions, but none is empirically proven.[5] This setting offers an excellent opportunity to investigate the efficacy of QE in stimulating real economic activity, specifically new housing investments.

Relying on housing and mortgage markets data that should capture the series of QE liquidity injections we construct four aggregate liquidity factors induced by QE using principal component analysis (PCA). The constructed liquidity factors are defined as follows: (1) *market liquidity*, the ease with which an asset such as housing can be traded, (2) *funding liquidity*, the ease/cost with which a household or economic agent such as a homebuilder can obtain financing, (3) *GSE credit availability*, the availability of credit in housing markets induced by QE via capital market activities of government sponsored agencies (GSEs), Fannie Mae/Freddie Mac and FHA., and (4) *shadow vacancy*, liquidity risk exposure associated with the build-up in inventory of single-family homes-for-rent, a structural factor that emerged in U.S. housing markets during the recent

[4] The average number of housing starts in the US since the government started collecting statistics in 1959 is about 1,500k per year. In January 2006, single-family housing starts in the US peaked at an annual unit rate of 2,273k. In April 2009, US housing starts troughed at an annual 478k unit rate. However, since April 2009 US housing starts have increased to an annual 586k unit rate in 2010, to an annual 612k unit rate in 2011, to an annual 784k unit rate in 2012, and to an annual 930k unit rate in 2013.

[5] Other factors that have been implicated in the sharp decline in housing construction include the vast number of current vacant units and tighter underwriting standards on residential mortgage loans.

crisis.[6] Next, we specified and estimated several versions of a micro-econometric model of housing investments that incorporates the four constructed liquidity factors as well as conventional observable variables that have been shown by prior studies to influence the supply of new investments in single family homes. At a policy level we are interested in isolating the responsiveness or sensitivity of new housing investments to fluctuations (or shocks) in the four constructed aggregate liquidity factors induced by QE. Thus, one of our contribution to the ongoing debate is in showing a specific channel of real economic activity, namely new investments in single family housing, through which the stimulus effects of QE are transmitted to boost GDP, rather than the aggregate output or GDP itself, as has generally been the practice in the literature.

Overall, we find that new housing investments liquidity betas, their sensitivities to QE liquidity shocks via the four constructed aggregate liquidity factors, play significant roles in explaining the level of new single family housing investments between January 2009 and December 2012. The results are robust as well as statistically and economically significant. In particular, we document the following results. First, based on the estimated liquidity betas, a unit positive shock to funding liquidity and market liquidity from QE is likely to increase new housing investments by 24 units and 56 units, per month per MSA, respectively. Second, interestingly, both the GSE credit availability factor and the shadow vacancy factor have separate and independent effect on the level of new housing investments. Indeed, we find that in the absence of GSE and FHA capital market activities induced by QE liquidity injections that channel credit into housing market the contraction in new housing investments would have been worse. Third, our counterfactual analysis suggests that the difference in output level forecasted by a model of new housing investments that reflects sensitivities to the four constructed liquidity factors induced by QE and a model that does not account for the sensitivities is about 300 units per month per MSA, which translates to a potential decline in new investments in single family housing of about 45.0% annually. [7]

[6] This inventor disguised the level of actually vacancy in housing provided impetus “flipping’ a real estate investment strategy where investors purchased empty single family home with the goal of reselling within a relatively short period at a profit. Typically, the subject property is undervalued purchased at deep discount at a foreclosure sale and may require some repair to restore value. .The strategy is a pure play on price appreciation that may or may not occur.

[7] Housing markets are clearly susceptible to “thin market” problems, but the key source of the problem is not the capital losses incurred by financial intermediaries. Rather, the key source of the difficulty is shocks to household’s balance sheets related to funding and market liquidity. Housing is the largest asset class in the typical US households’ portfolio. Housing has high funding liquidity in a given city-year when lenders are willing to lend money to anyone, e.g., those households with good or bad credit histories and/or high or low FICO scores. In contrast, housing has high market liquidity in a given city-year when the number of homeowners with low or negative equity in their houses is

Fourth, we explore the interaction between market liquidity and funding liquidity, in order to assess whether there is a mutually reinforcing effect (Brunnermeier and Pedersen 2009) between the two liquidity factors. We find that a combination of high market illiquidity and high funding liquidity exposure may actually reduce new housing investments activity by an additional amount of as much 40 units per month per MSA, all else equal. [8] Finally, we also provide evidence of interesting heterogeneous response across MSAs regarding the sensitivity of new housing investments to fluctuations in the aggregate liquidity induced by QE. Spacifically, the more a market is constrained on the supply side by excessive land use controls imposed by local authorities, the less effective will be the response of new housing investments to a positive shock in market and funding liquidity induced by unconventional monetary policy. [9] In general, based upon the results of our regression and simulation analyses, we may conclude that carefully designed policy measures that transmit positive shocks to market liquidity, funding liquidity and GSE credit availability can have a big effect on new investment in single family housing in certain markets.

While our paper is related to the growing literature seeking to uncover the effects of QE on financial markets and the real economy, e.g. Gabriel and Lutz(2014), Gambacorta, *et al* (2012), Chung *et al* 2011, Gertler and Karadi 2012, Kapetanios *et al* 2012, and Lenza *et al* 2011), we offer a different perspective. To the best of our knowledge the construction and utilization of the aggregate liquidity factors as transmission channels of QE's stimulus effects to real economy activity, in this case new housing investments, is novel. The prior literature has largely emphasized the so-called *portfolio balance mechanism* as a possible transmission channel through which QE may have affected real economic activity. [10] As shown in panel A of Figures 5

small. For example, when households owe more on their houses than they can sell them for, they can no longer afford to sell and buy a bigger home or refinance to pay off the outstanding loan balance, reducing overall market liquidity.

[8] This relationship is best described in Drehmann and Nikolau (2010). As the Northern Rock, Bear Sterns, and Lehman Brothers crisis unfolded, a significant negative relationship between market liquidity and funding liquidity emerged. This negative relationship is economically significant, but only during the crisis. After the failures of Northern Rock, Bear Sterns, and Lehman Brothers and during the pre-crisis, there is no significant relationship between market liquidity and funding liquidity.

[9] Gabriel and Lutz (2014) find that QE liquidity injections reduce housing distress the most in the more volatile housing markets such as California and Florida

[10] As articulated in Tobin (1969) and others the portfolio balance theory suggests that quantitative easing purchases reduce the yield-to-maturity on government securities and other securities that are close substitutes. The reduction in yield or reduced spread causes asset prices to increase, which in turn stimulates investment spending. Thus, the declines in yield is key to the transmission of LSAPs to the real economy. According to Gertler and Karadi (2012), the transmission channel to real output is LSAPs' ability to reduce excess return which causes asset prices to rise, which in turn induces investment spending. They further stress that the key to identifying this channel from their simulation of

and 6 the behavior of the constructed aggregate liquidity factors are generally consistent with liquidity conditions in housing and mortgage markets just before, when the crisis ensued and during the period when liquidity injection through QE took hold. Visual inspection of the figures show that the sharpest drop in funding liquidity and the sharpest rise in market illiquidity generally coincide with significant negative events during the crisis, such as the September 15, 2008 bankruptcy filing by Lehman Brothers. Such negative developments led to sharp deterioration in both credit and asset markets that brought transactions all but to a halt. The figures further show that the largest upward spike in funding liquidity factors (including GSE credit availability) and the biggest downward spike in market illiquidity (alternatively rise in market liquidity) can broadly be identified with significant injections (and improvement) of market-wide liquidity starting with QE1. These observations seem consistent with the view that our constructed liquidity measures do capture the dynamics of the aggregate liquidity injected by QE, and consequently the transmission of its stimulus effects to investments in new single family housing.

Moreover, in contrast to the macroeconomic or aggregate output focus of prior literature we emphasize the microeconomic in that we shed light on how the liquidity injected by unconventional monetary policy helps explain the level of output in a specific economic activity, new housing investments, that have been abnormally low in recent periods. Gabriel and Lutz (2014) study the effects of unconventional monetary policy on real estate markets and find *inter alia* that it has lowered key housing market interest rates and raised equity returns of homebuilders, but they do not study the underlying causes of the abnormally low investments in new single family housing of recent decades. Focusing attention on QE's possible effects on new housing investments provides additional insight on how monetary policy can be designed to more effectively target the housing sector given its extreme volatility and the abnormally low levels of new housing investments which has no doubt contributed to the stalling of US housing markets. As a final point of departure from prior literature, we also analyze the possible effect of the unusual build-up in the inventory of homes-for-rent (shadow vacancy) on new housing investments in the presence of the aggregate liquidity injected by QE. We show for the first time that this shadow vacancy is indeed a structural factor, a systematic illiquidity risk exposure that is

their model rests on the assumption that LSAP is equivalent to central bank intermediation with limits to arbitrage in private intermediation.

a drag on housing market, discourages investments in new single-family housing and may have dampened the ability of QE to bolster housing asset prices

The remainder of the paper is organized as follows. The next section provides background and context for the study in which we discuss the nature and implications of the stalled housing market for performance of the economy. Section 3 describes the data used in the empirical analyses and provides summary statistics. The section also discusses the key housing and mortgage market data used to construct the unobservable aggregate liquidity factors via PCA methodology and their times series behavior. Section 4 first motivate the reliance on aggregate liquidity factors as transmission channels of QE stimulative effects on housing markets and details the micro-econometric model for studying the responsiveness of new housing investment to fluctuations in the constructed aggregate liquidity factors induced by QE. Section 5 reports the main results from the estimation of the econometric model highlighting the role of the constructed aggregate liquidity factors induced by QE in explaining the abnormally low investments in new single family housing of recent years. This section also provides evidence of heterogeneity in the responsiveness of new housing investments to changes in the aggregate liquidity risk factors across housing markets. Section 6 reports the results of several simulations and counterfactual analysis that seek to tease out the economic effects of policy changes on new housing investments in the context of QE stimulus effects. In the final section we explore the implications of the findings for policymakers.

2.0 New Housing Investment Activity and Gross Domestic Product

The recent recession underscored the importance of the housing sector to overall performance of the economy. For a number of reasons, the housing sector, specifically new single-family housing investments or housing starts, are attractive candidates for studying the efficacy of QE at stimulating real economic activity. [11] The contributions of residential private investments and housing related consumption expenditures to U.S. GDP are well documented. Combined these components contributed roughly 18% of total GDP in the third quarter of 2013, which is a significant decline from its peak of contribution of 21% in the third quarter of 2006.

It is interesting to note that of the two broad categories, the share of new housing investments, the series to be explained, which peaked at 6.2% of GDP in 2006, have been the most volatile or cyclical components of aggregate demand. To highlight the extreme volatility of the series, Figure 2 shows the annualized new housing investments from 1959 when the

[11] New housing investments (housing starts) includes construction of new single-family homes, and residential remodeling.

government started collecting statistics to 2014, as well as annualized U.S. GDP. The figure provides evidence suggesting cyclical movements in new housing investments. The decade (1959-1964) was a period of slow growth in new housing investments with one moderate peak between 1960 and 1963 when new housing investments grew by 22.69%. The next episode was a boom in 1969-1974 when new housing investments grew by 64.53% (1970-1972), followed by a bust of almost equal magnitude (-50.87%) in 1974. A more substantial boom occurred between 1974 and 1979 when new housing investments surged by +72.50% only to be followed by a bust albeit of a smaller magnitude, -41.15% between 1978 and 1982.

In the annals of U.S. new housing investments, the period 1991to 2006 stands out, which for analytical purposes we have divided into three episodes: pre-boom cycle, January 1992 to January 2000, boom cycle, January 2001 to January 2006 and bust period. The first cycle was characterized by slow growth initially, followed by moderate-to-strong construction growth, punctuated by visible periods of retrenchments. The second cycle, the boom period, was marked by a prolonged and spectacular run-up in construction activity when new housing investments grew at annual rate of about 10 percent, with a peak activity in January 2006. Tabulations over this period revealed that the U.S. built (relative to the long-run average) around 2,300k excess units. The subsequent crash period, from January 2006 through April 2009, was a period of severe retrenchment in the housing market, in which new residential housing investments declined by about -81% mimicking the general collapse in house prices that triggered the recent financial crisis. Not surprising new housing investments contribution to GDP fell to a historical low of less than 3% of GDP. Moreover, Figure 2 also suggests the three cycles experienced by the housing sector over the study period corresponds with the three recessionary periods of recent decades, identified by the grey vertical lines in the figure.[12]

While the typical behavior of new housing investments over a long period is one of high volatility, the series have clearly become extremely much more volatile in recent years, with peak-to-trough declines of almost 80% from January 2006 to April 2009. The peak-to-trough ratio (January 2006 versus April 2009) of monthly construction activity is 4.75 (2273k/478k): an expansion nearly quintuples the monthly output of new residential investments while contraction cuts it by more than half. Thus the timing and amplitude of this substantial volatility in new construction has significant economic consequences for housing markets and the overall performance of the economy. In this context it is worth emphasizing that a big part of the

[12] This observation is consistent with the view of Leamer (2007 that the housing sector defines the business cycle

justification for Fed's unprecedented injection of liquidity in the economy through QE was among other purposes, especially aimed at stimulating new investments in the stalled housing sector. Thus, it is important to examine this striking trend of abnormally low housing investments to understand what might be holding back new investments, and in particular the role that QE might have played in stimulating new housing investments and by extension, for construction and allied industries.

In this context the linkage between new housing investments and other key sectors of the economy is relevant. As an illustration, Figure 3 shows U.S. new housing investments and household expenditures on durables. The share of GDP attributable to spending on durables rose in tandem with the rise in new housing investments. Although we note that while changes in durable goods expenditure mimic changes in new housing investments they are relatively less volatile because these expenditures are not wholly dependent on new construction. Indeed, the growth rate of new housing investments was about twice the growth rate of spending on durables (15.3% versus 7.3%) in recent decades. Nevertheless, the implication is clear. The economic importance of new housing investments is disproportionate to its GDP share largely because it has powerful multiplier effect through the economy due to its forward and backward linkages to other real economic sectors.[13] Thus focusing on new housing investments as one key channel of economic activity through which QE may boost GDP growth is warranted.

Further, according to the U.S. Federal Reserve houses represent substantial fraction of households net worth; the value of owner-occupied housing in 2008 was $25.4 trillion or roughly two thirds of total net worth of the median household. The implication is that an exogenous shock to house prices is likely to have a large and broad impact on household liquidity. Specifically, a negative shock will compromise the ability of existing home owners to trade-up which reduces demand for new housing investments, further depressing house prices and by association GDP growth. Visual inspection of Figure 4 which plots new housing investments and house price index (Case-Shiller 20-city home price index) suggests that the correlation between new housing investments and housing asset price is strong. Indeed the unprecedented rise in house prices in recent decades expanded homeowners housing wealth, which loosened borrowing constraints thereby increasing aggregate funding liquidity to support housing demand. The subsequent collapse of house prices led to underwater borrowers who owe more than their properties are worth. With a large number of underwater borrowers, market liquidity declined and credit

[13] Indeed, Moody's Analytics estimates the all-in job effects of housing to be four jobs for every single-family housing start. Hence, as stated by Leamer (2007) "housing is the business cycle" that deserves much more attention than previously realized.

constraints increased. As market illiquidity and credit constraints increase, the overall demand for housing slows in tandem with a decline in new housing investment. Drastic contraction in new housing investment mean fewer jobs, lower income, less money in the system and eventually lower GDP.[14]

Finally, while the bust in housing asset price certainly has something to do with the precipitous decline in new housing investment, given the size of the decline that is most likely not the whole story. Indeed the relation between new housing investment and GDP has been negative in recent periods (see Figure 2). Thus it is difficult to explain the abnormally low housing investments in terms of either the boom-bust in house prices and/or in terms of GDP growth alone as is traditionally the practice. It is therefore very important to understand whether and how the aggregate liquidity injected in the economy through the series of QEs (funding liquidity, market liquidity, and credit availability) might have stimulated new single family housing investments, and by implication the role and the specific channel through which QE boost GDP growth. The main purpose of this paper is to explain the cyclical patterns in new housing investments relying on the four constructed liquidity factors engendered by QE as key explanatory variables or transmission channels through which QE stimulus effects are transmitted to real economic activity.

