THE CONSEQUENCES OF MORTGAGE CREDIT EXPANSION: EVIDENCE FROM THE U.S. MORTGAGE DEFAULT CRISIS*

ATIF MIAN and AMIR SUFI

Abstract

We conduct a within-county analysis using detailed zip code level data to document new findings regarding the origins of the biggest financial crisis since the Great Depression. The recent sharp increase in mortgage defaults is significantly amplified in subprime zip codes, or zip codes with a disproportionately large share of subprime borrowers as of 1996. Prior to the default crisis, these subprime zip codes experience an unprecedented relative growth in mortgage credit. The expansion in mortgage credit from 2002 to 2005 to subprime zip codes occurs despite sharply declining relative (and in some cases absolute) income growth in these neighborhoods. In fact, 2002 to 2005 is the only period in the last eighteen years when income and mortgage credit growth are negatively correlated. We show that the expansion in mortgage credit to subprime zip codes and its dissociation from income growth is closely correlated with the increase in securitization of subprime mortgages. Finally, we show that all of our key findings hold in markets with very elastic housing supply that have low house price growth during the credit expansion years.

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The sharp rise in U.S. mortgage default rates has led to the most severe financial crisis since the Great Depression. A salient feature of the mortgage default crisis is that it is concentrated in subprime zip codes throughout the entire country. A comparison of subprime and prime zip codes, which are defined to be zip codes in the highest and lowest quartile based on the fraction of borrowers with a credit score under 660 as of 1996, reveals that subprime zip codes experience an increase in default rates since 2006 that is more than three times as large as prime zip codes in the same metropolitan area.[1] These same subprime neighborhoods experience a historic increase in mortgage credit from 2002 to 2005, experiencing credit growth that is more than twice as high as the growth in prime zip codes. Moreover, the unprecedented growth in subprime credit is not a regional phenomenon; instead, it exists in almost every metropolitan area of the Unites States.

Explanations for the extraordinary subprime mortgage growth and its concurrent house price increases have varied remarkably over time. In the aftermath of the crisis, explanations have ranged from irrational house price patterns to expansionary mortgage credit policies to lax lending standards associated with securitization. However, during the credit expansion, many established voices attributed the growth in mortgage credit and housing prices to fundamental economic improvements such as productivity and income gains.[2]

Our goal in this analysis is to empirically examine the competing explanations for the subprime mortgage expansion and the subsequent default crisis. Any such analysis requires micro-level data to test the competing hypotheses; as we demonstrate below, the use of more aggregated data can lead to erroneous conclusions. In this regard, we have the unique advantage

[1] All of the statistics mentioned in this paragraph are from the Table A.1 in the appendix, which shows mortgage credit growth, mortgage defaults, and income growth for subprime and prime zip codes within the top forty MSAs in the United States.

[2] See for example, Federal Reserve Chairman Alan Greenspan's testimony to the U.S. Congress on June 9th, 2005, or Council of Economic Advisors Chairman Ben Bernanke's testimony to the U.S. Congress on October 20th 2005.

of a detailed data set with information at the zip code level on credit, house prices, defaults, income, and other demographic variables. The geographical detail of our data helps us to uncover a number of important new facts. In addition, by exploiting within-county variation in credit growth, we can more effectively discriminate between competing explanations for the subprime mortgage expansion.

We outline three potential explanations for the expansion in mortgage credit to subprime zip codes from 2002 to 2005. First, the income prospects of subprime borrowers may have improved in the early 2000s. We classify this and similar explanations based on improvements in the credit-worthiness of subprime borrowers as *income-based* hypotheses.

Second, the expansion of credit to subprime borrowers may have been caused by an outward shift in the supply of mortgage credit by lenders. There are a variety of potential reasons for such a shift: greater diversification of risk, greater subsidization of risk through government-backed programs, or greater moral hazard on the part of originators due to securitization. Regardless of the reasons, we refer to explanations that an outward shift in the supply of mortgage credit may have caused the subprime mortgage expansion as *supply-based* hypotheses.

Third, lenders' increased expectations of future house price growth may have been responsible for the increase in subprime mortgage credit. Higher house price growth expectations lower the estimated losses given default for a lender, thereby enabling the lender to target riskier clients. We refer to such explanations as house price *expectations-based* hypotheses.

Let us now illustrate why it is necessary to have detailed micro-level data to separate the competing hypotheses. Consider a test of the *income-based* hypothesis using data aggregated at the MSA level for the top forty MSAs in the country.[3] The top left plot in Figure I shows

[3] We use MSA level data in our example, because this is the most widely used level of analysis in studies involving nation-wide housing markets.

evidence consistent with the *income-based* hypothesis: Income growth during the subprime mortgage expansion period (2002-2005) is stronger in MSAs with a higher share of subprime consumers. Similarly, credit growth is positively related to both the fraction of subprime borrowers (top-middle panel) and income growth (top-right panel). Taken together, the top row in Figure I supports the *income-based* hypothesis as an explanation for the expansion in subprime lending.

However, the bottom panel of Figure I shows why such an interpretation – based on MSA level data – may be misleading. Using *within-MSA* variation in the zip code level data, the bottom left panel of Figure I shows that zip codes with a higher fraction of subprime borrowers experience *negative* relative income growth from 2002 to 2005. In other words, the positive correlation between subprime population share and income growth at the MSA level may be spurious: MSAs with a greater share of subprime population grow faster, but the income growth is concentrated among prime segments of the population that *did not* experience disproportionately high credit growth[4]. This is confirmed by the bottom-middle panel which shows that credit growth is stronger in subprime zip codes. The first two plots in the bottom panel lead to an unusual result: income growth and credit growth are statistically significantly *negatively* correlated from 2002 to 2005 (bottom-right panel).

Figure I illustrates the power of the zip level dataset. It enables us to dispute the *income-based* hypothesis for subprime mortgage growth which would be mistakenly supported by MSA level data. In fact, a further breakdown of the zip code patterns reveals that even subprime zip

[4] One possible explanation for the positive correlation between income-growth and subprime population share at the MSA level might be that MSAs with a higher fraction of subprime population provide a greater supply of cheap unskilled labor which differentially attracts growth opportunities. However, most of the benefits of these growth opportunities may accrue to prime (skilled) individuals. If there is a contemporaneous expansion in the supply of credit to subprime areas, subprime populations will have disproportionately stronger credit growth therefore creating a spuriously positive correlation between income growth and credit growth in the between-MSA analysis.

codes with *negative absolute* income growth from 2002 to 2005 experience higher mortgage credit growth than prime neighborhoods with *positive absolute* income growth in the same MSA.

One could augment the *income-based* hypothesis to argue that despite lower income, changing business conditions - such as low risk free rates – disproportionately increase the home purchasing power for subprime populations. However, using the early 1990s as a comparison period when the risk free rate also falls sharply, we show that this is not the case. Our historical comparison further reveals that 2002 to 2005 is the only period when mortgage origination growth and income growth are negatively correlated. In all other time periods, income growth and mortgage growth are positively correlated as one would expect under standard models of mortgage lending.

The historically unique negative correlation between zip code income growth and mortgage growth from 2002 to 2005 suggests the possibility of a change on the supply side of the mortgage credit market. The *supply-based* hypothesis is also supported by the sharp drop in the subprime-prime interest rate spread from 2002 to 2005, which occurs despite a rapid increase in the quantity and observed riskiness of subprime mortgages. Our zip level analysis provides a number of additional results that support the *supply-based* hypothesis. First, we show evidence on the relaxation of earlier credit-rationing constraints. More specifically, we show that subprime zip codes are significantly more likely to be denied credit prior to the expansion in subprime mortgages. However, this changes radically from 2002 to 2005 as denial rates for subprime zip codes disproportionately fall.

Second, the historically unique period when credit growth becomes divorced from income growth coincides exactly with the expansion of subprime mortgage securitization. The

fraction of originated mortgages sold to non-government sponsored entities is steady at 30% from 1996 until 2002, at which point it rapidly ascends to almost 60% by 2005.

Third, the increase in the rate of securitization is much stronger in subprime zip codes compared to prime zip codes during this period, and the relative increase is driven primarily by securitized mortgages sold to financial institutions not affiliated with the mortgage originator.