3.0 Data Sources and Construction of Aggregate Liquidity Factors

3.1 Descriptive Statistics

Our data are from several sources and we work mainly with monthly time series from 2005-2012, with 2005 being the first year we are able to credibly match series across the 13 MSAs included in our analysis. Housing starts on single-family structures serve as our measure of new housing investments. Seasonally adjusted monthly housing starts aggregated at the MSA level are from the Federal Reserve Bank of St. Louis. Table 1 provides basic definitions of variables of interest including their source and frequency. We use MSA level data to account for possible variability of the aggregate liquidity factors across given year and MSA. The data cover 13 cities including Charlotte, Cleveland, Dallas, Denver, Los Angeles, Minneapolis, New York, Phoenix, Portland, San Diego, San Francisco, Seattle and Washington, D.C. Incidentally,

[14] Charles, Hurst, and Notowidigdo (2013) find evidence that housing bust undid the effects of the preceding housing boom. The latter created a number of well-paying jobs and seduced a number of high-school graduates to choose work over community college. When the boom ended and these jobs evaporated, these same men and women did not go back to school, thereby creating a hole in educational attainment for a large segment of the population.

Charlotte, Cleveland and Dallas were among the six metro areas that did not experience the recent house price boom.

Tables 2 and 3 provide summary statistics of the data used in this study for the whole sample and the 13 MSAs, respectively. Table 2 (panel A) shows that on average new single-family investments were about 806 units per MSA per month with a fairly large standard deviation, indicative of its substantial volatility. In general new housing investments have been trending downwards since December, 2006 (see panel B of table 2). Table 3 underscores the extent of the volatility in new housing investments over time and across the 13 MSAs included in the data. For example, the mean number of new housing investments for Dallas of 2064 units per month is more than eight times that of Cleveland, which had the lowest average number of new housing investments of 242 units per month over the study period. Our primary goal is to explain the variation in new housing investments as a function of the four aggregate liquidity factors while controlling for other fundamentals.

House price data are from S&P Case-Shiller 20-City Composite Home Price Index. Over the study period the mean house price index across the 13 MSAs is 156 with a sizable standard deviation of 32 and a spread of about 47% between a city with maximum price index and a city with minimum price. Such time-varying volatility across cities has economic consequences for both homeowners who trade housing assets and the construction sector and related industries. These agents rely on the state of market liquidity and funding liquidity in housing market as signals of when to build, how many new housing units to build, and what appliances and furnishings to supply. Construction costs (labor, materials and equipment) for a house of moderate quality are from Morris Davis (www.lincolninst.edu). As shown in Tables 2 and 3 there is substantial dispersion in construction cost across the 13 cities; it costs about 65% more to build the same modest quality house in Washington D.C. than it does in Charlotte, Raleigh-Durham and Greensboro MSA. Moreover, construction costs have been trending upwards during the study period. But the increases in construction cost alone cannot explain the dramatic decline in housing starts observed over the study period.

Table 4 shows percentage changes in the sixteen variables used in the study. Over the study period changes in some key variables were negative including new housing investments (the series to be explained), house price index, trading volume, and 30-year mortgage rate. On the other hand foreclosure rate and homes that sold at a loss have been trending upwards. The behavior of key variables is consistent with the deterioration in housing markets over the study period. Table 5 displays the pairwise correlation matrix among the variables. As shown in the table the correlation between housing starts and house price index, loan-to-value ratio, trading volume and sale-to-list ratio is positive; while housing starts negatively correlates with construction cost index (factor prices), FICO score, at loss sale, foreclosure sale, and the 30 year mortgage spread over 10-year Treasury note. Broadly, these results suggest a rising supply price of new housing investments and a declining supply cost of new housing investments. Thus, the direction of these correlations is consistent with theory.

3.2 Construction of Unobservable Aggregate Liquidity Factors

Since the four aggregate liquidity factors used to study the stimulus effects of unconventional monetary policy are unobservable we extract these factors using PCA methodology. A common approach in the literature is to use single indicators of liquidity such as time-on-the-market, transactions volume, market turnover, list-to-close price spread, rate of sale, and down-payment constraint, etc, to measure exposure to liquidity risk However, the concept of liquidity is broad, subtle and has many dimensions. In this regard, our perspective is that there are different aspects of aggregate liquidity factors in housing and mortgage markets that are time varying and no single observable variable by itself is a sufficient statistic to capture the depths and dynamics of the aggregate liquidity risk factors. Indeed, an important part of the story of this recession is not just the level of any of the single variable as stressed in previous studies, but also how the relevant variables come together to determine aggregate liquidity or the lack thereof in housing markets. Further, new housing investments would be sensitive to liquidity risks of various types due to illiquidity of the housing markets and to funding liquidity shocks stemming from households reliance on leverage and the associated credit constraints such as down-payment, mortgage payment burden and FICO score requirements.

Consequently, in this study we selected and utilized several variables generally viewed as indicators of different aspects of aggregate liquidity in housing and mortgage markets that should capture the liquidity shocks from QE to construct the unobservable aggregate liquidity factors. [15] In all twelve variables were selected and their characteristics are summarized in Table 6. For each of the 13 MSAs included in our sample over the time period 2005 to 2012, we obtained data directly from sources that already have been identified above as well as from Zillow Real Estate (www.Zillow.com). Zillow Real Estate has data for sale listings (i.e., for-sale inventory) as well

[15] Demyanyk and Van Hemert (2008) find that loan –to- value (LTV) ratios on subprime mortgages rose 79% to 86% from 2001 to 2006, while debt-income ratios rose 38% to 41% . Other reports suggest greater increase for prime mortgages. For example, UBS analysis (Lunch and Learn, April 16, 2007) find that LTV ratios for conforming first and second mortgages rose from 60.4% in 2002 to 75.2% in 2006.

as for the percentage of home sales in a given month where the home was foreclosed upon within the previous 12 months (e.g., sales of bank-owned homes after the bank repossessed a home during a foreclosure) and the percentage of homes that sold for less than the previous purchase price (e.g., a home purchased for $250k and then sold for $225k). The latter excludes foreclosure transactions. The for-sale inventory, the percentage of home sales in a given month where the home was foreclosed upon within the previous 12 months, and the percentage of homes sold for a loss are all variables which bear on normal market liquidity.

Of the twelve independent variables, we postulate six measure different dimensions of single-family housing market liquidity and shadow vacancy liquidity risk including trading volume, the inventory of homes for sale, the final sale price divided by the last list price (expressed as a percentage), the proportion of homes selling for a loss, foreclosure sales ratios, and the percentage of all rental units that are unoccupied or not rented at a given time, and the number of homes-for-rent. These variables are assumed to capture housing market conditions and possible changes in market liquidity induced by QE. The final sale price divided by the last list price and the proportion of homes selling for a loss measure liquidity in the price dimension, while all other variables are measures of open interest or transaction volume (including trends in distressed and non-distressed sales transactions) and trading intensity.

As house prices fall, homeowners with effective negative equity rates (i.e. those with loan-to-value ratio greater than 100%) increases. The larger the effective negative equity rate, all else equal, the greater the percentage of foreclosed sales and the more homeowners are equity locked into their homes. The larger the increase in equity lock-ins, the larger the decrease in market liquidity, while the greater the number of foreclosed sales, the greater the trading volume (albeit not from normal buyers, many buyers of foreclosed properties have been institutional investors and cash buyers). The offered-for-sale inventory of homes, as well as the percentage of homes that sold for less than the previous purchase price, are both strong indicators of a buyer’s market. Low turnover rates and declining market liquidity are consistent with a transition from a seller’s to a buyer’s market.

Given the above data sources, we measure the amount of sales activity in each of our 13 MSAs. The greater the amount of turnover in a market place, the easier it is to find and sell a particular house. Piazzesi and Schneider (2009) find that the market routinely applies a market illiquidity discount to housing. This discount vanishes as matching (i.e., turnover) becomes infinitely fast. In the current environment, many sellers (including most investor-owners) have been hesitant about putting their homes up for sale. Instead, these properties are put up for rent, creating a large shadow inventory out there of homes for sale. This shadow inventory is a structural factor and very much part of the housing market. The shadow inventory creates uncertainty about the best time to sell, signals low level of trading intensity and may put downward pressure on new housing construction. We posit that this structural factor has a separate and independent effect on new housing investments. The shadow vacancy rate is measured by the percent of homes that are vacant and rented. These data are from Zillow Real Estate.

Next, we assume that the remaining six independent variables measure different aspects of funding liquidity and credit availability through the GSEs including debt-to-income ratios, FICO credit scores, loan-to-value ratios, mortgage interest rates, GSE mortgage purchases, and FHA loan volume. Some of these variables were selected to capture tightening underwriting standards during market downturns and loose underwriting standards during booming markets. Other variables capture borrower's ability to qualify for mortgage and the level of mortgage credit availability. The first four variables are available at the three-digit ZIP code customer address level directly from Fannie Mae (www.fannie.mae) and Freddie Mac (www.freddiemac.com). We aggregate across these three-digit ZIP code boundaries to create monthly MSA level aggregates. Today's borrowers must have higher FICO scores, lower debt-to-income ratios, and higher down payments (i.e., lower loan-to-value ratios) to meet stricter underwriting conditions (i.e., lower funding liquidity). Variables measuring the availability of mortgage credit are available directly from the Board of Governors of the Federal Reserve System (www.federalreserve.gov). The availability of mortgage credit variables are policy variables. Here we focus on two availability of mortgage credit variables: the availability of mortgage credit from the Fannie Mae and Freddie Mac, the government sponsored enterprises (GSEs), and the availability of mortgage credit from the Federal Housing Administration (FHA).[16]

With the above dataset in hand, we extract the four unobservable aggregate market-wide liquidity factors each month over the sample period 2005-2012 using a PCA methodology. Each of the 12 variables is transformed by using percentage change in the variables from period to period, rather than their levels. The data transformations are undertaken to render the transformed variables stationary. As a standard practice of PCA the data have also been standardized by

[16] The purpose of GSE loans is to facilitate home purchasing and to encourage financial institutions to lend money to those seeking to buy or build new, both before and after, but especially after a financial crisis occurs. The purpose of FHA loans is to facilitate homeownership. FHA loans are one of the easiest types of mortgage loans to qualify for because they require a low down payment, lower credit scores, and generally less stringent rules on co-borrowers.

subtracting the mean of each data column for each element in the data column such that the matrix of original variables is replaced by the new matrix of demeaned variables X_{it}. The standardized *n* x *p* matrix X_{it} of the demeaned 12 original informational variables now reflect different aspects of aggregate market liquidity and funding liquidity in housing and mortgage markets that capture the liquidity injected in the system via QE purchases.

To reduce the dimensionality of the data, that is to extract the aggregate liquidity factors, we assume that housing and mortgage markets respond to a smaller set of *n* x *k* unobservable liquidity factors, where $k < p$, but still accounts for as much information as the original data. Then each of the following linear combinations ***F₁, F₂, Fₚ*** creates an aggregate liquidity factor. Specifically, the following equation is estimated via PCA methodology:

$$X_{it} = \phi F_{it} + \upsilon_{it} \qquad (1)$$

where ϕ is *n x k* matrix of factor loadings and υ_{it} is *n x 1* vector that accounts for idiosyncrasies due differences in MSAs and each time series. Consequently, $\boldsymbol{F_{it}}$, the principal components, aggregate liquidity factors extracted from the standardized data are assumed to encapsulate the evolution of unprecedented liquidity injected in the system by the series of QE purchases over the sample period, and thus constitute key transmission channels of the effects of the program to new housing investments.

3.2.1 The Constructed Aggregate Liquidity Factors

The PCA analysis reveals that there are four principal components, or aggregate liquidity factors, based on the eigenvalue and cumulative proportion of the total variance explained (See Table 7 panels A and B). The first principal component accounts for 22.62% of the total variance in the twelve underlying housing market trading activity and mortgage liquidity variables. This component can be interpreted as an aggregate measure of *funding liquidity* given that it assigns a positive weight of 0.3428 to the debt-to-income ratio; -0.3064 to FICO score, 0.2936 to loan-to-vale (LTV) ratio and 0.3334 to mortgage interest rate. In general, we note that the variables that load on funding liquidity factor move as expected.

In panel A of Figure 5 we plot the evolution of aggregate funding liquidity levels and the time series of the four variables that load on it linearly transformed according to the weightings suggested by the PCA, aggregated across the 13 MSAs. The plots also show in vertical gray lines the approximate inception of each of three QEs conducted by the Fed during the study period. As expected the time series graph shows extreme volatility in the variables obviously a result of the aftershock of the crisis and the various attempts by the Fed to inject liquidity through QE. However, the extreme volatility seems to moderate notably since inception of QE2. The behavior of our constructed aggregate funding liquidity measure is broadly consistent with the direction of movement of the four variables that load on it over the sample period. For example the peak in aggregate funding liquidity coincides with the trough in average FICO scores before the inception of the financial crisis. As depicted in the graph, once the crisis started, the estimates of aggregate funding liquidity are persistently negative, although there are periods in which the average estimate was positive mainly during the post-financial crisis period, which is suggestive of the mitigating effects of QE on aggregate liquidity in the economy. [17] The preponderance of the negative values is consistent with the severity of the crisis, especially in the earlier years when financial institutions tightened credit availability severely. To shed more light on the degree to which our funding liquidity construct captures the state of aggregate liquidity in the system over the study period, we have superimposed on the figure a measure of credit tightening standard (shown in diamond studs) from Federal Reserve survey. The striking conclusion from this figure is that our constructed measure of funding liquidity is very much apropos.

Additional evidence of the appropriateness of our funding liquidity construct is revealed in the three 3-dimensional graphs (panels B to D) depicting the relationship between our aggregate funding liquidity construct and four variables that load on it. We observe that an increase in either LTV ratio or debt-income ratio correlates positively with funding liquidity which improves a household's borrowing capacity. These visual images highlight the important role that leverage and down-payment constraint play in housing markets and homeownership (Linneman and Wachter, 1989, Zorn, 1989, Jones 1989, and Stein, 1995). The link between funding liquidity and house price is an interesting one. Stein (1995) made the point that a positive shock to fundamentals will increase house prices which in turn improves the equity position of incumbent households allowing them to trade up to larger homes. To test this proposition we run a simple regression of house price index on the constructed aggregate funding liquidity. The regression coefficient is 6.0682, with a t-statistics of 15.66 which is highly significant. The point estimates suggests that a unit positive shock on funding liquidity increases house price by 6.1%, which will

[17]In response to the distress in financial markets caused by the unprecedented decline in house prices the U.S. Federal Reserve starting in December 2007 numerous programs such as Term Auction Facility (TAF), Primary Dealer Credit Facility (PDCF), Term Securities Lending Facility (TSLF), Term Asset-Backed Securities Loan (TALF), Quantitative Easing etc. to improve the various credit and funding markets

clearly boost households' equity position, and thus enhance their ability to trade-up to larger homes.