Fourth, default rates increase significantly more from 2005 to 2007 in zip codes that experience an increase in the fraction of mortgages sold in private securitizations or to non-commercial bank finance companies from 2002 to 2005. This result hints at moral hazard on behalf of originators as a factor contributing to the expansion in credit supply, although we believe more research is needed on this precise mechanism (see Keys, Mukherjee, Seru, and Vig [2008] for an innovative natural experiment on this question).

Our last section of the analysis explores the validity of the house price *expectations-based* hypothesis as an explanation for the subprime mortgage expansion. It is well-known that aggregate house price growth in the U.S. reaches unprecedented levels from 2002 to 2005. Using zip code level house price indices, we further show that house prices increase disproportionately more for subprime zip codes within a given county during this period.

At first glance, these facts appear to support the *expectations-based* hypothesis that high house price expectations by lenders are responsible for the expansion in subprime mortgage credit from 2002 to 2005. However, it is also possible that an outward shift in the supply of credit increases credit growth as well as house price growth.

One way to separate these two hypotheses is to focus on areas where the *expectations-based* channel is not prevalent. Glaeser, Gyourko and Saiz (2008) point out that areas with extremely elastic housing supply (e.g. Wichita, Kansas) are highly unlikely to have large

(rational or irrational) increases in house price growth expectations because the quantity of housing stock adjusts quickly to any upward pressure on house prices. The expectations-based channel is therefore unlikely to be relevant in very elastic MSAs in which house price growth is bounded by the nominal increase in construction costs. Correspondingly, if the expansion of subprime mortgage credit is uniquely driven by an increase in lenders' expectations of house price growth, we should *not* find such mortgage credit growth in highly elastic areas.

Using a carefully constructed land-topology based measure of housing supply elasticity in Saiz (2008), we show that, as predicted, house price growth remains flat and close to the rate of inflation in very elastic MSAs. Yet all of our earlier results favoring the *supply-based* hypothesis continue to hold in this subsample. Under the relatively weak assumption that lenders understand the limits of house price growth in high supply elasticity MSAs, these results refute the house-price *expectations hypothesis* as a unique explanation for the subprime lending boom.

We also show that house price growth, like mortgage credit growth, is negatively correlated with income growth from 2002 to 2005, and this is the only period in the last eighteen years in which this correlation is negative. Additionally, even subprime zip codes with negative absolute income growth experience stronger house price growth than prime zip codes with positive absolute income growth in the same county. Taken together, these results suggest that the relative house price appreciation in subprime areas may have been the result of the shift in credit supply, although we believe more research is needed on this issue. At the very least, our results suggest caution in treating house price patterns as exogenous from credit conditions during both the expansion and the subsequent default crisis.

A number of recent papers have studied the subprime mortgage expansion and the ensuing default crisis (Gabriel and Rosenthal 2007; Demyanyk and Van Hemert 2007; Doms,

Furlong, and Krainer 2007; Gerardi, Shapiro, and Willen 2007; Dell'Ariccia, Igan, and Laevin 2008; Mayer and Pence 2008). Our study differs from this work both in the level of disaggregation as well as in the nature of outcomes that we observe over a very long period of time.[5] As we emphasize above, the level of disaggregation greatly helps us in isolating the channel behind the changes in credit and house prices. In the conclusion, we also show that our methodology explains a large fraction of the variation in both subprime mortgage growth and the resulting default crisis.

The rest of this paper proceeds as follows. The next section describes the data and summary statistics. Section II presents initial facts and the empirical model. Sections III through V present the results, and Section VI concludes.

I. Data and Summary Statistics

A. Data

Data on consumer debt outstanding and delinquency rates come from *Equifax Predictive Services.* Equifax keeps a credit history of most consumers in the U.S., and provided us with zip code level annual aggregate data for outstanding credit and defaults from 1991 to 2007, measured at the end of the year. The debt and default aggregates are broken down by the type of loans: mortgages, home equity lines, credit card debt, auto loans, student loans, and consumer loans. The default data is aggregated by various degrees of delinquency. We use 30 days or more delinquent as our definition of default, but our results are materially unchanged using a stricter definition such as 60 days or more delinquent.

We collect data on the flow of new mortgage loans originated every year through the "Home Mortgage Disclosure Act" (HMDA) data set from 1990 through 2007. HMDA is

[5] Gerardi, Shapiro, and Willen (2007) also have disaggregated data on all of these variables, but they focus only on Massachusetts and only on subprime mortgages.

available at the loan application level. It records each applicant's final status (denied / approved / originated), purpose of borrowing (home purchase / refinancing / home improvement), loan amount, race, sex, income, home ownership status, and also (in the case of originated loans) whether the loan was sold to the secondary market within the year. We aggregate HMDA data up to the zip code level, and drop any zip codes with missing Equifax or HMDA data between 1996 and 2007, giving us a final sample of 18,408 zip codes.[6] These zip codes represent 92% of the entire U.S. population.

Our zip code level house price data from 1990 to the first quarter of 2008 come from Fiserv's Case Shiller Weiss indices. FCSW use same house repeat sales data to construct zip level house price indices. One limitation of the data is that FCSW require a significant number of transactions in a given zip code to obtain reliable estimates of changes in house prices over time. As a result, FCSW has house prices for only 3,014 of the zip codes in Equifax-HMDA sample. While FCSW covers only 16% of the number of zip codes in the Equifax-HMDA sample, these zip codes represent over 45% of aggregate home debt outstanding.[7]

We also add zip code level data on demographics, income, and business statistics through various sources: Demographic data on population, race, poverty, mobility, unemployment and education are from the decennial Census. Data on wages, employment, and business establishments in a given zip code come from the Census Business Statistics from 1996 through

[6] HMDA data contain census tract, but not zip code, information. We match census tracts to zip codes using a match provided by *Geolytics*. The match quality is high: 85% of the matched census tracts in our final sample have over 90% of their population living in the zip code to which they are matched.

[7] Since one of our key hypotheses involves house price expectations, our core sample includes only the 3,014 zip codes for which we have zip code level house price data available. However, all of our results that do not require house prices are qualitatively similar and only slightly smaller in magnitude if we use the full sample of 18,408 zip codes. In the interest of full transparency, we replicate all of our regression results that do not use house price data on the full sample in the internet appendix. As the internet appendix shows, the main difference between the house price and non-house price sample is whether the zip code is in an urban environment. We also collect zip code level price indices for 2,248 zip codes from Zillow.com, an online firm that provides house price data. House price changes for FCSW and Zillow have a correlation coefficient of .91, and all of our results using house prices are robust to the use of Zillow indices.

2004. Average adjusted gross income data at the zip code level for years 1991, 1998, 2001, 2002, 2004, 2005, and 2006 come from the IRS. The income variable from the IRS is important because it tracks the income of residents living inside a given zip code, as opposed to Business Statistics which provide wage and employment statistics for individuals working, but not necessarily living, in a zip code. We also collect zip level statistics on total crime from 2000 to 2007 from *CAP Index*.

B. Summary Statistics

Panel A of Table I presents summary statistics for our sample of 3,014 zip codes in 166 counties. While mortgage and non-home debt increase at a similar annualized rate from 1996 to 2002, there is a rapid acceleration in mortgage debt from 2002 to 2005 relative to non-home debt (14.5% vs. 5.8%). The rapid acceleration in mortgage debt can also be seen in the mortgage origination data from HMDA. The annualized growth rate of originations for home purchase jumps from 14.4% from 1996 to 2002 to 19.4% from 2002 to 2005.

The rapid acceleration in mortgage debt is followed by a sharp rise in default rates. While mortgage default rates remain constant from 1996 to 2005, they increase by an average of 3.5% from 2005 to 2007. To put this into perspective, the standard deviation of the 1996 mortgage default rate is 2.4%, which implies that the increase in default rates from 2005 to 2007 is 1.5 times a standard deviation of the 1996 level. Given that the aggregate U.S. mortgage market is approximately $10 trillion, this implies an increase in $350 billion in defaults from 2005 to 2007.

A critical variable in our analysis is the fraction of subprime borrowers living in a zip code. Our main measure of subprime borrowers is consumers with a credit score below 660 as of 1996. The credit score is provided by Equifax, one of the three main credit bureaus in the U.S. The score is meant to capture a borrower's probability of default, and is computed using

variables such as the borrower's past payment history, credit utilization and credit balance. The 660 credit score threshold is critical in our sample period given origination guidance by Freddie Mac and Fannie Mae. For example, Freddie Mac in their automated origination guide in September 1996 advises that "applicants with FICO scores above 660 are likely to have acceptable credit reputations."[8] Further, the guide consistently measures borrowers above 660 as being "lower-risk borrowers." This determination by Freddie Mac and Fannie Mae has a significant impact on the definition of "subprime" borrowers in the mortgage lending industry—borrowers with a score below 660 are routinely described as "subprime".[9] We measure this variable as of 1996 to avoid feedback effects of lending on consumer credit scores during the subprime lending expansion. On average, 29% of consumers in a zip code have a credit score below 660 as of 1996.[10]

The between and within county standard deviations establish an important fact: the variation *within* counties in credit growth, default patterns, and the fraction of subprime borrowers is *larger* than the variation *across* counties. Aggregate MSA-level data miss the majority of the variation in both credit growth from 2002 to 2005 and default patterns from 2005 to 2007. In other words, it is critical to understand the variation within counties if we are to understand the causes and consequences of the mortgage default crisis.

[8] See http://www.freddiemac.com/corporate/reports/moseley/chap6.htm.
[9] See congressional testimony by Staten (2004) at http://financialservices.house.gov/media/pdf/033004ms.pdf#page=3.
[10] In contrast to other research in the area, our analysis is unique in its focus on *all* mortgages to subprime borrowers rather than mortgages deemed to be "subprime mortgages" by alternative definitions (see Mayer and Pence (2008) for a review of these definitions). There is a distinction: Subprime borrowers can obtain non-subprime mortgages and prime borrowers can obtain subprime mortgages. Further, this distinction is important. For example, Mayer and Pence (2008) argue that the northeastern United States "did not see especially high rates of subprime usage." Our evidence suggests otherwise: As the Table A.1 shows, subprime zip codes in Boston, Nassau, New York, Newark, and Providence all experience a growth in mortgage originations that is more than twice as large as prime zip codes within the same MSA from 2002 to 2005. We are more interested in subprime households increased access to credit, whether or not it comes from a mortgage defined to be "subprime."

Given the importance of subprime versus prime zip codes in our analysis, Panel B of Table I provides differences between zip codes based on our measure of credit quality. More specifically, we split zip codes into quartiles based on the fraction of consumers with a credit score below 660. Prime zip codes are zip codes in the lowest quartile and subprime zip codes are in the highest quartile within the county.

Subprime zip codes have reduced access to mortgage lending before the subprime mortgage expansion. A higher fraction of mortgages in subprime zip codes as of 1996 are backed by the Federal Housing Administration, and mortgage application denial rates as of 1996 are significantly higher. Homeownership data from the 2000 census shows a 25% lower homeownership rate in subprime zip codes. As of 2000, subprime zip codes have much lower median household income, much higher poverty rates, much lower levels of education, and much higher unemployment rates. They also have a significantly larger fraction of the population that is non-white.

II. Subprime Mortgage Expansion: Motivating Facts and Empirical Model

A. Motivating Facts

We begin by providing motivating facts for our empirical model through an examination of the subprime mortgage expansion and the subsequent default crisis. The top-left panel in Figure II plots the differential growth rate for the number of mortgages originated for home purchase between subprime zip codes and prime zip codes in the same county from 1992 to 2007. For these (and later) graphs, subprime (prime) zip codes are zip codes in the highest (lowest) quartile based on the fraction of consumers with a credit score below 660 as of 1991.[11] The relative growth rate of the number of mortgages originated for subprime zip codes is

[11] The choice of base-year for categorizing zip codes as "subprime" is not important for our results due to a high level of persistence in the rank of zip codes by subprime population share. For example, the correlation between share of subprime population in 1991 and 1996 is .8.

relatively flat from 1992 to 1998, with only a slight increase in 1995. From 1998 to 2001, there is a slight increase in relative growth rate for subprime zip codes. However, the increase from 2002 to 2005 is significantly larger. Mortgage origination growth is almost 35 percentage points higher in subprime versus prime zip codes from 2002 to 2005. The top-right panel in Figure II repeats the exercise for origination amounts, and finds a similar pattern.

While our dataset does not contain information on interest spreads, others have documented a sharp drop in subprime relative to prime interest rate spreads during the credit expansion years. For example, Chomsisengphet and Pennington-Cross (2006) show that the subprime mortgage spread for 30-year fixed rate mortgages drops sharply from 2001 to 2004. Demyanyk and Van Hemert (2008) reach a similar conclusion using a different data set. The combination of a sharp decline in the price of subprime mortgages and a sharp increase in the quantity of mortgages to subprime borrowers hints at a shift in the supply of mortgage credit. We explore this in greater detail below.

The lower panel in Figure II shows that the relative expansion in mortgage lending to subprime zip codes is followed by a sharp relative increase in default rates compared to prime zip codes in the same county. The difference in the default rate between prime and subprime zip codes is positive throughout the sample, which reflects the fact that subprime borrowers on average default more than prime borrowers. However, the sharp increase in the relative mortgage default rate in 2007 is unprecedented in the last eighteen years. The 2007 mortgage default rate for subprime zip codes is almost a full 6 percentage points larger than for prime zip codes, which is almost twice as large as the difference in every other period including the 2001 recession. As mentioned in the introduction, this differential is not driven by any one geographical area.

Instead, subprime zip codes throughout the entire country have significantly larger default rates than prime zip codes (see Table A.1).

B. Empirical Model

The above facts show a rapid relative expansion in mortgage credit and a sharp decline in interest spreads for subprime zip codes from 2002 to 2005. We motivate the empirical analysis with a simple model of mortgage lending to help understand these patterns. Our model focuses on mortgage loans for self-occupied home purchases, rather than refinancing of existing mortgages or mortgages issued for investment properties. Doing so simplifies modeling choices, and also keeps theory consistent with our originations data which is limited to mortgages taken out for self-occupied home purchases.

Consider customers living in zip code z in county c at time t. There is a measure one of consumers in each zip code, all of whom want to own a house that costs P_{zt} to purchase. A buyer must put up (γP_{zt}) as down payment to buy a house, where γ is fixed over time for simplicity. A qualified customer takes the mortgage this period, and promises to completely pay off the principal and interest next period. He can then reapply for a loan next period. Long term contracts can thus be seen as a series of one-period contracts.

A fraction f_z of customers in a zip code are "prime". Prime customers have a high enough income profile such that they can always make the down payment, and there is no future default risk.[12] As a result, all lenders are willing to lend to prime customers at the risk free rate normalized to 1.

The remaining (1- f_z) of customers are considered "subprime" because there is a chance that they may default next period due to financial distress. The expected default probability of a

[12] One can think of prime customers as those who are "qualified" under the regulatory guidelines to be guaranteed by GSEs.

subprime customer is denoted by $\delta(I_{jzt})$, where I_{jzt} denotes the expected income (at time t) of customer j living in zip code z in period $t+1$. By modeling default as a function of income only, we are abstracting away from strategic defaults, i.e. defaults where a borrower has the cash-flow to pay his mortgage payments, but chooses to default nonetheless because of negative equity in the house. In case of default next period, the lender recovers only a fraction α of the full house value through foreclosure.[13]

The mortgage market is competitive at the national level, and banks are willing to lend to risky subprime borrowers at a risk premium of θ_t. Thus the interest rate offered to a subprime borrower at time t is given by:

$$r = \frac{1}{1-\delta} - \left(\frac{\alpha\delta}{(1-\gamma)(1-\delta)}\right)\Delta P_{zt}^{e} + \theta \;\; if\; r \leq \bar{r} \tag{1}$$

$$r = \infty \; otherwise$$

ΔP_{zt}^{e} is equal to $\left(\frac{P_{zt+1}}{P_{zt}}\right)$ and denotes expected house price appreciation in a borrower's zip code. The constant $\bar{r}$ reflects the interest rate ceiling beyond which no lender is willing to lend. We do not model explicitly the underlying friction that leads to an interest rate ceiling above which originators are unwilling to lend—borrower moral hazard (Diamond 1991, Holmstrom and Tirole 1997) or adverse selection (Stiglitz and Weiss 1981) are potential reasons.[14]

Let g_{zt} be the fraction of subprime customers in a zip code that are able to get a mortgage for home purchase. These are the customers who are not credit-rationed, i.e. customers for whom the right hand side of (1) is less than $\bar{r}$.