The second principal component, which can be interpreted as *market illiquidity factor*, is defined by its eigenvalue of 1.8446 and negative loading of -0.1856 on the sale-to-list ratio, a positive loading of 0.3644 on selling-for-a-loss, a negative loading of -0.4322 on trading volume, and a positive weighting of 0.4418 on the foreclosure-sales ratio (See Table 6 panel B). The second principal component or the market illiquidity factor explains 14.19% of the total variance in the twelve underlying housing market trading activity and mortgage liquidity variables, and so may also be useful to explain new housing investments.

Figure 6, panels A to G, plot aspects of the micro structure of cumulative market illiquidity factor. Panel A illustrates several key points about the evolution of market illiquidity. First, housing market illiquidity reached a trough (i.e. heightened market liquidity) around February 2006, before the start of the crisis. Second, starting in 2007 liquidity in housing market started to diminish rapidly. Then once the crisis ensued illiquidity increased significantly and intensified, eventually peaking in 2009. Indeed the sharpest drop in market liquidity occurred in periods that can be associated with significant developments in the financial crisis such as the filing of bankruptcy by Lehman Brother which occurred in September 2008. It is also quite remarkable that the peaks of two PCA-select variables of housing market illiquidity (foreclosure sales ratio, sale for loss ratio) coincide with the peak of aggregate market illiquidity, while trading volume, a traditional measure of liquidity, and sale to list ratio troughed as market-wide illiquidity factor peaked, as one would expect. Third, since 2009 (after the QE2 and the onset of QE3) market liquidity returned to the housing market in a pronounced way consistent with significant pick-up in transactions.

The relationship between the aggregate market illiquidity and trading volume is quite interesting especially since QE3, and some simple statistical analysis validate this visual impression. We regress trading volume against the aggregate market illiquidity factor after QE3 was initiated. The regression coefficient is -0.11063 with t-statistics of -153.79, which is highly significant. The point estimate suggests that a 10 percent drop in aggregate market illiquidity, i.e. a positive shock to market liquidity induced by QE, increases trading volume by 1.1% per month per MSA, or roughly a 13% pick-up in annual transaction volume. The series of 3-D plots (panels B to G) provide additional insights on the behavior of our constructed market illiquidity factor that are broadly consistent with movements of the variables that traditionally measure aspects of market illiquidity (liquidity). Trading volume first increases with market illiquidity and then decreases. This dichotomy in behavior suggests the source of increase in trading volume matters. Intuition suggests that an increase in trading volume initiated by sellers (e.g. foreclosure sale) is quite different from that generated by buyers; the latter most likely is indicative of decreasing market illiquidity or increasing market liquidity.

The third and fourth principal components are defined, respectively, by the positive weightings on the availability of mortgage credit variables and by the positive weighting on the shadow vacancy rate. The third and fourth principal components explain, respectively, 11.76% and 8.54% of the total variance in the twelve underlying housing market trading activity and mortgage liquidity variables.[18] The third principal component can be interpreted as an aggregate measure of credit availability induced by QE through the capital market activities of the GSEs (Fannie, Freddie) and FHA loans. The negative loading on credit availability factor by the sale inventory variable may appear odd and needed explanation. Our explanation goes as follows. As mortgage credit availability induced by QE through the GSEs goes up the borrowing capacity of households improves there by allowing them to trade housing assets. The resulting pickup in transaction in turn reduces the sale inventory for any given supply. Hence, the association (negative) of sale inventory with mortgage credit availability.

The fourth principal component, *shadow vacancy factor*, can be interpreted as a measure of market softness or the lack of intensity in transaction in falling housing markets. This factor loads positively on the inventory of homes-for-rent (0.8679) and negatively on sale-price-to-list-price ratio (-0.3550). Although this factor is related to trading volume it does provide additional information on transaction intensity that cannot be gleaned directly from conventional trading volume. In what follows, we use the principal components or the aggregate liquidity factors induced by QE as explanatory variables in a simple micro-econometric model that attempt to explain variations in new housing investments due to fluctuations in the aggregate liquidity factors over the sample period, while controlling for standard determinants of new housing investments.

4.0 The Empirical Model of New Housing Investments

If the enormous liquidity injected in the system through the series of QEs implemented by U.S. Fed do in fact influence the level of real economic activity, new housing investments are prime candidates that should respond to fluctuations in the series of liquidity injections via QE. To test this proposition, we specify and estimate a micro-econometric model of new housing

[18] None of the remaining principal components had eigenvalues greater than 1.

investments that incorporates the four constructed liquidity factors that presumably capture the series of QE liquidity injections as well as standard observable variables that have been shown to influence the supply of new housing investments. The goal of this empirical work is to isolate the liquidity betas of new housing investments, that is their sensitivities to fluctuations in the aggregate liquidity factors we constructed that are designed to capture the liquidity effects of QE.

As in Gertler and Keradi (2012), we start from the perspective that the unprecedented liquidity injection via QE is a form of intermediation by the U.S. Fed, although we do not model this intermediation. Rather, we simply assume that the substantial liquidity injected in the system by QE is impounded by relevant housing and mortgage market variables used to extract the four unobservable aggregate liquidity factors. As the liquidity injected by QE is in effect a systematic factor it must be priced into asset markets including the housing sector and should influence investment decisions. Thus, we consider the four aggregate liquidity factors (*market liquidity*, *funding liquidity*, *GSE credit availability* and *shadow vacancy*) as alternative key channels through which the stimulus effects of QE might have been transmitted to new housing investments over the study period.

Our focus on the constructed aggregate liquidity factors as plausible transmission channels of QE's stimulus effects to new housing investments are motivated by several observations. The literature suggests that fluctuations in aggregate liquidity exhibit commonality across asset markets and a thesis that a lack of aggregate liquidity has negatively affected developers' ability to build. Some related evidence supports this view: Brunnermeier and Pedersen (2009), for example, show that market liquidity and funding liquidity are mutually reinforcing and their considerations are crucial factors in the demands for most assets and the lack thereof can lead to reduced total activity.[19] Since the housing asset is highly leveraged and equity down-payment is an additional constraint, housing demand and supply of new housing investments will be sensitive to buyer exposure to funding liquidity and such liquidity must be broad to support strong demand and supply. If liquidity risk considerations are central to builders' strategy (and we think they are) one will observe a correlation between the aggregate liquidity measures we constructed and new housing investments.

[19] Specifically, Brunnermeier and Pedersen (2009) suggest that binding market liquidity and funding liquidity constraints can lead to liquidity spirals in which a small change in fundamentals may cause a large decline in liquidity and fragility, with a feedback effect on prices and required returns through reduced trading.

Further, empirical evidence in Drehmann and Nikolau (2010) suggests that funding liquidity risk was especially severe in this recession. A decrease in aggregate liquidity can cause households and homebuilders to become reluctant to take on positions. As trading falls, aggregate market liquidity deteriorates further, especially if debt and equity capital are already low, which elevates volatility, thereby creating a liquidity spiral. More fundamentally, while there were other reasons for the Fed's unprecedented injection of liquidity in the system, the decision to embark on QE was in large part driven by the desire to stabilize a still ailing and contracting housing sector that triggered the crisis in the first place. In fact approximately 83% of the $1.75 trillion of total asset purchases under QE1 were agency MBS and agency debt. Indeed the GSEs and FHA are mandated to channel credit into housing as part of their capital market activities. Consequently, as stated earlier it would seem reasonable to surmise that the aggregate liquidity factors in the housing and mortgage markets sector must have been augmented by QE.

Our econometric model is an augmentation of the standard models of new single family housing investments supply which explicitly incorporates the four constructed liquidity factors and observable determinants typically included in such standard models. [20] Formally, we model the supply of new housing investments, NHI_{it}, as follows:

$$\begin{aligned} NHI_{it} = \alpha_0 &+ \alpha_1 HAP_{it} + \alpha_2 HRC_{it} + \alpha_3 MCS_{it} + \alpha_4 GDP_{it} + \alpha_5 NVC_{it} \\ &+ \alpha_6 FLQ_{it} + \alpha_7 MLQ_{it} + \alpha_8 GCA_{it} + \alpha_9 SVC_{it} + \varepsilon_{it} \qquad (2) \end{aligned}$$

In the structural model represented in equation (2) the first five variables are standard observable determinants of new housing investments defined as follows: HAP_{it} is housing asset price, HRC_{it} is housing replacement cost, MCS_{it} is mortgage cost spread (mortgage interest rate minus 10-year Treasury yield), *GDP* is gross domestic product (our measure of aggregate income), and NVC_{it} is normal vacancy in housing markets that is observable. The last four regressors are the unobservable liquidity factors induced by QE extracted using the PCA methodology, defined as follows: FLQ_{it} is a measure of metropolitan-level funding liquidity factor, MLQ_{it} is a measure of metropolitan-level market liquidity factor, GCA_{it} is a measure of metropolitan-level credit

[20] See for example Smith (1969) for the relationship between residential construction cycles and the availability of credit for Canada; Topel and Rosen (1988) for analysis of US single family housing supply where short-run elasticity is less than long,; Rose (1989), Malpezzi, Chun, and Green (1998) for the effects of topographical constraints on the supply of housing; Jaffee and Rosen (1979), Hendershott (1980), An, Bostic, Deng, and Gabriel (2006), Mian and Sufi (2009) for the impact of mortgage credit availability on house prices and housing starts; Glaeser et al (2006), Saks (2006) Quigley and Raphael (2005), and Mayer and Somerville (2000) for the impact of regulation on housing supply; and Hesley and Cappoza (1990), Grenadier (1996) Bar-Illan and Strange (1996) and Mayer and Summerville (2007) for optimal timing of housing investment under irreversibility and uncertainty.

availability factor induced by QE through capital market activities of the GSEs and FHA, SVC_{it} is a measure of metropolitan-level shadow vacancy factor due to the build-up in the inventory of single family homes-for-rent, and ε_{it}, is a random error term. The subscript i in the equation (2) is used to index areas or MSAs and t to denote periods.

Our perspective is that given recent developments in financial and asset markets, current asset prices (housing asset price and replacement cost) and other standard determinants of new housing supply may not be sufficient statistics for investment decision in new single family housing. In the current environment homebuilders must form expectations about future house prices under unusual circumstances and at the same time form expectations about the state of aggregate liquidity in the economy and by implication assess the probability of intervention by monetary authorities in deciding whether or not to build and how much housing to supply. In this regard, we deviate from traditional models in which the mortgage market affects new housing investments largely through the cost of mortgage credit. Instead; we propose that the volume of new house construction actually undertaken critically depends upon the overall level of market liquidity, funding liquidity, GSE credit availability, and shadow vacancy factor. [21] That is, we assume that the expected profitability of building a house is a function of the probabilities of being able to sell the house (market liquidity and shadow vacancy), and homebuyers capacity to finance the purchase of houses via a combination of mortgage debt and equity down-payment (funding liquidity and GSE credit availability). To the extent builders' and households' liquidity are central part of the recent trend in the abnormally low investment in new single family housings, one would expect to see a pronounced correlation between our aggregate liquidity factors and new housing investment, particularly if builders and households are capital constrained. Thus, it is particularly important to understand the separate effects of market liquidity, funding liquidity, credit availability and shadow vacancy on new housing investments, and by extension, for construction and related industries.

With regard to the shadow vacancy factor, the econometric model attempts to tease out the separate effect on new housing investments of build-up in inventory of single family homes-for-rent, a structural factor that signals the lack transaction intensity separate from trading volume per se. In particular, there are at least two reasons why our construct of trading intensity (shadow

[21] In carrying out their statutory goals these housing-related government sponsored agencies (GSEs) tap new sources of funds in capital markets to increase liquidity in mortgage and housing markets. During the crisis and initial phases of quantitative easing when banks began constricting their lending, Fannie and Freddie were responsible for about 90% of all mortgage originations which, effectively meant they were the only lenders still operating. This meant that the GSEs combined owned or guaranteed a total of $4.992 trillion (47.37% 0 of the $10.539 trillion mortgage market.

vacancy) can provide additional power beyond trading volume in explaining new housing investments. First, a low absolute trading intensity (high inventory of single homes-for-rent or shadow vacancy) can alter returns as the housing market struggles to readjust the inventory. Additionally, unlike in other asset markets a few deep pocketed arbitrageurs cannot easily counteract a market-wide liquidity shortage, as observed over the study period. Indeed, this particular housing market phenomenon witnessed over the study period provides an excellent laboratory experiment to test the hypothesis that trading intensity (or the lack thereof) has separate independent effect on new housing investments especially when liquidity constraints are binding on builders.

In the econometric model specified above, the demand for housing is influenced by the asset price of housing, and the asset price of housing is simultaneously influenced by the demand for housing. All else equal, a higher price of housing reduces the demand for housing. In the long-run, we assume that the asset price of housing should equal the replacement cost minus any depreciation. However, in the short-run the housing market may not always be in equilibrium, and if disequilibrium does exist, house prices may diverge from housing replacement-cost pricing. To address the obvious endogeneity problem, we specify a model of the housing asset price as follows:

$$HAP_{it} = \beta_0 + \beta_1 FLQ_{it} + \beta_2 GDP_{it} + \beta_3 NVC_{it} + \mu_{it} \qquad (3)$$

From (2) and (3),

$$\begin{aligned} NHI_{\text{it}} = {} & (a_0 + a_1\beta_0) + a_2 HRC_{it} + \alpha_3 MCS + (a_4 + a_1\beta_2) GDP_{it} + (\alpha_5 + \alpha_1\beta_3) NVC \\ \vdots \quad & (\alpha_6 + \alpha_1\beta_1) FLQ_{it} + \alpha_7 MLQ + a_8 GCA_{it} + \alpha_9 SVC + a_1 u_{it} + \varepsilon_{it} \qquad (4) \end{aligned}$$

where μ_{it} are differences (unobserved by the researcher) that are unrelated to the impact of market liquidity, funding liquidity, GSE and FHA credit availability or shadow vacancy, such as local supply constraints from land use control, natural or preserved features that restrict the number new houses that are built. Equation (4), the reduced form model, is the main focus of the analysis and subsequent discussions of the results are based mainly on the estimation of this model.

To account for the nature of our data, we use an estimation method that is suited to panel data, deals with a dynamic regression specification, controls for unobserved time- and MSA-specific effects, and deals with possible endogeneity in the explanatory variables. This is the generalized method of moments (GMM) for dynamic models of panel data developed by

Arellano and Bond (1991) and Arellano and Bover (1995). We employ a forward mean-differencing procedure (Arellano and Bover (1995)), also known as Herlmert transformation, to eliminate the fixed effects. This procedure removes only the forward mean, i.e., the mean of all the future observations available for each MSA-month. As suggested by Love and Zicchino (2006), we also perform time-demeaning transformation to control for time fixed effects before the Helmert transformation. We subtract the mean of each variable calculated for each MSA-month from the respective variable. Since the fixed effects are correlated with the regressors due to lags of the dependent variables, the mean-differencing procedure is commonly used to eliminate fixed effects. Once we have done the transformation, there will be no intercept in the models.

5.0 Empirical Results of Investment in New Single-family Housing

5.1 Baseline Results

This section presents the main empirical results on whether expected new housing investments are related to their sensitivities to fluctuations in the four constructed aggregate liquidity factors induced by QE. As a diagnostic check, we first report the results of univariate regressions to assess whether the sign on the coefficients of key explanatory variables, particularly those on the aggregate liquidity factors, are separately and independently in accord with expectations. Table 8 shows the results of the univariate regression. The first column of the table displays the estimated coefficients based on the contemporaneous values of the independent variables while the second and third columns show the results with the constructed aggregate liquidity factors lagged at various levels indicated within square brackets. The motivation for the lagging the liquidity factors is that the mere expectation of QE being implemented might cause relevant variables in housing and mortgage markets associated with various liquidity dimensions to react in anticipation. Remarkably, the univariate analysis suggests that new housing investments are responsive to changes in each of the four constructed aggregate liquidity factors induced by QE. Positive liquidity shocks from unconventional monetary are likely to boost new housing investments. In this context we note that both the credit availability and shadow vacancy factors would be expected to exert separate and significant influence on the construction decision of homebuilders. As well the signs on the coefficients of traditional observable determinants are consistent with theory in that new housing investments are driven in part by changes in housing asset price and other traditional fundamentals.