[13] We assume that the lenders always loses some principal in the event of default, i.e. $\alpha P_{zt+1} < (1-\gamma) P_{zt}$. This assumption is justified by Pence (2006), who shows that average mortgage losses on foreclosures range from 30 to 60%.

[14] Gabriel and Rosenthal (2007) explicitly model how a supply expansion affects borrowers with a Stiglitz and Weiss (1981) adverse selection problem. Their conclusions are similar to ours.

(i) Income profile (I_{jzt}):

An upward shift in the income distribution of the subprime population reduces the likelihood of default (δ) for subprime customers, and hence leads to a higher acceptance rate for mortgages in (1). More generally, an upward shift in I_{jzt} captures credit-worthiness factors such as higher wages and better expected employment that increase the ability to repay debt.

(ii) Credit supply factor (θ_t): A reduction in the risk premium makes mortgages affordable for a greater fraction of the population. The risk premium in the mortgage market may go down for a number of reasons, including greater diversification of mortgage risk across financial institutions, lax lending standards on behalf of originators, government programs that subsidize the risk of lending to subprime borrowers, or simply a misperception of actual risk by the financial market.

(iii) Expected house price appreciation (ΔP_{zt}^{e}):

An increase in expected house price appreciation lowers the lender's expectation of a loss in case of default, and increases the acceptance rate for mortgages in (1).

The total number of customers with access to the mortgage market in a zip code is:

$$L_{zt} = f_z + g_{zt} * (1 - f_z).$$

More generally, in addition to factors modeled above, there may be time-varying factors at the county level, such as local productivity shocks, and other idiosyncratic factors at the zip code level that influence the determination of L_{zt}. This gives us the estimating equation:

$$L_{zt} = f_z + g_{zt} * (1 - f_z) + \alpha_{ct} + \varepsilon_{zt} \quad (2)$$

Equation (2) shows that loan originations in a given zip code will be a function of the fraction of subprime borrowers, and the fraction of subprime borrowers that receive a mortgage. Since equation (2) includes county interacted with time fixed effects, county-level changes in income,

home prices or other variables that uniformly effect zip codes in a given county are removed. First differencing (2) gives us:

$$\Delta L_{zt} = \beta_t * (1 - f_z) + \alpha_c + \Delta\varepsilon_z \quad (3)$$

where $\beta_t = \Delta g_{zt}$.

Equation (3) represents our primary regression specification, where $(1 - f_z)$ represents the fraction of subprime borrowers in a zip code in the initial period. As we show in Figures 2 and 3, there is a rapid relative expansion in mortgage lending to subprime borrowers from 2002 to 2005, which implies that the estimate of β_t in equation (4) is statistically significantly positive and economically meaningful. As equation (1) shows, the positive estimate of β_t could be due to one of three potential factors: improved income prospects of subprime borrowers (*income-based hypothesis*), a decline in the risk premium charged by lenders (*supply-based hypothesis*), or increased house price expectations (*expectations-based hypothesis*).[15] The next three sections explore each of these potential causes.

III. Testing the Income-Based Hypothesis

Figure II shows a rapid increase in credit growth to subprime zip codes from 2002 to 2005. This result is further confirmed by column (1) of Panel A in Table II. Using county fixed effects, it shows a statistically significant positive relation between mortgage origination growth in a zip code from 2002 to 2005 and the fraction of subprime borrowers as of 1996.[16] The point

[15] Strictly speaking, our model generate a positive β_t (i.e. higher relative mortgage growth for subprime zip codes) under the house price appreciation hypothesis only if the house price expectations go up *differentially* so for subprime zip codes. However, one can imagine that a *level* increase in house price growth expectation helps subprime customers more because they have a higher probability of default and hence a reduction in loss given default is more useful to them.

[16] The inclusion of county fixed effects means that our measure of subprime borrowers is deviated from county means in the regressions. An alternative specification is to use the absolute measure of the fraction of borrowers that are subprime while using deviations from county means for all other variables. In unreported results, we find similar quantitative results when using this alternative specification.

estimate implies that a one standard deviation increase in the fraction of subprime borrowers (.094) leads to a 5 percentage point increase in the annualized growth rate of mortgage originations from 2002 to 2005. This represents a ¾ standard deviation change in the left hand side variable.[17] As our theoretical model highlights, one potential explanation for the strong relative growth in mortgage originations to subprime zip codes is the improved income prospects in these areas.

A. Credit Growth and Income: 2002 to 2005

Is the strong relative growth in mortgage originations to subprime zip codes justified by improvements in subprime borrower income? Columns (2) through (4) in Panel A suggest that the answer is "no." High subprime share zip codes experience relative *declines* in income, employment, and establishment growth compared to other zip codes in the same county. In other words, mortgage origination growth is stronger in high subprime zip codes *despite* relatively worsening income, employment, and business opportunities in these areas.[18]

A counter argument under the income-based hypothesis is that there may be a non-linearity in the manner in which borrower income affects lender origination decisions. In particular, while subprime zip codes experience relative declines in income, it may be the case that there is an absolute increase in income for subprime households *and* the elasticity of credit demand with respect to income is significantly stronger for subprime populations.

[17] Given the presence of county fixed effects in all specifications, we use within county standard deviations when discussing economic magnitudes. Within county standard deviations are reported in Table I, Panel A.

[18] The inclusion of county fixed effects is critical to capture the negative correlation between measures of economic growth and the fraction of subprime borrowers. As we show in the internet appendix, the correlations between employment growth/establishment growth and the fraction of subprime borrowers is positive when county fixed effects are excluded. Likewise, the negative correlation between mortgage credit growth/house price growth and income growth is positive when county fixed effects are not included. This is consistent with Figure I and the corresponding discussion in the introduction: examining data at a level more aggregated than zip codes leads to misleading conclusions concerning income growth patterns, mortgage credit growth, and subprime borrower share.

However, in results reported in the internet appendix, we focus on the extreme case of 26 subprime zip codes that have negative absolute nominal income growth from 2002 to 2005 to mitigate this concern. We compare these zip codes to prime zip codes in the same county with positive absolute nominal income growth. We find that annualized mortgage growth in the negative income growth subprime zip codes is 12% higher than in prime zip codes. In fact, 19 of the 26 subprime zip codes with negative income growth experience stronger growth in mortgage originations compared to prime zip codes with positive income growth in the same county. In other words, we do not find any evidence in favor of the income-based explanation even in this extreme robustness test of comparing negative income growth subprime zip codes to positive income growth prime zip codes in the same county.

B. Credit Growth and Income: Historical Evidence

Since credit growth is larger in subprime zip codes that experience a decline in relative (or absolute) income, one would expect a negative correlation between credit growth and income growth during the 2002 to 2005 period. This is confirmed by column (1) of Table III.

In historical terms, how common is this negative correlation? Conceptually, most standard models of credit growth would predict a positive correlation between income growth and credit growth. We would expect more credit to flow into areas where income-based credit demand conditions disproportionately improve. Indeed, columns (2) through (8) show that 2002 to 2005 is the *only* period in the last eighteen years when credit growth is negatively correlated with income growth. The top panel in Figure III plots the credit growth and income growth correlations shown in Table III over time.[19] The 2002 to 2005 period produces a historically unique negative correlation between income growth and credit growth.

[19] As noted in data section, we only have zip code level income information from the IRS for 1991, 1998, 2001, 2002, 2004, 2005, and 2006.

The lower-left panel of Figure III shows the historical relative income growth of subprime versus prime zip codes. Subprime zip codes experience a decline for most of the last eighteen years, which confirms the well-documented increase in income inequality in the United States over this time period. Interestingly, there is an increase in the relative income growth of subprime versus prime zip codes from 1998 to 2002, which corresponds to the increase in mortgage origination growth for subprime zip codes shown earlier in Figure II. In other words, from 1998 to 2002, subprime areas experience both positive relative income growth and positive relative mortgage origination growth.

The lower-right panel of Figure III plots the relative mortgage debt to income ratio for subprime zip codes. The net effect of high relative growth in mortgage credit to subprime zip codes despite negative relative income growth during 2002 to 2005 is a sharp spike in the relative mortgage debt to income ratio for subprime zip codes.[20] By 2005, the mortgage debt to income ratio of subprime zip codes is almost 10 percentage points higher than prime zip codes, which is almost one full standard deviation of the 2002 level. The extreme jump in the mortgage debt to income ratio of subprime zip codes from 2002 to 2005 helps explain the subsequent sharp relative increase in subprime zip code mortgage default rates documented above.

C. Income-based Measures as Controls

The findings above show that credit growth and income growth from 2002 to 2005 are negatively correlated. It should therefore come as no surprise that income-based covariates that control for changes in credit quality – such as income growth, wage growth, and business establishment growth – do not explain the relative credit growth to subprime zip codes in a

[20] The mortgage debt to income ratio is measures as total mortgage originations in a zip code (HMDA) divided by total income of residents in a zip code (IRS).

regression framework. Columns (1) and (2) in Table IV show that the estimate from Table II, column (1) (.469) is unchanged with the inclusion of income growth and crime growth controls.

One concern with the results in columns (1) and (2) is that subprime areas have more inelastic housing supply, which may induce a stronger effect on origination growth of even small changes in borrower income. The specification reported in column (3) therefore includes zip code level measures of the elasticity of housing supply; our coefficient of interest remains unchanged.

We also adopt a non-parametric geography-based approach to controlling for local housing characteristics such as housing supply elasticity. The idea is to construct 3-square mile "blocks" within each county such that zip codes are assigned to that block if their center falls within the block. We can then put in 3-square mile block fixed effects to control for *any* housing characteristic that effects zip codes uniformly within a 3-square mile block. The median zip code diameter is 0.7 miles, so the use of three square mile blocks is very refined.

Column (4) shows that the inclusion of 3-square mile block fixed effects increases the R^2 of the regression from .45 to .94. Yet it has almost no effect on our coefficient of interest. The result shows quite powerfully that the coefficient on subprime population share reflects the effect of applicants' credit scores on credit growth and not some effect of the neighborhoods in which applicants live.

In columns (5) and (6), we examine the annualized growth in mortgage and non-mortgage debt balances from the *Equifax* data. Non-mortgage debt balances include credit card debt, automobile debt, student loans, and consumer loans. The estimate on the fraction of subprime borrowers in column (5) shows that the increase in mortgage originations in high subprime areas corresponds with an increase in mortgage debt outstanding.

However, non-mortgage debt balances experience a relative decline in subprime areas. In other words, it is not the case that subprime zip codes experience a relative increase in all types of leverage from 2002 to 2005. Instead, the increase in leverage is concentrated in mortgage debt. This result also disputes the income-based hypothesis because a general improvement in income opportunities of subprime consumers should affect all margins of household borrowing. More broadly, any alternative explanation for the subprime mortgage expansion must accommodate a relative decline in non-mortgage debt for subprime households.

D. Business Cycle Conditions and Interest Rate Environment

While the historical credit growth and income growth correlations dispute an income-based explanation for the credit expansion to subprime zip codes, another concern is that business conditions during this time period differentially increase mortgage credit for subprime populations.[21] In particular, perhaps declining interest rates or post-recession economic adjustments (as was the case from 2002 to 2005) are macroeconomic conditions that are naturally conducive to relatively stronger mortgage growth to subprime borrowers.

First, from a theoretical perspective, it does not follow automatically that the above macroeconomic environment should necessarily increase mortgage growth to subprime borrowers. Consider the case of a declining 3-month Treasury bill rate. A decline in the risk free rate decreases the cost of owning a house, which disproportionately benefits non home-owners who are more likely to be subprime borrowers. However, the price of housing will also adjust upward to reflect the lower cost of credit. Higher house prices increase the total expected debt

[21] It should be kept in mind that since we have county fixed effects in a first-differenced specification, all macro shocks - even those that are unique at the level of county – that impact everyone in the economy equally are automatically absorbed away. It is only the differential reaction to a given macro shock that can potentially bias our coefficient of interest.

burden as well as down payment requirement for non home-owners. Therefore, the theoretical effect is ambiguous.

Fortunately, our data spans a period during the 1990s when the economic environment is similar in important ways to the early 2000s. The 1990 to 1994 period is similar to the 2001 to 2005 period: The U.S. economy is emerging from recession, and risk-free interest rates are declining. The top panel in Figure IV shows that the evolution of the 3-month Treasury bill rates from 1990 through 1994 is very similar to that from 2001 through 2005.[22]

The lower panel plots the coefficients of specifications that regress mortgage origination growth on county fixed effects and the share of subprime population in the zip code. We adjust the time scale so "Year0" reflects 1990 for the first period, and 2001 for the comparable second period. The set of coefficients from 2001 to 2005 reiterate our earlier finding that growth in mortgage credit to subprime zip codes is disproportionately stronger. If this result were driven by a differential effect of business conditions (such as declining interest rates or post-recession dynamics) on subprime borrowers, then we would expect similar coefficient estimates from 1990 to 1994.

However, we find the exact opposite. Mortgage credit growth is significantly slower in subprime zip codes from 1990 to 1994. These findings contradict the hypothesis that a sharp drop in risk free rates mechanically causes an expansion in mortgage credit to subprime areas. However, there is an important caveat. While the risk free rate drops by a larger amount from 1990 to 1994 (5% versus 4%), the level of the risk free rate is significantly lower in the 2001 to

[22] The 30 year fixed rate mortgage rate also falls from 2001 to 2005, but it is important to emphasize that decline in the 30 year fixed rate mortgage is consistent with all three of our hypotheses. Either an increase in borrower income, a shift in the supply of mortgage credit, or increases in house price growth expectations would lead to a reduction in the 30 year fixed rate mortgage.

2005 period. While the drop in interest rates is present in both periods, the very low absolute level of risk free rates is unique to the latter period.

This may matter if one believes that mortgage growth to subprime areas is non-linear and kicks in when the risk free rate reaches very low levels. However, even if the effect were non-linear, it is hard to see why it would be non-monotonic. In other words, the drop in the risk free rate from 8% to 3% from 1990 to 1994 should induce some relative growth in mortgage credit to subprime borrowers if the interest rate hypothesis holds. We find no such effect.

In addition, we demonstrate above that subprime zip codes experience a relative decline in non-home debt balances from 2002 to 2005. This evidence further contradicts the argument that the emergence from a recession in 2001 coupled with a low risk free rate mechanically increases borrowing by lower credit quality households. Any business cycle concern must explain why subprime zip codes experience a simultaneous increase in mortgage debt and decrease in non-home debt.

IV. Testing the Supply-Based Hypothesis

At a minimum, the preceding section makes it difficult to explain the expansion of mortgage credit to subprime zip codes with an income-based hypothesis. In fact, the evidence is even stronger: growth in mortgage credit to subprime zip codes occurs *despite* shocks to the credit worthiness of subprime borrowers that historically lead to decreases in mortgage growth. This fact hints at an outward shift in the supply of credit that is strong enough to increase mortgage originations to subprime zip codes despite worsening borrower income prospects in these neighborhoods. Similarly, from a macroeconomic perspective, a supply-based explanation is quite likely given that the price of subprime mortgage risk falls sharply in the first half of 2000s despite a large increase in the quantity of subprime credit. In this section we provide

further evidence in favor of the supply-based hypothesis. This evidence is also useful in guiding us to the likely causes of the shift in mortgage supply.