Our particular interest here centers on the behavior of the constructed aggregate liquidity factors in a multivariate setting while controlling for observable determinants typically used to study the supply of new single family housing investments. To this end, we estimated the structural model and several versions of the reduced form model that account for possible endogeneity of the housing asset price for the 13 MSAs over the period 2005:Q1-2012:Q4 . Two sets of three specifications of the model are estimated; the first set has all the variables set at their contemporaneous values and the second has the four aggregate liquidity factors lagged at various levels.

Table 9 reports the results for the whole sample. Column 1 shows the regression results for the structural model of new housing investment that include the standard determinants of housing starts and three of the four aggregate liquidity factors extracted from the data. Funding liquidity factor, GDP growth rate and normal vacancy are excluded in this regression since these variables are employed as instruments for house prices in reduced–form regressions.

Our main focus are the reduced form regression results reported in columns 2 and 3 of table 9 in which the housing asset price is replaced by the instrumental variables. The most striking feature of the results is that new housing investments have significant liquidity betas to all four of the constructed aggregate liquidity factors. That is fluctuations in these aggregate liquidity factors do affect the decisions of homebuilders to invest in new single-family housing as hypothesized earlier. For example, focusing on column 2, the point estimate of 23.93 on the funding liquidity factor, t-statistics of 2.83, is statistically significant and implies that a unit positive shock to this factor induced by QE increases new housing investments by 24 units per month per MSA. In contrast a negative shock of one unit to market illiquidity factor reduces output by 56 units per month per MSA. Combined these results suggest that absence of market liquidity has a more corrosive impact on new residential housing investments.

Interestingly, the credit availability liquidity factor (QE liquidity effects via the agencies and FHA loans capital market activities) appears to have separate and independent effect on new housing investments, in that new housing investments do have statistically significant beta with respect to changes in this aggregate liquidity risk factor. The point estimate of 53.37 on this factor (t-statistics 7.32) suggests that a one unit positive shock on credit availability induced by QE via the agencies and FHA new loans increases housing investments by approximately 53 units per month per MSA, which almost eliminates the negative effect when market illiquidity worsens. Earlier, we argued that depending on whether a transaction is seller or buyer initiated, trading volume per se is not an unambiguous gauge of transaction intensity in housing markets, especially in falling markets. Our conjecture is that the shadow vacancy factor is a more appropriate metric for capturing trading intensity (or the lack thereof) in housing markets. As shown in column 2 of table 9, new housing investments are significantly sensitive (negative beta) to fluctuations in shadow vacancy factor. The point estimate on the shadow vacancy factor suggests that all else equal a negative shock that increases the inventory of homes-for-rent will increase market illiquidity, which could decrease new housing investments further, in this case by as much as -15 units per month per MSA or -180 unit annually. It is worth stressing that an increase in shadow vacancy (absolute low trading intensity) implies sales delay, which entails forgone interest to the homebuilder, possible discounting of the price of the new homes, and ultimately delay in moving to the next project and/or going out of business. The negative sign on the shadow vacancy factor is consistent with this interpretation.

Column 3 of table 9 repeats the reduced form estimation with one additional innovation, an interaction term between funding liquidity and market illiquidity, to test for evidence of liquidity spiral in housing market. The coefficient on the interaction term suggests there is an additional effect when market illiquidity and funding liquidity come together. The negative point estimate of the interaction term of -45.31 (t-statistics -3.99) which is highly significant suggests that all else equal such combination reinforces illiquidity and new housing investments may actually plummet by as much as -45 units per month per MSA, clearly an undesirable outcome for the economy. This finding is consistent with Brunnermeier and Pedersen (2009) that market liquidity and funding liquidity are mutually reinforcing.

Finally, to check the robustness of our results we re-estimate the housing starts equation for the three alternative specifications this time with lagged values for the aggregate liquidity factors. Funding liquidity is lagged one month; market illiquidity is lagged two months and credit availability and shadow vacancy factors are lagged two quarters each. The results with lagged values of the four aggregate liquidity factors are reported in the last three columns of table 9. We observe that the results are generally similar to the ones from the estimation of the model with contemporaneous values and the coefficients are relatively stable. The one noticeable difference is that the sensitivity of new housing investments to fluctuations in the shadow vacancy factor has visibly increased in absolute value by at least two-folds. The results provide additional evidence in favor of the pricing of the four aggregate liquidity factors in new single-family housing investments. Overall, we conclude that all four aggregate liquidity factors are transmission channels through which QE stimulate new investments in single family housing.

5.2 Additional Robustness Checks

5.2.1: Heterogeneous Impact of Aggregate Liquidity Factors

The analysis thus far has implicitly assumed that housing markets are homogeneous across the 13 MSAs and has not explored the possibility of heterogeneity in policy impacts across different housing markets. The sources of heterogeneity could be land use regulation or the design of the precise mechanism through which the QE impacts economic activity. To extent that either or both of these forms of heterogeneity exist the response of new housing investments to the four aggregate liquidity factors may differ across housing markets. With regard to land use regulation, coastal cities (e.g. San Francisco, New York) generally display very high levels of land use regulation, whereas interior cities (e.g. Dallas, Minneapolis) are typically much less regulated. Consequently, there may be considerable differences across housing markets in the responsiveness of new housing investments to the four constructed aggregate liquidity factors. To test this geography of monetary policy impact hypothesis, we repeat our earlier multivariate regressions for two sub samples: (1) unconstrained housing markets (housing markets that are less regulated) and (2) constrained housing markets (housing markets that display high levels of land use regulation).

Table 10, columns 1- 6 and columns 7-12 report the estimation results for the constrained and the unconstrained housing markets, respectively. Regardless of alternative specification of the estimated econometric model and whether or not the factors are lagged, new housing investments in the unconstrained housing markets such as Charlotte, Cleveland, Dallas, Denver and Minneapolis are extremely sensitive to fluctuations in all four aggregate liquidity factors. Rather striking, the results paint a different picture for the constrained housing markets. New housing investments in the constrained housing markets including the coastal cities of Los Angeles, San Diego, San Francisco, New York, Portland, Seattle and Washington D.C. appear to be sensitive to only fluctuations in market illiquidity and credit availability factors, but not funding liquidity or the shadow vacancy factor over the study period. The latter result suggests that new housing investments in the high appreciation areas such as coastal California markets may be less sensitive to aggregate liquidity shocks induced by unconventional monetary policy.

5.2.2: Possible Source of Heterogeneity

Next, we investigate the two possible reasons for heterogeneity in the responsiveness of new housing investments to fluctuations in the aggregate liquidity factors induced by QE across housing market regimes. The results are presented in Table 11. Panel A shows the results of estimating the heterogeneity model with a dummy variable which equals 1 if the city is supply constrained and zero otherwise. We see that the intercept for unconstrained housing markets is positive and significant, implying that all else equal an unconventional monetary policy shocks (such as QE) to fundamentals yields on average 105 more units of new housing investments per month per MSA if the housing market is less constrained. In contrast the effective intercept for the constrained housing markets of 56.45 (-48.45+104.85) suggests that an equivalent unconventional monetary policy shock to fundamentals would increase new housing investments by only 56 units per month per MSA, if the housing market is constrained. The results in this panel confirm our earlier conclusion that the responsiveness of new housing investments to unconventional monetary policy shock is likely to vary according housing market regimes.

Panel B of table 11 drills down even further, seeking to uncover whether the muted sensitivity of new housing investments to fluctuations in the constructed aggregate liquidity factors induced by QE is due more to market regime (constrained versus unconstrained) or the transmission channels of QEs effects itself. To shed light on this important issue, we re-estimate the heterogeneity model, this time interacting the dummy variable with each of the four aggregate liquidity factors. As shown in panel B of Table 11 the coefficients on the interaction terms are negative and none is significant, except that of credit availability factor. Further and interestingly, the magnitudes of intercepts for both the constrained and unconstrained housing markets are essentially unchanged, and continue to be significant. These results support the contention that the muted response of investments in new single-family housing in constrained housing markets is due more to market regime (i.e. excessive land use control) and less to the precise transmission channel through which the QEs effects become manifested.

6.0: Model Simulation Analyses

In this section, we conduct several simulations designed to illustrate the performance of the model and how QE affects new housing investments through the transmission channels, namely the four aggregate liquidity factors constructed from the data. We start with the basic in-sample exercise that compares the model's forecast of new housing investments with the actual housing investments over the study period. Next, we then conduct a series of counterfactual analysis designed to tease out the effects of QE at stimulating real activity through the transmissions channels. Finally, simulations of the model provides a unique opportunity to examine a set of policy issues aimed at helping the languishing housing market recover in the midst of new qualified mortgages (QM) rules and the fundamental debate about the federal government's role in the residential mortgage finance system.

6.1: Model's forecasting Performance

We begin the assessment of the model by comparing the model's in-sample new housing investments forecast with the actual housing investments for various samples over the study period. Results obtained from fitting the model with observed values for the independent variables including the four aggregate liquidity factors are displayed in various panels of Figure 7. Generally, the model's forecast of new housing investments under-predicts for the period before the crisis (2005 to 2007) and over-predict for the period after the crisis. Nevertheless, we observe that the model performs relatively better after the crisis in that the variance between the model's forecasts and the actuals is less for the period after the crisis than for the period before the crisis. Specifically, the model under-predict by 475 units per month per MSA for the period 2005-2007, whereas for the period 2008-2012 the model over-predict output in new single-family housing investments by only 211 units per month per MSA. Further, the performance of the model in the case of Cleveland and Charlotte, cities that did not experience the boom in house prices that started in 1998 is noteworthy. Here, we observe that the model's new housing investments forecast more closely match the actual new housing investments observed over the study period, especially in the case of Charlotte where the variance between the predicted and the actual new housing investments is less than 1%, 0.23% to be precise. Over the entire study period, there is also some evidence that the model's new housing investments forecast tend to be above the actual new housing investments for cities generally considered to have more stringent land use controls, such as San Diego and San Francisco.

The observable discrepancy between the model's forecast of new housing investments and the actual housing investments for the period before 2008 may be an aberration. Indeed, the dramatic increase in actual new housing investments observed before 2008 appears to mimic the boom in house prices that occurred over the same period that cannot be explained by changes in fundamentals (See Figure 4). Figure 2 also reveals that while the relation between new housing investments and GDP growth rate was positive up to 2007, there has been a fundamental change in this relationship since then. Specifically, the relationship has turn negative. Shiller (2006) attributes the boom in house prices to psychological factors. An alternative explanation is the so-called Greenspan put; the idea that investors including homebuilders in the U.S. came to expect that the Federal Reserve would take steps to prevent asset prices from falling (but not from rising), and that this insurance or put option greatly induced homebuilders to build more houses under the erroneous belief that prices will not go down. We conjecture that the same market psychology and or the erroneous belief by investors including homebuilders that they are protected against downside risk may also have been at work in the case of investments in new single-family housing over the study period.

6.2: Counterfactual Analysis

Next, we conduct a series of counterfactual analysis to assess the efficacy of QE at stimulating investments in new single-family housing over the study period based on two scenarios: a policy scenario, i.e. the Fed intervenes via QE liquidity injections, and a no policy scenario i.e. Fed does not implement QE. The objective of this thought experiment is to tease out what new housing investments might have looked like had the Fed not intervened through QE. In constructing our counterfactual analysis, we continue to assume that stimulus effects of QE are transmitted through the program's impacts on the data used to extract the aggregate liquidity factors. That is the ultimate transmission channels of how QE affects new housing investments are through the four constructed liquidity factors. Several forecasts of the model's new housing investments are constructed conditional on the impact of QE over various sample periods to the end of the study period, December 2012. The model's forecast of new housing investments which reflect the effects of the QE is our baseline prediction.

For the no policy scenario, i.e. if the Fed did not intervene, the model is calibrated by simply fixing the levels of the constructed aggregate liquidity factors at the following key event dates associated with the crisis that mostly precede the start of QE: (1) August 9, 2007 – BNP Paribas terminated withdrawals from three of its hedge funds, an action considered by many to be the first signal of the impending crisis; (2) September 15, 2008 – Lehman Brothers files for bankruptcy, an important indicator of the meltdown of the shadow banking system, (3) November 25 2008 – Fed announced it would implement QE1 when financial markets and institutions came under maximum stress; and (4) October 2010, the Fed announced QE2 restricted to purchases of long term Treasury bonds. The counterfactual forecasts are then compared with the baseline forecasts which reflect the impact of QE. The difference between our baseline forecast of new housing investments and the counterfactual forecast is taken as the economic impact of QE, or the extent to which QE stimulates investments in new single-family housing.

In Figure 8, the panels report the results of this thought experiment under the four events dates parsimoniously designed to capture the level of duress in financial markets and probability of intervention by the Fed. The black line is the model's prediction of new housing investments that reflect the stimulus effects of QE, and the red line reports the response of the model assuming no intervention by the Fed. Under each event date there is a sharp drop in output if the Fed did not intervene to inject liquidity in the system via QE. As the panels show the drop in new housing investments is the sharpest under the BNP Paribus event-date when the nature of the unfolding crisis was murky at best and the fear of the unknown was perhaps at its highest point. The response in this panel suggests that had the Fed not intervened, new housing investments on average would have declined (relative to the baseline forecast) by 309 units per month per MSA or by -44.68% per month per MSA.

Moving the event date to either the period around the filing of bankruptcy of Lehman Brothers (September 2008) or around the period when it became certain the Fed would initiate the purchase of high grade securities (November, 2008) including agency MBS and agency debt to stabilize financial markets and stimulate economic activity, we observe that the response of counterfactual forecast is dramatic. The output drop is now only about 18% to 19% lower relative to the baseline case with Fed intervention via QE. In fact when we move the event-date needle to subsume QE1 and QE2 (November 2010), new housing investments output for the baseline forecast that includes the effects of QE and that of counterfactual forecast, which experimentally is not suppose to include the effects of QE, are very similar. The variance between the two forecasts is now only 35 units per month per MSA, or a decline in output of about 5% relative to the baseline forecast where the Fed intervenes via QE liquidity injections. Indeed, we would expect these results because liquidity in asset markets was substantially better during this period due to stabilizing and stimulating effects of QE. Perhaps the market expectations of Fed intervention and/or the initiation of QE1 attenuate the decline in new housing investments substantially.

We presume that the last experiment with event-date November, 2010 incorporates the cumulative build-up of the shocks from QE (QE1 and QE2). Hence, the policy works by improving the relevant housing market fundamental variables that are used to construct aggregate liquidity factors which act as the transmission channels for the effect of QE to real activity. This would imply that even mere anticipation of QE purchases could have significant effects on new housing investment through the constructed aggregate liquidity factors. Overall, we conclude that the results are broadly consistent with the notion that had the Fed not intervened to stabilize financial markets and stimulate economy activity through quantitative easing, investments in new single family housing would have been much lower. Based on our simulation analysis the drop in new housing investments output could have been anywhere from -5% to as high as -44% lower than the corresponding base line figure depending on the event date used, or alternatively depending on the approximate date when the market became certain the Fed will intervene through QE. In sum the gist of our counterfactual results is consistent with the view that QE, especially QE1, has been effective at stimulating real economic activity, quite apart from its positive effect on general level of market interest rates. Of course in our case we show that QE has been effective in stimulating a specific economic activity, namely new housing investments [22]

6.3: Sensitivity Analysis

Finally, we conduct a series of simulations of the model based on a set of policy issues aimed at helping the languishing housing market recover and to shed light on the fundamental debate about the federal government's role in the residential mortgage finance system. In particular, we conduct sensitivity analysis of the model to illustrate how external shocks to policy variables such as loan-to-value ratio (LTV), debt-to-income ratio (DTI), FICO scores, GSE and FHA credit activities, and the four aggregate liquidity factors may work to moderate downturn in housing markets. The simulation procedure is described as follows: all variables are set equal to their mean values over the 2005-2012 sample period. The aggregate liquidity factors are reconstructed accordingly for these mean values. The model is then used to simulate the effects of different policy interventions to stimulate investment in new single housing given the parameter estimates from the previous section. This produces a base forecast upon which other information can be added. Comparisons are then made to the baseline forecast.

A distinguishing feature of the policy analyses conducted here is that we entertain the new qualified mortgages (QM) rules. Fannie Mae and Freddie Mac have said that they would be willing to guarantee low-down payment loans (as low as 3% of the value of the home) if private mortgage insurers would be willing to insure the 20 percent that the borrower has not covered with a down payment. Currently, low-down payment mortgage insured by FHA make up nearly 14 percent of mortgages originated. We first simulate what would have happened to new housing investments over the study period if Fannie and Freddie had participated in low down-payment program that doubles the size of low down-payment market from 14 percent to 28 percent of all mortgages originated. Based on this thought experiment the actual effective LTV for the low down-payment mortgage market over the study period would be approximately 73% as opposed

[22] Incidentally, QE1 which cost $1.7 trillion was the single largest government intervention, lasted the longest (17 months), particularly aimed at stimulating investments in housing sector, and was initiated when financial market and institutions were under highest stress.

to 69% with FHA as the only participant in this market.[23] We simulate the model assuming this policy variable is increased from 69% to 73%. For all the other variables including the aggregate liquidity factors, we simulate shocks to them by increasing or decreasing each variable from its mean value over the 2005-2012 period.

Table 12 reports the results of these experiments. Panel A of table suggests that a policy shock due to participation of Fannie/Freddie in the low down-payment program that increases the LTV for low down-payment loans by 460 basis points (from 68.79% to 73.39%) would have increased new housing investments on average by 17.66% per year per MSA over 2005-2012 period. Here it is worth pointing out that new housing investments are highly dependent (as one would expect) upon loan-to-value ratios. This point has been known for a long time. When loan-to-value ratios are low (or equivalently when equity down-payment ratios are high) and funding liquidity is tight, households generally become extremely reluctant to take on new investments, especially “capital intensive" investments in single-family housing. [24]

Panel B of Table 12 shows the results of simulating the model by increasing the debt-to-income ratio (DTI) – from roughly 35% to 42%, the maximum payment-to-income ratio allowable under the new QM rules. A common finding throughout the housing demand literature is that tight initial mortgage payments relative to income (i.e., low payment-to-income ratios) can significantly reduce the level of household formations as well as new housing investments. We also show that tight initial mortgage payments relative to income can significantly reduce new housing investments. For example, as the average payment-to-income ratio increases from 35% to 42% (and lending constraints loosen), new housing investments increase from a baseline case of 1053 units per month per city to a monthly 1,164 unit rate, an increase of over 126% annually. Obviously, this is an exaggerated amount, but it does indicate the sensitivity of housing starts to changes in DTI.

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[23] The 73% figure is calculated as follows: Average LTV in period t = %FHA share x.97 + (1- %FHA share) x average LTV on Fannie and Freddie loans in period t = Average LTV in 2005-2012 = 0.14 x.97 + (1-.0.14) x Average LTV on Fannie and Freddie loans. Therefore the average LTV on Fannie and Freddie = 0.687948 = 0.14 x.97 + 0.86 x X. Hence, X, average LTV on Fannie/Freddie loans over the study period (2005-2012) = 0.642032, approximately 64%. Now assuming Fannie/Freddie participation that doubles the share of low down-payment loans to 28%, the effective LTV over the study = 0.28 x. 97 + (-0.28) x.642032 = 0.733863 or approximately 73%.

[24] Often, reductions in loan-to-value ratios are quite common (as we find here) in periods of declining demand. Declining loan-to-value ratios serve to ration credit both by reducing the amount loaned to actual borrowers and by eliminating some would-be borrowers who would require loans with low down-payments. See Jaffee and Rosen (1979) for evidence along these lines.

Panel C of table 12 shows the effects of tightening of underwriting standards on housing starts. Specifically, an increase in FICO scores from the mean of 745 observed during the study period to 780 is expected to sharply decrease housing starts from monthly 1053 units per MSA down to 922 units. Clearly, this result shows that changes in underwriting standards that increases FICO scores would significantly reduce entry into homeownership market which in turn decreases new housing investments. Panels D and E of Table 12 show the effects of capital market activities of the GSEs and FHA on new housing investments. Tighter capital markets (i.e., lower loan purchases by the GSEs and FHA insurance) hinder growth. Conversely, liberalization in capital markets (e.g. QE induced purchases) facilitates growth. We find that large dollar volume of loan purchases by the GSEs – an increase from \$3.1 trillion \$3.5 trillion - increases new housing investments by 39.15%. Further, we report similar findings for FHA loan insurance. An increase in FHA insured loan from \$3.9 trillion to \$4.2 trillion increases new housing investments by 46.59%.

Panel F of Table 12 shows the effects of a one-standard deviation shock to each of the constructed aggregate liquidity factors compared to long run average new housing investments for the sample. A one-standard deviation increase in funding liquidity increases new housing investments by roughly 18%. Also as predicted, new housing investments increase with an improvement in market liquidity. A one-time decrease in market illiquidity increases new housing investments from a baseline case of 1053 units per month per city to a monthly 1,098 unit rate. Also shown in this panel is the simulated effect of a one-standard deviation increase in credit availability. In this phase, as credit availability increases, new housing investments increase – from a baseline case of 1053 units per month per city to a monthly 1,107 unit rate, an increase of 82%. This result suggests that other things being equal, in the absence of the GSEs and FHA during the post-financial crisis, new housing investments would have fallen even more than otherwise, and the decrease would have been significant.

Finally as the shadow vacancy factor decreases (equivalently as inventory of homes-for-rent decrease), new housing investments also increase – from a baseline case of 1053 units per month per city to a monthly 1,064 unit rate, an increase of 13%%. Hence, the high shadow vacancy rate also help explains the abnormally low number of new housing investments of recent years. Since new housing investments respond to fluctuations in all the aggregate liquidity factors a warranted explanation for the abnormally low number of new housing investments of recent decades appears to be decrease in aggregate liquidity in housing and mortgage markets. Further, the behavior of the aggregate liquidity factors is consistent with the view that these aggregate liquidity factors are alternative channels through which the stimulus effects of QE are transmitted to the housing sector, in particular, new housing investments, as a specific channel of economic activity that most likely boost GDP or aggregate output growth.

7.0: Summary and Conclusions

Since January 2006, new housing investments (housing starts), in the U.S. have dramatically fallen to well below normal levels and have remained there. This trend has potentially troubling implications for U.S. GDP growth. Yet we know very little about what caused this dramatic shift, and what role unconventional monetary policy can play in mitigating or reversing this trend. In this paper, we specify and estimate a model of new housing investments supply that incorporates four constructed aggregate liquidity factors that capture the Fed's unprecedented liquidity injections via QE as well as standard observable determinants of new housing supply. The main results suggest that new housing investments liquidity betas (their sensitivities to liquidity shocks from QE transmitted through the constructed aggregate liquidity factors) play a significant role in explaining the abnormally low investments in new single family housing of recent years. Further the results suggest that in the absence of credit availability induced by QE via capital market activities of the GSEs and FHA during the post-financial crisis period, the contraction in new single-family housing investments would have been worse.

Additionally, new housing investments are found to be extremely sensitive to the build-up in the inventory of homes-for-rent, a structural factor that emerged in housing markets as a consequence of the harshness of the recent crisis. Overall, our counterfactual analysis would suggest that QE has been efficacious in stimulating economic activity in that investments in new single family housing might have been much lower had the Fed had not implemented the unconventional monetary policy involving large scale asset purchases. Remarkably, there is also evidence of heterogeneity in the responsiveness of new housing investments to fluctuations in the aggregate liquidity factors induced by QE across housing markets due to land use restrictions. This suggests that heterogeneity in housing markets or housing market regimes should be assessed and considered in the designing policy interventions. As restrictions on new housing construction pile on top of each other, especially in high-priced, high-demand coastal California markets, the restrictions prevent builders from putting up new housing altogether, and the supply of new housing becomes much less sensitive to changes in market liquidity and funding liquidity induced by unconventional monetary policy. Overall, these results imply that policy makers concerned about why the housing market has stalled should also look to easing restrictions on new housing supply as the most effective means of promoting a stronger housing sector in some markets. .

Finally, as a closing comment, an important policy priority for future work in this area is to understand the individual circumstances and aggregate economic conditions that can make markets relatively insensitive (or muted) to positive shocks or fluctuations in aggregate liquidity. This study takes a step in this direction. One explanation for this insensitivity to unconventional monetary policy shocks is excessive land use restrictions on new housing construction. As communities become more and more restrictive in the amount of development they will permit, the end result is less new development in the areas where the demand is the greatest, and therefore less sensitivity to changes in aggregate liquidity factors. Notwithstanding the usual caveats, our aggregate liquidity factors do provide a reasonable parsimonious approach to identify the transmission channels of unconventional monetary policy, the efficacy of QE in stimulating output, and in highlighting a specific economic activity, namely new housing investments, through which QE boost aggregate output or GDP growth.

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Table 1: Definition and sources of variables used in the study (2005-2012)

No	Variables	Description	period	unit
1	Housing start	Privately Owned Housing Starts Authorized by Building Permits: 1-Unit Federal Reserve Bank of St. Louis	198801-201403 Monthly MSA level.	unit
2	House price index	S&P/Case-Shiller Home Price Indices 19 cities Index January 2000 = 100	200001 –201401 Monthly MSA level.	100
3	Construction cost	Morris Davis 48 cities Las Vegas has no data	198412 - 201309 Quarterly MSA level.	dollars
4	Trading volume	S&P/Case-Shiller Home Price Indices 20 cities.	200001 – 201401 Monthly MSA level.	unit
5	Debt-to-Income Ratio	Fannie Mae Single-Family Loan Performance Data Glossary and Freddie Mac Single-Family Loan-Level Dataset MSA level.	199303-201305 Monthly MSA level average.	percentage
6	Credit Score	The same as above.	199303-201305 Monthly MSA level average.	score
7	Loan-to-Value	The same as above.	199303-201305 Monthly MSA level average.	percentage
8	Mortgage rate	The same as above	199303-201305 Monthly MSA kevel average	percentage
9	Sale price to list ratio	Zillow	200810-201404 Monthly MSA level.	decimal
10	Selling for loss ratio	Zillow	199801-201404 Monthly MSA level.	percentage
11	Foreclosure sale	Zillow	199801-201404 Monthly MSA level.	percentage
12	Sale inventory	Zillow	201001-201404 Monthly MSA level.	unit
13	Home for rent	Zillow	201002-201404 Monthly MSA level.	unit
14	Vacancy rate	U.S. Department of Commerce: Bureau of Economic Analysis Homeowner Vacancy Rates for the 75 Largest Metropolitan Statistical Areas:	200501 - 201312 Quarterly	percentage
15	Agency-and GSE-Backed Mortgage purchase	Board of Governors of the Federal Reserve System	194910-201310 Quarterly National level.	billion
16	FHA loan	Board of Governors of the Federal Reserve System	194901-201312 Quarterly National level	billion

Table 2: Summary statistics of variables used in the study for the period 2005-2012

Panel A: This table reports descriptive statistics for the variables used in our analysis.

Variable	N	Mean	Median	Std Dev	Minimum	Maximum
House Price index (100)	96	156.35	142.75	22.11	131.77	189.96
Housing start (unit/month)	96	806.10	564.81	474.87	315.54	1871.00
Construction cost index (100)	96	163.54	170.01	14.84	133.19	184.06
Debt to income ratio (%)	96	35.45	36.42	2.68	31.23	39.21
FICO score	96	744.74	744.60	19.35	717.52	768.61
Loan to value ratio (%)	96	68.79	68.42	2.07	63.94	73.12
Sale to list price ratio	51	0.97	0.97	0.01	0.96	0.98
Selling for loss ratio (%)	96	18.01	20.71	11.57	3.42	37.95
Sale inventory (# of units)	36	23616.72	25381.92	4352.39	14929.31	28374.62
Trading volume (unit/month)	96	5215.48	4967.42	1558.13	3186.46	9677.54
Foreclosure sale ratio (%)	96	13.81	16.01	8.51	2.33	29.68
Vacancy rate (%)	96	2.44	2.41	0.26	1.96	2.98
Home-for- rent (units)	35	11857.63	11219.85	7097.01	1945.77	27637.31
Mortgage rate (%)	96	5.50	5.73	0.78	3.95	6.69
30 year mortgage rate spread (%)	96	2.51	2.69	0.62	1.47	3.81
GDP growth rate (%)	96	0.25	0	1.19	-2.88	6.81
GSE Mortgage purchase (Billion)	96	3140.19	3587.85	1577.03	980.17	5376.71
FHA loan (Billion)	96	3921.91	3796.48	360.84	3335.31	4713.48

Panel B: This table reports variable average over time.