As we illustrate theoretically in section II.B, subprime consumers experience higher growth in credit when supply shifts outwards because these consumers are ex-ante more likely to be credit rationed. The top-left panel in Figure V provides direct evidence on greater credit rationing for subprime borrowers before the credit boom. The HMDA data tracks all mortgage applications as well as approved mortgages, which enables us to compute the percentage of applications that are denied in each zip code. We plot this "denial rate" in 1996 against the fraction of the population that has a credit score below 660 in 1996. Each variable is demeaned at the county level to conduct a within county analysis. The top-left panel in Figure V shows that zip codes with higher subprime population share have a higher fraction of applicants being denied credit.

If an expansion in credit supply relaxes credit rationing constraints, then we should directly observe a reduction in denial rates once the supply curve starts to shift. Moreover, since subprime zip codes are more likely to be credit rationed, the reduction in the denial rate should be stronger for high subprime zip codes. The top-right panel of Figure V confirms this prediction. It plots the difference in denial rate for subprime and prime zip codes over the last eighteen years. One can see a relative tightening of credit conditions for subprime areas in the late 1990s. However, since the beginning of 2002, there is a sharp relaxation in credit constraints for subprime zip codes. The denial rate for subprime zip codes disproportionately falls from 2002 to 2005. The trend in the top-right panel of Figure V is also confirmed in Column (1) of Panel A in Table V. The drop in denial rate between 2005 and 2002 is significantly larger in

higher subprime zip codes. Interestingly, Figure V shows that the denial rate shoots up in 2007 back to its 2000 peak.

The bottom-left panel in Figure V suggests a possible mechanism for these patterns. It shows a sharp increase from 2002 to 2005 in the fraction of mortgages sold by originators to non-GSE investors within a year of origination. The magnitude of the increase is quite striking: from 1996 to 2002, the fraction sold is constant at 30%; it then increases sharply to almost 60% in just three years. The sharp increase in the ability of originators to unload their mortgages onto outside institutions reflects the wave of securitization in the mortgage market. More importantly, the timing of the sharp rise in securitization in the bottom-left panel coincides exactly with the switch in credit growth-income growth correlations from positive to negative in 2002.

If the ability to sell (securitize) originated mortgages at a faster rate than before induces a shift in mortgage credit supply to subprime borrowers, then we should observe a higher increase in securitization in subprime zip codes that experience much larger increases in credit growth. The bottom-right panel of Figure V confirms this prediction. It shows the relative growth in mortgages sold to non-GSE investors for subprime versus prime zip codes. The six percentage point relative increase from 2002 to 2006 in subprime zip codes is 1.5 standard deviations of the 2001 level. One can also see that the rapid relative increase in securitization in subprime zip codes completely reverses in 2007.

Column (2) in Panel A of Table V confirms in a regression framework the plot in the bottom-right panel of Figure V. An additional advantage of the HMDA data set is that it allows us to further break down mortgages sold to non-GSE financial institutions into sub-categories. There are four such sub-categories: (i) mortgages sold to "affiliates" (such as subsidiaries) of the institution originating a mortgage, (ii) mortgages sold to commercial banks as individual

mortgages, (iii) mortgages sold into securitization pools directly by the originator, and (iv) mortgages sold to other non-commercial bank institutions. Regarding the last category, while we cannot be certain whether mortgages sold to non-commercial bank financial firms are sold for the purpose of securitization, Ashcraft and Schuermann (2008) show that the ten largest issuers of mortgage backed securities from securitization pools all fit into this category. Therefore, the last two categories represent mortgages likely sold directly for the purpose of securitization.[23]

Columns (3) through (6) of Panel A present results from regressions relating the change in each of the four sub-components on county fixed effects and the subprime population share. The results indicate that it is only the change in the last two sub-categories, (i.e. those representing an increase in securitization) that are positively correlated with subprime population share. The change in the first two sub-categories is negatively correlated with subprime population share.

Panel B of Table V examines how the change in the fraction sold to non-GSE investors and the change in its four sub-categories is correlated with the change in subsequent mortgage default rates from 2005 to 2007. We find that zip codes where originators sell more mortgages to non-GSE investors do not experience a disproportionate increase in default rates. However, when the change in mortgages sold represents mortgages that are sold for securitization (columns (4) and (5)), the change is positively correlated with subsequent increase in default rates.

The results in Table V hint at undetected moral hazard on behalf of originators selling for the purpose of securitization as a potential cause for higher mortgage default rates. Originator incentives are likely more closely aligned with affiliated versus non-affiliated investors, and the estimate in column (2) (Panel B) shows that an increase in mortgage sales to affiliates does not

[23] The mean change in fraction sold to non-GSE investors over 2002-05 is 24.7%. This change is divided across the four sub-categories as 5.4%, 3.9%, 5.2%, and 10.8% respectively.

lead to higher default rates. Likewise, column (3) of Panel B demonstrates that zip codes in which originators sell more mortgages to other commercial banks do not experience an increase in default rates. Given that commercial banks have specialized screening abilities, these results suggest that originators only sold bad loans to unaffiliated investors lacking the skills to judge loan quality.[24] The increase in default rates from 2005 to 2007 is concentrated only in zip codes where originators increased sales for the purpose of securitization (column (4)) or increase sales to non-financial firms that are likely securitizing loans (column (5)).

As a caveat it is important to emphasize that we view our evidence on moral hazard as suggestive. It is difficult to assert that undetected moral hazard on behalf of originators causes the spike in mortgage defaults for two reasons. First, there is a lack of exogenous within-county variation across zip codes in the ability of originators to sell mortgages. Without such variation, it is difficult to rule out alternative explanations. Second, we do not have loan-level interest rate data, which makes it difficult to examine whether moral hazard is priced.

The results in this section provide support for the supply-based hypothesis for the expansion in mortgage credit to subprime zip codes from 2002 to 2005. There is an additional piece of evidence presented above that also supports the supply-based hypothesis. As we demonstrate in Section III.C, non-mortgage debt balances for subprime zip codes decrease from 2002 to 2005. Given that securitization advancements are concentrated in the subprime mortgage market from 2002 to 2005, the simultaneous decrease in non-mortgage debt and increase in mortgage debt for subprime zip codes suggests that the pattern is driven by a mortgage credit specific supply shift.

[24] The fact that some commercial banks took major capital hits during the mortgage default crisis partially contradicts this argument. However, the evidence thus far suggests that the only commercial banks that experienced major losses are those heavily involved in securitization through special investment vehicles off-balance sheet.

An explanation of the precise reason for the expansion in securitization during this time period is beyond the scope of our analysis. However, it is likely that the global savings glut in the U.S., the push to expand affordable housing through Freddie Mac and Fannie Mae, and technological advancements in risk management all played a role. Isolating the precise channel for the rise in securitization is material for future research.

V. Testing the House Price Expectations Based Hypothesis

A. Separating the House Price Expectations-Based Hypothesis and the Supply-Based Hypothesis

Can the rapid relative expansion of mortgage originations in subprime zip codes from 2002 to 2005 be explained by changes in lenders' expectations of future house price growth? As Section II.B illustrates, an increase in house price growth expectations can generate disproportionately stronger mortgage credit growth in subprime zip codes. Moreover, as the top left panel in Figure VI illustrates, house price growth increases during the 2002 to 2005 period. In fact, using our zip code level data on house prices, we demonstrate, for the first time to our knowledge, that house prices increase disproportionately more for subprime zip codes within a given county (top right panel in Figure VI).

At first glance the house price expectation hypothesis looks plausible in the face of evidence shown in the top of Figure VI. However, it is equally possible that an outward shift in the supply of mortgage credit increases both the rate of house price appreciation as well as mortgage credit growth. How can one distinguish between these two hypotheses?

One way to separate the two competing explanations is to find an environment where the shift in the supply of mortgage credit continues to matter but it is not possible for house price expectations to change dramatically. Glaeser, Gyourko and Saiz (2008) argue that house price expectations cannot be significantly higher than the inflation rate for house construction costs in

areas with extremely elastic housing supply. The basic idea is that any upward pressure on house prices is quickly met by an increase in the supply of housing stock in the spot market. As a result, actual and expected growth in house prices are never far above the inflation rate for house construction costs.