Variables	Dec-05	Dec-06	Dec-07	Dec-08	Dec-09	Dec-10	Dec-11	Dec-12
House Price index (100)	185.83	187.89	173.51	142.67	140.15	136.41	131.77	142.84
Housing start (unit/month)	1750.54	1130.38	674.77	350.46	561.69	434.15	465.23	618.23
Construction cost index (100)	140.66	150.64	159.03	171.01	170.03	173.56	180.79	184.06
Debt to income ratio (%)	36.03	38.47	38.39	38.46	33.46	32.33	33.36	31.53
FICO score	728.76	726.40	725.48	744.65	763.44	766.73	764.44	761.75
Loan to value ratio (%)	66.96	67.30	69.32	72.48	66.15	68.09	72.55	70.20
Sale to list ratio	.	.	.	0.96	0.98	0.97	0.97	0.98
Selling for loss ratio (%)	4.11	5.86	8.83	19.91	23.00	26.19	35.19	33.96
Sale inventory (#units)	.	.	.	.	.	27545.0	23421.8	14929.3
Trading volume (unit/month)	7358.31	5935.46	3883.46	4193.54	4867.08	3606.54	3665.15	4132.38
Foreclosure sale ratio (%)	2.74	3.90	9.62	25.41	19.80	21.33	18.78	11.18
Vacancy rate (%)	2.44	2.61	2.48	2.98	2.70	2.75	2.45	2.88
Home-for-rent (units)	.	.	.	.	.	7447.92	12879.9	27637.3
Mortgage rate (%)	5.63	6.69	6.63	6.42	5.14	4.82	4.72	3.95
30 year mortgage rate spread (%)	1.88	1.61	2.61	3.81	2.59	2.78	3.07	2.65
GDP growth rate (%)	6.81	4.86	2.72	-2.87	3.61	3.99	5.01	.
GSE Mortgage purchase (Billion)	3548.48	3841.12	4464.42	4961.43	5376.71	1139.47	1304.80	1437.04
FHA loan (Billion)	3592.20	3796.21	3699.93	3463.69	4257.48	4075.61	4381.05	4713.48

Table 3: Mean values of key variables across 13 MSAs

Variables	N	Charlotte	Cleveland	Dallas	Denver	Los Angeles	Minneapolis	New York	Phoenix	Portland	San Diego	San Francisco	Seattle	Washington, D.C.
House Price index (100)	96	120.80	109.35	119.50	130.65	205.17	138.73	186.15	151.12	155.81	188.88	165.16	157.43	203.84
		(7.76)	(9.07)	(3.33)	(5.26)	(43.00)	(23.21)	(19.45)	(48.62)	(18.26)	(40.44)	(36.48)	(19.38)	(27.80)
Housing starts (unit/month)	96	858.03	241.86	2063.55	608.60	612.78	606.41	864.02	1641.14	507.29	270.06	315.46	787.52	1102.56
		(563.37)	(128.83)	(1159.78)	(434.39)	(406.74)	(409.20)	(418.35)	(1312.85)	(295.25)	(161.58)	(186.04)	(389.52)	(473.76)
Construction cost index (100)	96	186.22	140.85	160.10	161.28	156.11	149.41	150.89	177.25	156.89	169.46	173.97	166.66	176.98
		(19.56)	(7.87)	(15.06)	(13.54)	(12.95)	(7.75)	(13.21)	(16.79)	(13.54)	(17.29)	(22.68)	(17.49)	(17.98)
Debt to income ratio (%)	96	33.55	34.10	34.77	34.60	37.79	34.83	36.80	35.31	35.59	36.73	36.00	35.87	34.91
		(2.94)	(2.58)	(2.12)	(2.68)	(2.62)	(3.27)	(2.58)	(2.64)	(2.78)	(2.57)	(2.33)	(3.04)	(3.38)
FICO score	96	741.47	741.42	738.78	751.20	742.84	748.62	735.13	741.54	747.62	750.97	755.67	746.07	740.29
		(18.68)	(18.14)	(16.45)	(15.31)	(23.06)	(18.85)	(20.54)	(24.15)	(18.46)	(18.79)	(15.99)	(19.15)	(26.33)
Loan to value ratio (%)	96	74.34	74.61	76.57	72.56	60.64	72.46	66.08	71.63	70.39	61.65	57.13	69.09	67.21
		(3.23)	(2.13)	(1.80)	(1.94)	(4.29)	(2.23)	(1.98)	(2.79)	(2.52)	(5.10)	(5.99)	(2.71)	(2.49)
Sale to list ratio	51	0.96	0.94	0.98	0.98	0.98	0.97	0.95	0.98	0.97	0.98	0.99	0.98	0.98
		(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Selling for loss ratio (%)	96	17.39	17.52	17.77	17.43	15.30	22.35	14.75	23.15	15.79	23.40	18.01	13.80	17.45
		(12.25)	(11.95)	(8.81)	(10.28)	(11.29)	(12.42)	(6.94)	(19.23)	(11.36)	(15.27)	(11.93)	(11.70)	(11.45)
Sale inventory (units)	36	14904.97	13404.92	35888.06	15407.31	36353.14	16101.36	72698.42	30298.94	11309.14	12689.22	9515.61	16897.67	21548.67
		(2753.65)	(1562.89)	(6848.89)	(4575.29)	(7963.24)	(3824.85)	(5916.84)	(8761.70)	(2807.44)	(2620.07)	(3151.56)	(5430.12)	(4155.27)
Trading volume (unit/month)	96	2165.85	1198.17	5987.71	4580.80	9188.00	4452.75	10431.00	9453.35	2946.25	2716.43	4074.35	3997.28	6609.29
		(1015.87)	(511.83)	(1336.10)	(1371.55)	(2860.52)	(1264.00)	(4426.17)	(3176.95)	(1189.41)	(654.38)	(1062.16)	(1777.06)	(2883.92)
Foreclosure sale ratio (%)	96	8.76	19.28	13.04	18.89	18.28	9.12	2.00	23.79	9.66	19.48	17.73	9.14	10.30
		(3.89)	(8.74)	(4.30)	(7.88)	(13.86)	(7.58)	(1.34)	(20.26)	(7.61)	(14.83)	(14.54)	(7.60)	(8.23)
Vacancy rate (%)	96	2.55	2.43	2.54	2.90	2.32	2.37	2.82	2.08	2.35	2.51	2.55	1.67	2.60
		(1.27)	(1.00)	(0.80)	(1.03)	(0.88)	(0.83)	(1.50)	(0.95)	(1.42)	(0.94)	(0.93)	(0.85)	(0.97)
Home for rent (units)	35	2890.26	1040.17	14028.20	3340.51	15474.00	3605.43	71358.34	13243.14	2193.57	5206.26	4520.91	5518.06	11730.37
		(960.45)	(646.94)	(10166.56)	(2524.00)	(7416.13)	(2114.17)	(44489.28)	(6788.49)	(1661.64)	(3377.04)	(3282.40)	(3982.59)	(6834.69)
Mortgage rate (%)	96	5.50	5.55	5.53	5.49	5.49	5.47	5.53	5.59	5.46	5.48	5.48	5.46	5.48
		(0.78)	(0.79)	(0.79)	(0.78)	(0.79)	(0.78)	(0.78)	(0.78)	0.77)	(0.78)	(0.77)	(0.77)	(0.79)
30 year mortgage rate spread (%)	96	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
		(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)	(0.62)
GDP growth rate (%, month)	96	0.25	0.14	0.33	0.25	0.16	0.23	0.24	0.20	0.45	0.17	0.25	0.36	0.27
		(1.19)	(0.90)	(1.62)	(1.20)	(1.12)	(1.02)	(1.09)	(1.51)	(1.89)	(0.94)	(1.50)	(1.54)	(1.04)
GSE Mortgage purchase (Billion)	96	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19	3140.19
		(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)	(1577.03)
FHA loan (Billion)	96	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91	3921.91
		(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)	(360.84)

Table 4: Percentage change of variables at different time intervals

	%change from 2005:01-2008:09	% change from 2008:09-2012:12	% change from 2005:01-2012:12
(1) House Price index	-7.99	-5.31	-12.87
(2) Housing start	-69.04	24.82	-61.36
(3) Construction cost index	26.21	8.93	37.47
(4) Debt to income ratio	58	-16.14	32.5
(5) FICO score	3.23	2.85	6.17
(6) Loan to value ratio	0.61	0.32	0.94
(7) Sale to list ratio		2.11	
(8) Sale for loss ratio	279.89	116.49	722.41
(9) Sale inventory		-37.95	
(11)Trading volume	-16.68	-24.87	-37.40
(12) Foreclosure sale ratio	559.11	-43.88	269.91
(13) Vacancy rate	16.79	16.88	36.50
(14)Home-for- rent		1320.38	
(15) Mortgage rate	-1.65	-33.67	-34.76
(16) GSE Mortgage purchase	43.60	-70.63	-57.82
(17) FHA loan	-10.07	41.32	27.09

Note: Sale to list ratio is available from 2008:10 to 2012:12. Sale inventory is available from 2010:01 to 2012:12. Home-for-rent is available from 2010:02 to 2012:12.

Table 5: Pair-wise correlation matrix of variables

	Price index (100)	Housing start (unit/month)	Construction cost index (100)	Debt to income ratio (%)	FICO score	Loan to value ratio (%)	Sale to list ratio (X)	Selling for loss ratio (%)	Sale inventory (units)	Trading volume (unit/month)	Foreclosure sale ratio (%)	Vacancy rate (%)	Home for rent (units)	Mortgage rate (%)	30 year mortgage rate spread (%)	GDP growth rate (%)	GSE Mortgage purchase (Billion)	FHA loan (Billion)
Price index (100)	1.000	0.184	-0.278	0.595	-0.501	-0.681	0.223	-0.542	0.318	0.483	-0.513	0.010	0.323	0.386	-0.439	0.040	0.243	-0.359
Housing start	0.184	1.000	-0.310	0.190	-0.544	0.247	0.308	-0.441	0.299	0.501	-0.414	-0.030	0.220	0.271	-0.511	0.077	0.137	-0.325
Construction cost index (100)	-0.278	-0.310	1.000	-0.462	0.633	0.029	0.433	0.668	-0.245	-0.259	0.469	0.014	-0.057	-0.493	0.600	-0.030	-0.319	0.553
Debt to income ratio (%)	0.595	0.190	-0.462	1.000	-0.760	-0.223	-0.139	-0.689	0.340	0.312	-0.295	-0.022	0.127	0.865	-0.315	-0.026	0.599	-0.727
FICO score	-0.501	-0.544	0.633	-0.760	1.000	-0.051	0.516	0.852	-0.464	-0.384	0.594	0.023	-0.333	-0.812	0.607	-0.008	-0.552	0.742
Loan to value ratio	-0.681	0.247	0.029	-0.223	-0.051	1.000	-0.273	0.158	-0.139	-0.199	0.091	0.007	-0.112	-0.001	0.189	-0.019	-0.065	0.069
Sale to list ratio (X)	0.223	0.308	0.433	-0.139	0.516	-0.273	1.000	0.369	-0.328	0.315	0.159	-0.098	-0.220	-0.348	-0.270	0.019	-0.180	0.330
Selling for loss ratio (%)	-0.542	-0.441	0.668	-0.689	0.852	0.158	0.369	1.000	-0.321	-0.282	0.642	0.023	-0.132	-0.761	0.677	-0.020	-0.565	0.778
Sale inventory	0.318	0.299	-0.245	0.340	-0.464	-0.139	-0.328	-0.321	1.000	0.628	-0.227	0.070	0.665	0.215	0.005	0.003	-0.177	-0.205
Trading volume	0.483	0.501	-0.259	0.312	-0.384	-0.199	0.315	-0.282	0.628	1.000	-0.214	-0.076	0.419	0.171	-0.318	-0.031	0.131	-0.238
Foreclosure sale ratio (%)	-0.513	-0.414	0.469	-0.295	0.594	0.091	0.159	0.642	-0.227	-0.214	1.000	-0.027	-0.440	-0.285	0.595	-0.078	-0.127	0.281
Vacancy rate (%)	0.010	-0.030	0.014	-0.022	0.023	0.007	-0.098	0.023	0.070	-0.076	-0.027	1.000	-0.010	-0.025	0.041	0.033	-0.008	0.028
Home for rent	0.323	0.220	-0.057	0.127	-0.333	-0.112	-0.220	-0.132	0.665	0.419	-0.440	-0.010	1.000	-0.271	0.056	-0.017	0.300	0.283
Mortgage rate (%)	0.386	0.271	-0.493	0.865	-0.812	-0.001	-0.348	-0.761	0.215	0.171	-0.285	-0.025	-0.271	1.000	-0.388	-0.016	0.716	-0.823
30 year mortgage rate spread (%)	-0.439	-0.511	0.600	-0.315	0.607	0.189	-0.270	0.677	0.005	-0.318	0.595	0.041	0.056	-0.388	1.000	-0.105	-0.175	0.378
GDP growth rate (%)	0.040	0.077	-0.030	-0.026	-0.008	-0.019	0.019	-0.020	0.003	-0.031	-0.078	0.033	-0.017	-0.016	-0.105	1.000	-0.096	0.003
GSE Mortgage purchase (Billion)	0.243	0.137	-0.319	0.599	-0.552	-0.065	-0.180	-0.565	-0.177	0.131	-0.127	-0.008	0.300	0.716	-0.175	-0.096	1.000	-0.703
FHA loan (Billion)	-0.359	-0.325	0.553	-0.727	0.742	0.069	0.330	0.778	-0.205	-0.238	0.281	0.028	0.283	-0.823	0.378	0.003	-0.703	1.000

Table 6: Housing and Mortgage Market Data used extract Unobservable Liquidity Factors via Principal Component Analysis

Panel A, Percentage change in the variables at different time intervals

	Mean	Median	Std Dev	Minimum	Maximum	%change from 2005:01-2008:09	% change from 2008:09-2012:12	% change from 2005:01-2012:12
(1) Debt to income ratio	35.45	36.42	2.68	31.23	39.21	58	-16.14	32.5
(2) FICO score	744.74	744.6	19.35	717.52	768.61	3.23	2.85	6.17
(3) Loan to value ratio	68.79	68.42	2.07	63.94	73.12	0.61	0.32	0.94
(4) Sale to list ratio	0.97	0.97	0.01	0.96	0.98		2.11	
(5) Sale for loss ratio	18.01	20.71	11.57	3.42	37.95	279.89	116.49	722.41
(6) Sale inventory	23616.7	25381.2	4352.4	14929.31	28374.62		-37.95	
(7)Trading volume	5215.48	4967.42	1558.1	3186.46	9677.54	-16.68	-24.87	-37.4
(8) Foreclosure sale ratio	13.81	16.01	8.51	2.33	29.68	559.11	-43.88	269.91
(9)Home-for- rent	11857.63	11219.9	7097.0	1945.77	27637.31		1320.38	
(10) Mortgage rate	5.5	5.73	0.78	3.95	6.69	-1.65	-33.67	-34.76
(11) GSE Mortgage purchase	3140.19	3587.85	1577.03	980.17	5376.71	43.6	-70.63	-57.82
(12) FHA loan	3921.91	3796.48	360.84	3335.31	4713.48	-10.07	41.32	27.09

Panel B correlation matrix

	Debt to income ratio (%)	FICO score	Loan to value ratio (%)	Sale to list ratio (X)	Selling for loss ratio (%)	Sale inventory (units)	Trading volume (unit/month)	Foreclosure sale ratio (%)	Home for rent (units)	Mortgage rate (%)	GSE Mortgage purchase (Billion)	FHA loan (Billion)
Debt to income ratio (%)	1	-0.76	-0.223	-0.139	-0.689	0.34	0.312	-0.295	0.127	0.865	0.599	-0.727
FICO score	-0.76	1	-0.051	0.516	0.852	-0.464	-0.384	0.594	-0.333	-0.812	-0.552	0.742
Loan to value ratio	-0.223	-0.051	1	-0.273	0.158	-0.139	-0.199	0.091	-0.112	-0.001	-0.065	0.069
Sale to list ratio (X)	-0.139	0.516	-0.273	1	0.369	-0.328	0.315	0.159	-0.22	-0.348	-0.18	0.33
Selling for loss ratio (%)	-0.689	0.852	0.158	0.369	1	-0.321	-0.282	0.642	-0.132	-0.761	-0.565	0.778
Sale inventory	0.34	-0.464	-0.139	-0.328	-0.321	1	0.628	-0.227	0.665	0.215	-0.177	-0.205
Trading volume	0.312	-0.384	-0.199	0.315	-0.282	0.628	1	-0.214	0.419	0.171	0.131	-0.238
Foreclosure sale ratio (%)	-0.295	0.594	0.091	0.159	0.642	-0.227	-0.214	1	-0.44	-0.285	-0.127	0.281
Home for rent	0.127	-0.333	-0.112	-0.22	-0.132	0.665	0.419	-0.44	1	-0.271	0.3	0.283
Mortgage rate (%)	0.865	-0.812	-0.001	-0.348	-0.761	0.215	0.171	-0.285	-0.271	1	0.716	-0.823
GSE Mortgage purchase (Billion)	0.599	-0.552	-0.065	-0.18	-0.565	-0.177	0.131	-0.127	0.3	0.716	1	-0.703
FHA loan (Billion)	-0.727	0.742	0.069	0.33	0.778	-0.205	-0.238	0.281	0.283	-0.823	-0.703	1

Table 7: Results of Principal component analysis

. Panel A: Eigenvalue in the principal component analysis.