This insight presents us with a strategy for empirically discriminating between the supply based and house price expectations based hypotheses. If the house price expectations hypothesis explains the expansion in lending to subprime borrowers, then we should see no dramatic changes in subprime mortgage credit growth in high housing supply elasticity MSAs given that house price expectations are tightly bounded in these areas. In contrast, the supply based hypothesis remains applicable even in high housing supply elasticity MSAs.

The bottom left panel in Figure VI compares the evolution of house price growth for highly elastic housing supply MSAs with that of highly inelastic MSAs. We measure housing supply elasticities at the MSA level using Saiz (2008). His study introduces a new index of housing supply elasticity for MSAs that is based on a metro area's land topology metrics such as elevation and presence of water bodies. One of the attractiveness of this index is that it captures fundamental housing supply constraints driven by the geographical terrain of an area.

We classify an MSA as "highly elastic" if it falls in the top 10% of MSAs according to the Saiz measure of housing supply elasticity, and "highly inelastic" if it falls in the bottom 10% of the list. The highly elastic MSAs are (starting with the most elastic): Wichita KS, Fort Wayne IN, Indianapolis IN, Tulsa OK, Dayton OH, Omaha NE, Kansas City MO, McAllen TX, and Little Rock AR. The highly inelastic MSAs are (starting with the most inelastic): Los Angeles

CA, Fort Lauderdale FL, San Francisco CA, New York NY, Boston MA, Oakland CA, San Diego CA, Chicago IL, and San Jose CA.[25]

The bottom-left panel of Figure VI shows that consistent with the basic economic intuition in Glaeser, Gyourko, and Saiz (2008), house price growth is flat and remains low (hovering around the rate of inflation) throughout the last decade.[26] On the other hand, house price growth in inelastic MSAs shows significant upward trend during the last decade followed by a large collapse in 2006 and beyond. The bottom-right panel goes a step further and shows that there is no relative increase in house prices for subprime zip codes from 2002 to 2005 in highly elastic MSAs. The relative house price growth for subprime zip codes is completely flat for elastic MSAs from 2002 to 2005, but rises sharply for inelastic MSAs.[27]

The evidence in Table VI disputes the hypothesis that house price expectations are uniquely responsible for the expansion in credit to subprime borrowers from 2002 to 2005. More specifically, it shows that despite house price expectations remaining low and flat in the sample of very elastic MSAs, our key results continue to hold in these MSAs. From 2002 to 2005, high subprime share zip codes within these MSAs experience negative relative income growth, a relative increase in the fraction of originated mortgages sold for the purpose of securitization,

[25] In order to select the most extreme MSAs in terms of elasticity, we pick MSAs from our full sample, not the sample that is restricted to Case Shiller home prices. MSA level housing price indices are from OFHEO. However when a test uses zip level house prices (i.e. the top-right and bottom-right panels in Figure VI), we have to limit ourselves to zip codes present in the Case Shiller home price data set that represents 84 MSAs. Correspondingly, we have to redefine the most elastic and inelastic MSAs for the top-right and bottom-right panels in Figure VI. The most elastic MSAs in the house price sample are: Akron OH, Atlanta GA, Charlotte NC, Cincinnati OH, Greensboro NC, Toledo OH, and Youngstown OH.

[26] This figure highlights that our assumption that lenders understand that house price appreciation is bounded in highly elastic MSA is a relatively weak assumption. Even some irrational house price expectations by lenders (such as adaptive expectations) would still recognize the limits of house price appreciation in highly elastic MSAs. There is a possible scenario (under irrational beliefs) where an expansion in house prices in the inelastic housing supply areas leads to an expansion in credit supply in elastic areas. This could be the case if lenders irrationally extrapolate the increase in home prices in inelastic areas to house price patterns in elastic areas.

[27] It is interesting to note that the relative house price declines for subprime zip codes beyond 2006 after the subprime mortgage market collapses. This is entirely in line with the predictions of Glaeser, Gyourko, and Saiz (2008) which shows that an expansion in the quantity of housing in preceding years forces house prices to go below construction costs when housing demand pressures recede.

and positive relative mortgage origination growth. In addition, from 2005 to 2007, high subprime share zip codes within these high housing supply elasticity MSAs experience a sharp relative increase in mortgage default rates. The robustness of our findings in these high housing supply elasticity MSAs is inconsistent with the house-price expectations hypothesis and further supports the supply-based hypothesis.

B. The Interaction of Housing and Credit Markets

While the results above are inconsistent with the view that house price growth is a unique explanation of the subprime lending expansion, a key question remains: What explains relative house price growth in high subprime share zip codes from 2002 to 2005?

Section III.B shows that the years from 2002 to 2005 is the only period in recent history in which income growth and credit growth are negatively correlated. Further, income growth is substantially lower in subprime zip codes that experience very high relative mortgage credit growth. Since subprime zip codes also experience significantly stronger house price growth from 2002 to 2005 (Figure VI top-right panel), one would also expect a negative correlation between income growth and house price growth. This is confirmed by column (1) of Table VII. Furthermore, columns (2) through (8) show that, as with income growth, 2002 to 2005 is the only period in the last eighteen years in which house price growth is negatively correlated with income growth. This relationship is significantly positive in all other periods as one would expect under basic models of housing demand. The top panel in Figure VII plots the house price growth and income growth correlation over time, and shows the historically unique nature of the securitization years.

Table 8 provides further evidence that house prices become divorced from underlying income dynamics from 2002 to 2005. It isolates our sample to the 26 subprime zip codes that

experience negative absolute income growth from 2002 to 2005. These negative income growth subprime zip codes experience 1.1% higher relative annualized house price growth from 2002 to 2005 compared to prime zip codes with positive income growth in the same county. In fact, in 17 of the 26 negative income growth subprime zip codes, house price growth is stronger than in prime zip codes with positive income growth.

As in the case of credit growth, one may be concerned that house price growth is higher for subprime zip codes despite negative income growth because of business conditions. However, comparing the relative house price growth estimates for 2001 to 2005 with those of 1990 to 1994 in the bottom panel of Figure VII, we find that relative house price growth in the early period is significantly negative despite a similar macroeconomic environment.

Relative house price growth patterns from 2002 to 2005 are unique in the last eighteen years. It is the only period in which house prices rise by more in zip codes with negative relative income growth. This unique pattern coincides exactly with the expansion of subprime mortgage securitization. While further research is needed to isolate causality in a more convincing manner, the evidence suggests that the expansion of mortgage originations in subprime zip codes, driven by securitization, may itself be responsible for the relative house price growth in subprime areas. At the very least, the evidence cautions against treating house prices movements in the last decade as independent from the expansion and collapse of subprime mortgage securitization.

Finally, we want to emphasize that there may be a feedback mechanism between credit growth and house price growth. It is a well established theoretical result that increasing collateral value may also increase credit availability for previously constrained households, which forces a cycle by further pushing up collateral value (Kiyotaki and Moore (1997)). In fact our results in Table 8 lend support to such a feedback effect. The coefficients in Table 8, which are estimated

on a sample of very elastic housing supply MSAs, are smaller than the overall effects seen earlier in our full sample specification. Since these coefficients continue to be significant and quite large quantitatively despite no house price appreciation, they highlight the implausibility of the house price expectations-based hypothesis as the unique explanation for our core results. However, the fact that the coefficients are relatively smaller in magnitude is consistent with the idea that there is a feedback effect between house price growth and credit growth in more inelastic MSAs.

VI. Conclusion

We find evidence of sharp relative growth in mortgage credit followed by a sharp relative increase in defaults in high subprime share zip codes. This pattern is prevalent in almost every city in the U.S. (see Appendix Table). These facts demonstrate that any study seeking to understand the origins of the mortgage default crisis must explain the expansion of mortgage credit to subprime neighborhoods across the entire country.