	Eigenvalue	Difference	Cumulative Eigenvalue	Proportion	Cumulative Proportion
1	2.7150	0.8835	2.7150	0.2262	0.2262
2	1.8315	0.4204	4.5464	0.1526	0.3789
3	1.4111	0.3868	5.9575	0.1176	0.4965
4	1.0243	0.0511	6.9818	0.0854	0.5818
5	0.9732	0.1144	7.9551	0.0811	0.6629
6	0.8588	0.1433	8.8139	0.0716	0.7345
7	0.7156	0.1008	9.5295	0.0596	0.7941
8	0.6148	0.0600	10.1442	0.0512	0.8454
9	0.5548	0.0386	10.6990	0.0462	0.8916
10	0.5162	0.0766	11.2152	0.0430	0.9346
11	0.4396	0.0944	11.6548	0.0366	0.9712
12	0.3452		12	0.0288	1

Panel B Standardized scoring coefficients (Factor Loadings)

	Factor1	Factor2	Factor3	Factor4
Growth rate of Debt to income ratio	0.34279*	-0.05613	-0.02006	-0.04169
Growth rate of FICO score	-0.30641*	0.08479	-0.03936	0.05123
Growth rate of Loan to value ratio	0.2936*	0.01674	0.01946	0.06424
Growth rate of mortgage rate	0.3334*	0.01056	0.03153	-0.03385
Growth rate of Sale to list ratio	-0.02108	-0.18559*	0.01251	-0.35504*
Growth rate of Selling for loss ratio	-0.03374	0.36438*	0.05985	-0.19304
Growth rate of Trading volume	0.03315	-0.43224*	-0.04473	-0.05174
Growth rate of Foreclosure sale ratio	-0.05358	0.44183*	0.02158	-0.03494
Growth rate of GSE mortgage purchase	-0.02949	0.05553	0.53763*	-0.00185
Growth rate of FHA loan	0.06131	0.02907	0.28556*	0.14729
Growth rate of Sale inventory	0	-0.02001	-0.51071*	0.07688
Growth rate of Home for rent	-0.04839	-0.10566	0.06104	0.86797*

Note: Factor1 is Aggregate Funding liquidity Factor; Factor2 is Market illiquidity Factor; Factor3 is Credit Availability Liquidity Factor (liquidity induced by QE via GSE and FHA credit activities), and Factor4 is Shadow vacancy Liquidity Factor (inventory of home-for-rent)

Table 8: Simple regressions for whole sample

This table reports simple regression results of housing starts on each explanatory variable including the four aggregate liquidity factors for 13 MSAs, using the generalized methods of moments (GMM). All the variables have been demeaned by subtracting the mean. Model (1) uses contemporaneous value of variables and models (2) and (3) use lag values of aggregate liquidity factors. The level of lag is shown in the square brackets.

		Model (1)		Model (2)		Model (3)
	Lag	Estimate	Lag	Estimate	Lag	Estimate
House Price index (100)	[0]	25.36*** (46.75)	[0]	25.36*** (46.75)	[0]	25.36*** (46.75)
Construction cost index (100)	[0]	-46.48*** (-47.74)	[0]	-46.48*** (-47.74)	[0]	-46.48*** (-47.74)
Funding liquidity factor	[0]	42.35*** (16.29)	[1]	30.07*** (15.38)	[1]	30.07*** (15.38)
Market illiquidity factor	[0]	-179.77*** (-80.65)	[1]	-196.45*** (-74.13)	[2]	-206.85*** (-50.46)
Credit availability factor	[0]	3.35*** (22.06)	[1]	2.51*** (16.93)	[6]	9.59*** (38.06)
Shadow vacancy factor	[0]	-30.52*** (-67.33)	[1]	-34.87*** (-34.21)	[6]	-10.33*** (-9.85)
Mortgage rate spread (%)	[0]	-23.14*** (-50.94)	[0]	-23.14*** (-50.94)	[0]	-23.14*** (-50.94)
GDP growth rate (%)	[0]	60.81*** (36.3)	[0]	60.81*** (36.3)	[0]	60.81*** (36.3)
Vacancy rate (%)	[0]	0.84*** (29.63)	[0]	0.84*** (29.63)	[0]	0.84*** (29.63)

Table 9: Multivariate panel regression of housing starts

This table reports multivariate regression results for the whole sample. The procedure used is GMM with panel data technique that is pooled fixed effect model. All series have been de-trended by subtracting the cross-sectional means to mitigate the problem of cross-sectional dependence. The regressions are estimated for both the structural model and reduced form model. The first three column show the regression based on contemporaneous value of explanatory variables and the last three columns show results with liquidity factor, market illiquidity factor, credit availability factor and shadow vacancy factor lagged at 1, 2, 6, and 6 months, respectively.

	No lag			With lag		
	Structural Model	Reduced Form model	Reduced form model with interaction	Structural Model	Reduced Form Model	Reduced form model with interaction
Housing price index (100)	3.88*** (5.72)			3.64*** (5.52)		
Construction cost index (100)	-46.71*** (-60.01)	-49.03*** (-85.92)	-48.93*** (-85.76)	-46.8*** (-60.29)	-49.22*** (-85.21)	-48.9*** (-84.81)
Funding liquidity actor		23.93*** (2.83)	14.56* (1.66)		25.06*** (2.97)	14.52* (1.7)
Market illiquidity factor	-48.38*** (-5.28)	-56.27*** (-6.4)	-45.77*** (-4.99)	-85.01*** (-9.59)	-80.04*** (-9.61)	-76.02*** (-9.15)
Funding liquidity*market illiquidity			-45.31*** (-3.99)			-68.41*** (-6.5)
Credit availability factor	28.97*** (3.94)	53.37*** (7.32)	49.81*** (6.79)	49.77*** (6.29)	50.3*** (6.58)	47.96*** (6.31)
Shadow vacancy factor	-19.26** (-2.35)	-15.27* (-1.95)	-9.42 (-1.19)	-35.76*** (-3.42)	-37.47*** (-3.71)	-45.72*** (-4.51)
Mortgage rate spread (%)	-8.05*** (-5.55)	-5.85*** (-4.23)	-6.23*** (-4.5)	-10*** (-6.94)	-8.23*** (-6.02)	-8.53*** (-6.27)
GDP growth rate (%)		55.48*** (8.81)	52.38*** (8.27)		34.82*** (6.04)	33.63*** (5.87)
Vacancy rate (%)		-0.23 (-0.74)	-0.14 (-0.45)		-0.39 (-1.3)	-0.2 (-0.65)

Table 10: Heterogeneity analysis

This table reports the heterogeneity in the response of housing starts to each of the four aggregate liquidity factors. The regression is estimated for two sub-samples: cities with low levels of land use regulation (unconstrained housing markets) and cities with high levels of land use regulations (constrained housing markets). The procedure used is GMM with panel data technique that is pooled fixed effects model. All series have been de-trended by subtracting the cross-sectional means to mitigate the problem of cross-sectional dependence. The regressions are estimated for both the structural model and reduced form model. The first three column under each market regime show the regression based on contemporaneous value of explanatory variables and the last three columns show results with liquidity factor, market illiquidity factor, credit availability factor and shadow vacancy factor lagged at 1, 2, 6, and 6 months, respectively.

	Unconstrained cities						Constrained cities					
	No lag			With lag			No lag			With lag		
	Structural Model	Reduced Form Model	Reduced Form with interaction	Structural model	Reduced Form model	Reduced Form with interaction	Structural Model	Reduced Form model	Reduced Form with interaction	Structural Model	Reduced form	Reduced form with interaction
Housing price index (100)	2.42**			-0.09			0.85			1.32*		
	(2.33)			(-0.09)			(1.15)			(1.84)		
Construction cost index (100)	-41.73***	-42.52***	-42.52***	-44.86***	-44.68***	-44.69***	-44.78***	-45.26***	-45.21***	-43.61***	-44.94***	-44.76***
	(-57.69)	(-67.96)	(-67.88)	(-60.41)	(-71.1)	(-71.1)	(-35.88)	(-51.58)	(-51.55)	(-35.59)	(-50.97)	(-50.87)
Funding liquidity factor		21.78*	22*		25.24**	22.6*		8.24	1.64		8.36	0.01
		(1.84)	(1.76)		(2.2)	(1.95)		(0.65)	(0.13)		(0.65)	(0)
Market illiquidity factor	-18.49	-24.05*	-24.12*	-55.85***	-59.75***	-58.98***	-56.35***	-76.23***	-66.57***	-85.68***	-82.73***	-77.91***
	(-1.45)	(-1.87)	(-1.87)	(-4.58)	(-4.93)	(-4.86)	(-4.2)	(-5.74)	(-4.8)	(-6.66)	(-6.73)	(-6.32)
Funding liquidity *market illiquidity			0.7			-21.12*			-38.22**			-52.81***
			(0.06)			(-1.88)			(-2.38)			(-3.47)
Credit availability factor	30.44***	50.69***	50.82***	38.32***	39.67***	39.5***	32.5***	48.65***	47.39***	42.92***	43.79***	42.13***
	(2.6)	(4.06)	(4)	(3.36)	(3.47)	(3.46)	(2.7)	(3.99)	(3.89)	(3.53)	(3.58)	(3.46)
Shadow vacancy factor	-15.55*	-16.88**	-16.94**	-26.24***	-25.25***	-25.73***	-21.71	2.94	12.09	-5.84	-9.24	-22.94
	(-1.85)	(-2.02)	(-2)	(-3.22)	(-3.13)	(-3.18)	(-0.95)	(0.13)	(0.52)	(-0.26)	(-0.41)	(-1.01)
Mortgage rate spread (%)	-7.84***	-6.56***	-6.55***	-10.71***	-10.54***	-10.66***	-4.77**	-2.56	-2.77	-6.3***	-4.77**	-4.95**
	(-3.54)	(-2.96)	(-2.96)	(-4.96)	(-4.93)	(-4.99)	(-2.11)	(-1.13)	(-1.22)	(-2.82)	(-2.15)	(-2.24)
GDP growth rate (%)		51.26***	51.31***		26.95***	26.86***		49.45***	47.15***		29.69***	28.19***
		(4.72)	(4.7)		(2.78)	(2.77)		(4.99)	(4.74)		(3.33)	(3.17)
		-0.36	-0.36		-0.19	-0.2		0.29	0.39		0.2	0.39
		(-0.99)	(-0.99)		(-0.54)	(-0.57)		(0.75)	(1)		(0.52)	(1.02)

Table11: Robustness check of heterogeneity

Panel A: This panel reports the regression using dummy variable to indicate the presence or absence of the degree of land use or degree of constraint in housing supply. Dummy variable equal 1 if the cities display high level of land use control and 0 otherwise.

Variables	Estimates
Construction cost index (100)	-29.26*** (-23.21)
Factor1- Funding liquidity	27.49** (2)
Factor2- Market illiquidity	-68.95*** (-2.82)
Funding liquidity*market illiquidity	-4.81 (-0.27)
Factor 3- FHA and GSE mortgage loans	56.53*** (4.49)
Factor4-Shadow vacancy	-27.51 (-1.63)
Mortgage rate spread (%)	57.57** (2.56)
GDP growth rate (%)	-3.9 (-1.25)
Vacancy rate (%)	-0.29 (-0.55)
Unconstrained cities	104.85*** (3.9)
Constrained cities	-48.45*** (-2.68)

Panel B: This panel reports the results of whether heterogeneity is due supply constrained, the transmission channel for QE effects (i.e. the four aggregate liquidity factors) or both. The dumpy variable is interacted with each of the aggregate liquidity factors to test for this hypothesis

Variables	Estimates
Construction cost index (100)	-29.34*** (-23.19)
Funding liquidity factor	36.57* (1.92)
Market illiquidity factor	-30.15 (-1.36)
Funding liquidity*market illiquidity	-3.13 (-0.17)
Credit availability	34.96** (2.24)
Shadow vacancy factor	-29.81* (-1.73)
GDP growth rate (%)	59*** (2.8)
Mortgage rate spread (%)	-3.48 (-1.09)
Vacancy rate (%)	-0.28 (-0.53)
Unconstrained cities	101.88*** (3.8)
Constrained cities	-46.86*** (-2.61)
Constrained dummy*funding liquidity	-16.05 (-0.59)
Constrained dummy*market illiquidity	-61.91 (-1.32)
Constrained dummy*credit availability	40.69* (1.84)
Constrained dummy*shadow vacancy	19.91 (0.26)

Table 12 Changes in housing start changes due to shocks to major policy variables and the aggregate liquidity factors

Panel A: Effect of change in LTV on housing starts

Date	LTV level	Housing start	Compound annual growth rate
13-city average LTV for low down-payment loans	68.79%	1053.16	
New LTV due to change +4.60%	73.39%	1067.53	17.66%

Panel B: Effect of change in debt-to-income (DTI) on housing starts

Date	DTI level	Housing start	Compound annual growth rate
13-city average DTI over sample period	35.45%	1053.16	
New DTI due to change of +6.55%	42%	1164.43	233.76%

Panel C: Effect of change in FICO score on housing starts

Date	FICO level	Housing start	Compound annual growth rate
13-city average FICO score over sample period	744.74	1053.16	
New average FICO score due to change of +35.6	780.00	922.41	-79.62%

Panel D Effect of change in GSE mortgage purchase on housing start

Date	GSE mortgage level	Housing start	Compound annual growth rate
13-city average over sample period	3140.19	1053.16	
New purchase level due to change of $359.81B	3500.00	1082.56	39.15%

Panel E Effect of change in FHA loan on housing start

Date	FHA loan level	Housing start	Compound annual growth rate
13-city average over sample period	3921.91	1053.16	
New purchase level due change of +$4278.09B	4200.00	1087.27	46.59%

Panel E Effect of change in rate spread by 150 bps on housing start

Date	Rate spread	Housing start	Compound annual growth rate
13-city average mortgage spread over sample period	2.51%	1053.16	
New spread due to change of +150 bps	4.01%	1049.51	-4.08%

Panel F Effect of change in factor on housing start

Change one standard deviation in Factors	Expected housing start after	Expected housing start before	Compound annual growth rate
Funding liquidity (add one σ)	1067.60	1053.16	17.75%
Market illiquidity (minus one σ)	1098.84	1053.16	66.45%
Credit availability (add one σ)	1107.06	1053.16	82.02%
Shadow vacancy (minus one σ)	1064.03	1053.16	13.11%

Figure 1 U.S. Federal Reserve balance sheet (December 20140

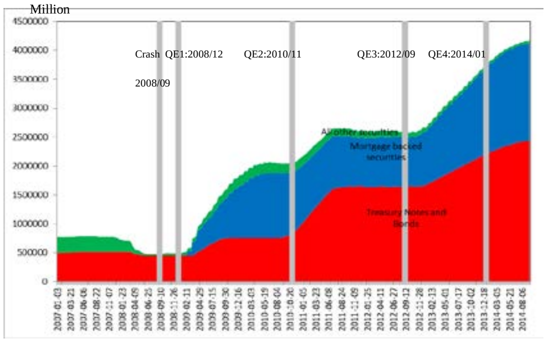


Figure 2 New housing investments and real GDP (1959-2014)

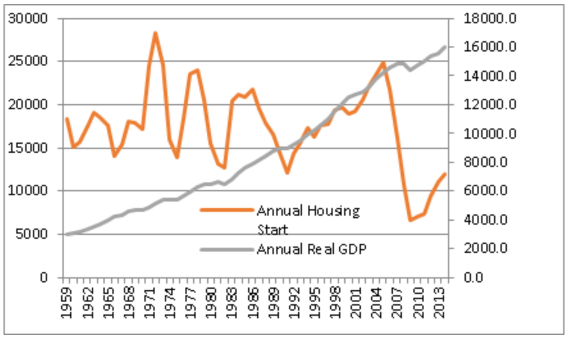


Figure 3: New housing investments and household consumer durables

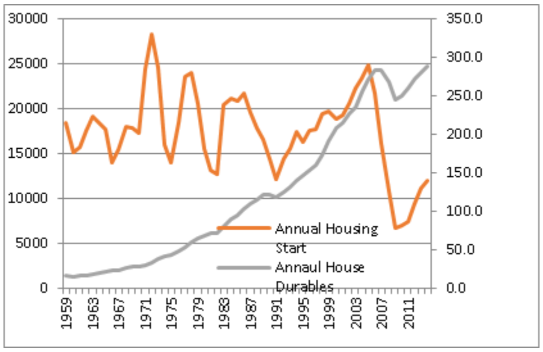


Figure 4: New housing investments and S&P Case-Shiller housing pricei iindex

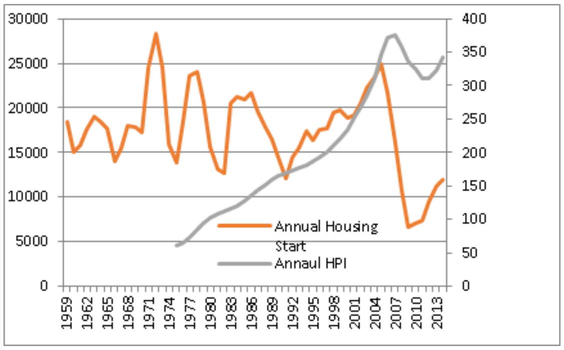
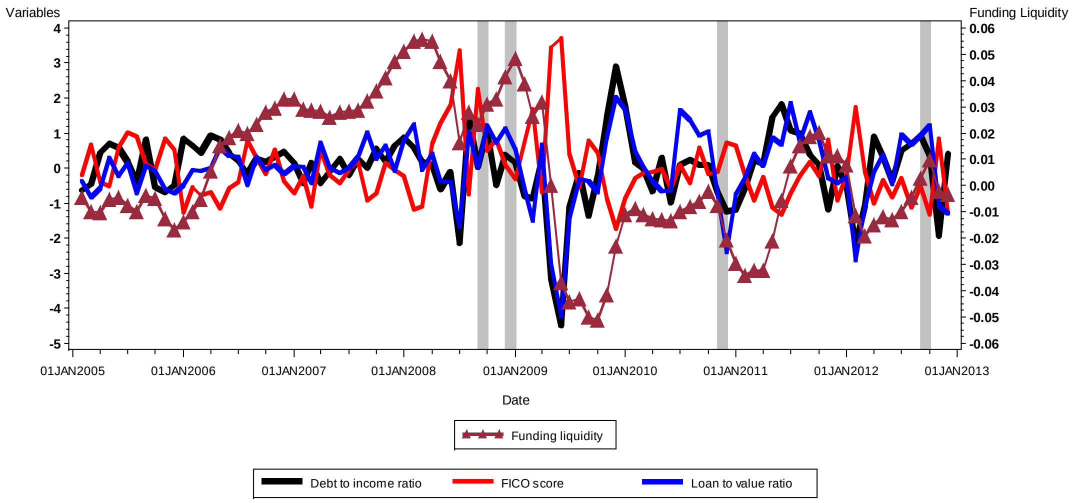


Figure 5: Cumulative level of funding liquidity and the time series of three key variables (debt to income ratio, FICO score, and LTV) that load on funding liquidity.

Panel A: Funding liquidity, debt to income ratio, FICO score, and LTV



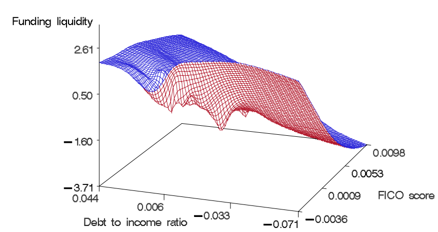
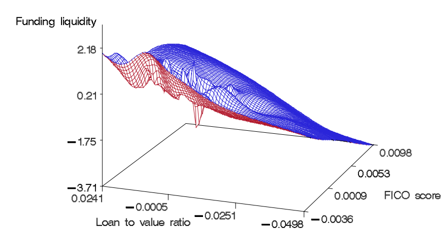
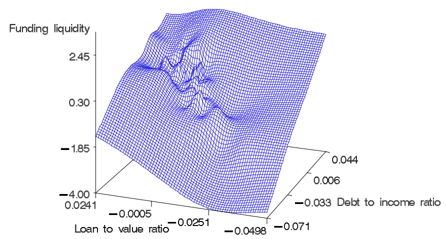
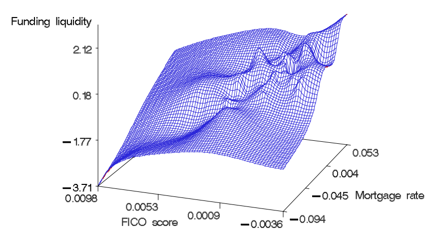
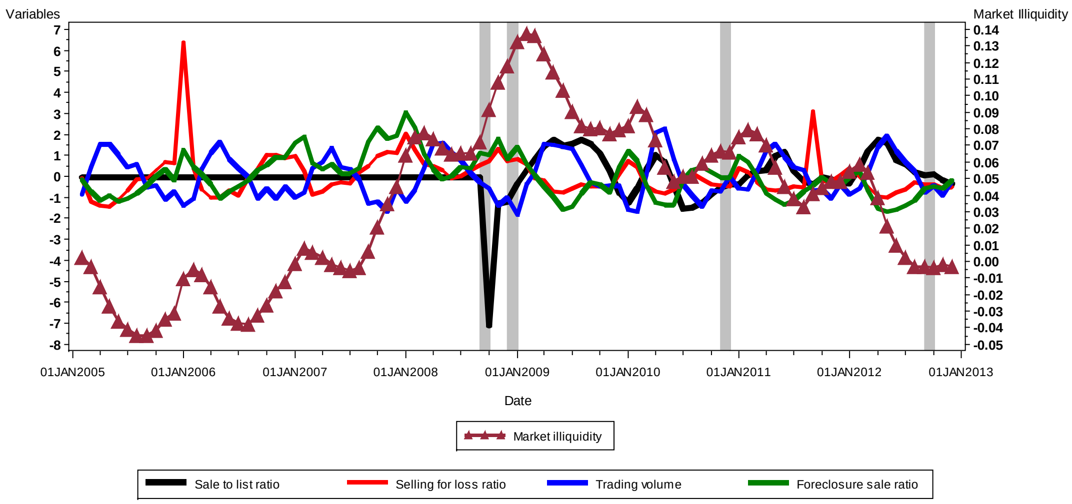
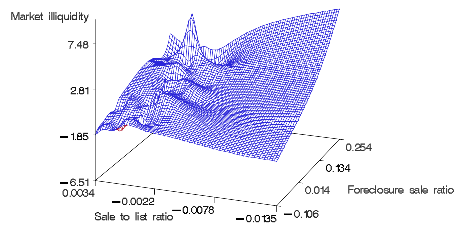
Panel B Funding liquidity, debt to income ratio, and FICO score	Panel C Funding liquidity, loan to value ratio, and FICO score
	
Panel D Funding liquidity, loan to value ratio, and debt to income ratio	Panel E Funding liquidity, FICO score, and mortgage rate
	

Figure 6: Cumulative level of market illiquidity and the time series of four key variables (sale to list ratio, selling for loss ratio, trading volume, and foreclosure sale ratio) that load on the market illiquidity factor.

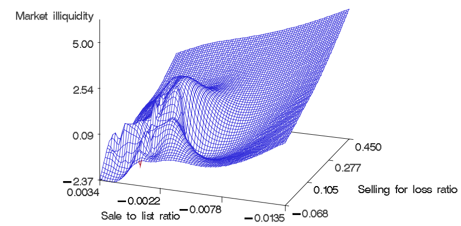
Panel A: Market illiquidity, sale to list ratio, selling for loss ratio, trading volume, and foreclosure sale ratio



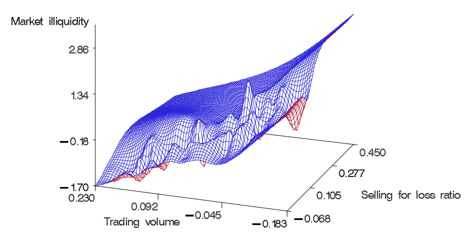
Panel B Market illiquidity, sale to list ratio, and foreclosure sale ratio



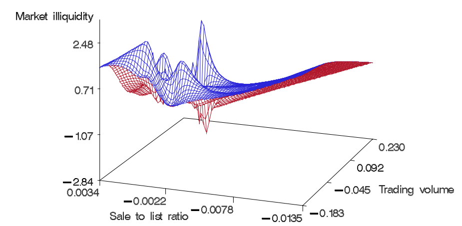
Panel C Market illiquidity, sale to list ratio, and selling for loss ratio



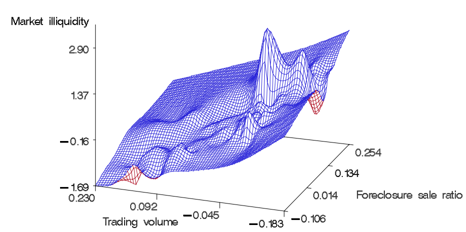
Panel D Market illiquidity, trading volume, and selling for loss ratio



Panel E Market illiquidity, sale to list ratio, and trading volume



Panel F Market illiquidity, trading volume, and foreclosure sale ratio



Panel G Market illiquidity, foreclosure sale ratio, and selling for loss ratio

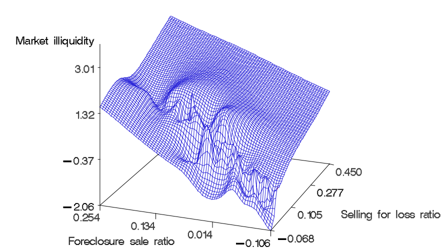


Figure 7: Actual and model forecast of new housing investments for 13 MSA.
Plots in black are actual new housing investments starts and plots in red are model forecast

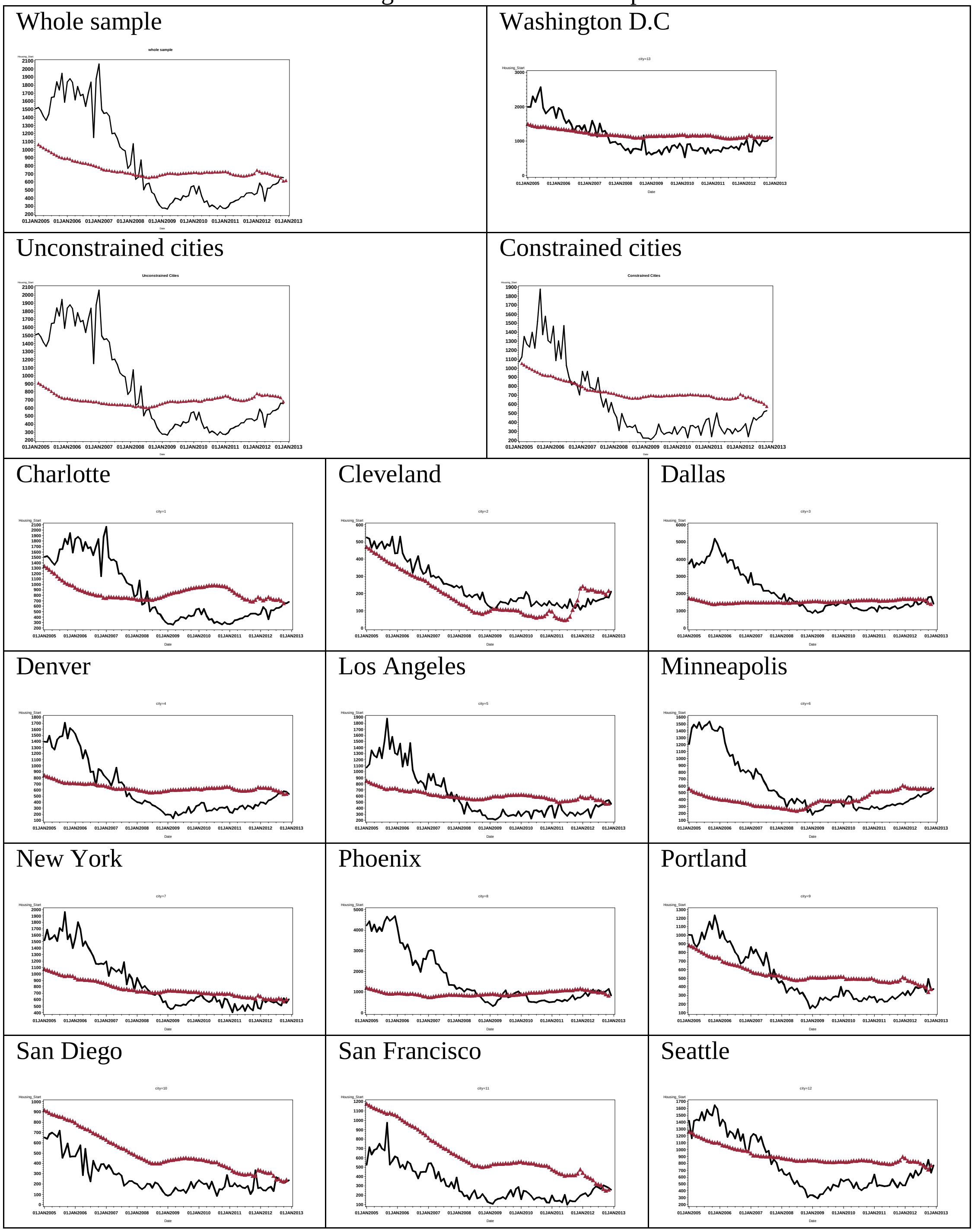
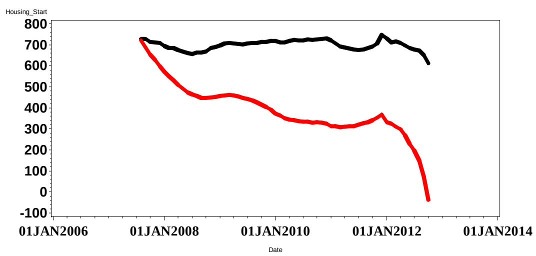


Figure 8: Counterfactual output levels of new housing Investments

Plots in black are for the policy scenario (i.e. the Fed intervenes via QE) that reflects the stimulus effects of QE, and plots in red are the no policy scenario (i.e. the Fed does not intervene via QE) that do not reflect the stimulus effects of QE. For the no policy scenario the model is calibrated by fixing the aggregate liquidity factors at events dates prior to initiation of QE and after the initiation of QE.

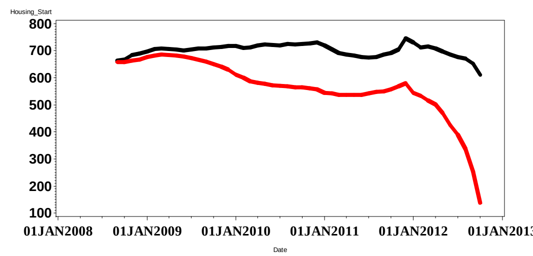
2007/08-2012/12 9 (BNP Paribus terminated withdrawal from three of its hedge funds

Starts	average
With QE	698.78
Without QE	389.58



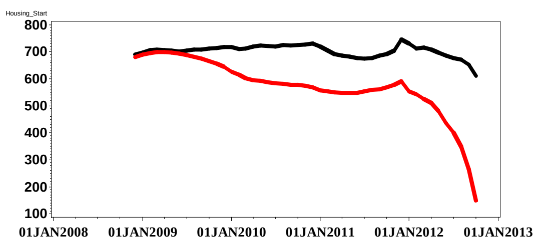
2008/09-2012/12 (Leman Brother files for bankruptcy)

Starts	average
With QE	701.02
Without QE	565.28



2008/12-2012/12 (initiation of QE1)

Starts	average
With QE	702.91
Without QE	571.75



2010/11-2012/12 (Q1, QE2 in place and QE3 announced)

Starts	average
With QE	694.21
Without QE	658.76