Our unique zip code level data set enables us to uncover several new facts regarding the rise in mortgage credit to subprime neighborhoods. We show that subprime zip codes experience strong relative growth in mortgage credit from 2002 to 2005 despite negative relative, and in some cases absolute, income growth. In fact, this is the only period in the last eighteen years in which the correlation between mortgage credit growth and income growth at the zip code level is negative. This latter fact suggests a historically unique shift in the supply of mortgage credit. There is a possibility that historically low risk free rates from 2001 to 2005 are responsible for the subprime mortgage credit expansion; however, there is no such expansion when risk free rates drop sharply from 1990 to 1994, and there is no corresponding shift in non-mortgage consumer credit from 2001 to 2005. Additionally, the robustness of the results to the inclusion of

very refined 3-square-mile-block fixed effects shows that mortgage credit growth in subprime zip codes cannot be explained by local housing factors such as housing supply elasticity.

Concurrent with these patterns is a rapid growth in the securitization of subprime mortgages, a disproportionate decline in denial rates for subprime zip codes, and a drop in the subprime-prime interest spread. All of these patterns hold within very elastic housing supply MSAs in which an increase in house price expectations is theoretically and empirically unlikely.

At a minimum, our analysis provides a set of new facts that are important for understanding the rapid rise in subprime mortgage credit. Going forward, any explanation for the rise of subprime mortgages must be simultaneously consistent with the empirical facts we uncover. We interpret our results as being less supportive of an income-based or house price expectations-based explanation and more supportive of the supply-based hypothesis. However, we also recognize the limitation of our analysis. Since we do not have direct instruments for an expansion in supply of credit, we are careful to avoid making strict causality claims.

As a last exercise, we can use our microeconomic estimates to answer an important macroeconomic counter-factual: How would mortgage lending and house prices have evolved if the mortgage credit expansion toward subprime zip codes had *not* occurred? Since our analysis is based on within-county analysis, we sort zip codes by 1996 subprime population share within each county and categorize them into 20 equal bins with 5% of zip codes in each bin. Let i index each bin within a given county and denote by s_i the mean subprime population share inside a 5% bin. Given a coefficient of .47 (Table II, column (1)) for the marginal effect of 1996 subprime population share on mortgage growth from 2002 to 2005, the incremental subprime-driven loan origination growth in bin i is equal to $.47*(s_i - s_1)$. The total *subprime-driven* mortgage credit growth is therefore equal to: $\sum_{i=2}^{20}\left(.47 * (s_i - s_1)\right)$. The total *overall* mortgage credit growth

can be similarly computing by sorting zip codes within a county by mortgage credit growth, creating 20 equal sized bins, and computing $\sum_{i=2}^{20}(g_i - g_1)$, where g_i denotes mean mortgage credit growth rate inside the *i*th 5% mortgage credit growth bin. The ratio of total subprime-driven credit growth to total overall credit growth conveys the importance of the supply-based hypothesis in explaining the overall "explainable" variation in our estimation methodology. We conduct the above analysis for mortgage credit growth during 2002 to 2005, house price growth during 2002 to 2005, and default rate increase during 2005 to 2007. Under the assumption that the coefficients on the subprime share variables reflect the supply-based hypothesis outlined in Section II.B., the supply-based hypothesis can explain 21.4%, 39.9% and 40.9% of the variation within counties for the three variables, respectively.

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Table I: Panel A
Summary Statistics

	Mean	SD	Between county SD	Within county SD	10th	50th	90th
Equifax Data							
Mortgage debt annualized growth, 1996 to 2002	0.089	0.065	0.048	0.058	0.030	0.082	0.153
Non-home debt annualized growth, 1996 to 2002	0.073	0.092	0.040	0.087	0.019	0.068	0.122
Mortgage debt annualized growth, 2002 to 2005	0.145	0.081	0.049	0.071	0.056	0.141	0.235
Non-home debt annualized growth, 2002 to 2005	0.058	0.064	0.034	0.059	-0.016	0.054	0.132
Mortgage default rate, 1996	0.030	0.024	0.013	0.021	0.005	0.024	0.060
Non-home default rate, 1996	0.068	0.035	0.019	0.030	0.029	0.063	0.114
Mortgage default rate change, 1996 to 2005	-0.003	0.028	0.018	0.023	-0.032	-0.004	0.026
Non-home default rate change, 1996 to 2005	-0.008	0.031	0.018	0.026	-0.040	-0.007	0.025
Mortgage default rate change, 2005 to 2007	0.035	0.038	0.024	0.032	-0.003	0.027	0.087
Non-home default rate change, 2005 to 2007	0.018	0.026	0.012	0.024	-0.010	0.016	0.049
Subprime consumer fraction (under 660), 1996	0.287	0.113	0.063	0.094	0.154	0.269	0.446
Fiserv Case Shiller Weiss Data							
House price annualized growth, 1996 to 2002	0.096	0.033	0.034	0.011	0.049	0.101	0.137
House price annualized growth, 2002 to 2005	0.153	0.078	0.078	0.016	0.041	0.145	0.255
HMDA Data							
Mortgage origination for home purchase ann. growth 1996 to 2002	0.144	0.089	0.068	0.067	0.052	0.133	0.240
Mortgage origination for home purchase ann. growth 2002 to 2005	0.194	0.189	0.130	0.150	0.014	0.170	0.405
Fraction sold to non-agency investors, 1996	0.253	0.081	0.078	0.045	0.154	0.249	0.357
Change in fraction sold, 1996 to 2002	0.044	0.057	0.045	0.043	-0.027	0.043	0.114
Change in fraction sold, 2002 to 2005	0.241	0.051	0.038	0.038	0.179	0.240	0.307
IRS and Census Statistics of U.S. Business							
Income annualized growth, 1991 to 1998	0.052	0.025	0.012	0.022	0.028	0.048	0.083
Income annualized growth, 1998 to 2002	0.023	0.020	0.011	0.017	0.001	0.025	0.043
Income annualized growth, 2002 to 2005	0.048	0.035	0.021	0.031	0.015	0.040	0.091
Income annualized growth, 2005 to 2006	0.041	0.044	0.023	0.040	-0.002	0.037	0.090
Employment annualized growth, 2002 to 2005	0.016	0.058	0.030	0.053	-0.037	0.012	0.076
Establishment annualized growth, 2002 to 2005	0.017	0.029	0.019	0.024	-0.010	0.013	0.049

This table presents summary statistics for the 3,014 zip codes in our sample.

Table I: Panel B
Subprime Versus Prime Zip Codes

	Prime zip codes	Subprime zip codes
Measures of mortgage credit availability		
Fraction of subprime borrowers in 1996 (under 660)	0.159	0.444**
Fraction of loans backed by FHA in 1996	0.041	0.239**
Fraction of mortgage applications denied, 1996	0.148	0.307**
Homeownership rate, 2000	0.812	0.557**
Demographic variables from Census 2000		
Median household income ($000)	76.4	38.9**
Poverty rate	0.038	0.169**
Fraction with less than high school education	0.077	0.289**
Fraction unemployed	0.031	0.081**
Fraction non-white	0.079	0.415**

This table presents characteristics of prime and subprime zip codes in our sample. Prime and subprime zip codes are determined by splitting zip codes into four quartiles based on the fraction of subprime borrowers (credit score less than 660) as of 1996. Prime zip codes are the lowest quartile and subprime zip codes are the highest quartile.
**,* Difference between prime and subprime statistically distinct from 0 at the 1% and 5% levels, respectively.

Table II
Can Productivity/Income Growth Explain Subprime Credit Expansion from 2002 to 2005?

	(1) Mortgage origination growth 2002 to 2005	(2) Income growth 2002 to 2005	(3) Employment growth 2002 to 2005	(4) Establishment growth 2002 to 2005
Fraction subprime borrowers, 1996	0.469**	-0.141**	-0.074**	-0.042**
	(0.029)	(0.006)	(0.011)	(0.005)
N	2946	2946	2946	2946
R^2	0.42	0.35	0.15	0.33

This table presents the correlation across zip codes between measures of income growth, employment growth, and business growth and the fraction of subprime borrowers. All regressions include county fixed effects.
**,*Statistically distinct from 0 at the 1% and 5% levels, respectively.

Table III
Historical Mortgage Credit Growth and Income Growth Correlations

	Dependent variable: Mortgage originations for home purchase growth, annualized							
	(1) 2002-2005	(2) 1991-1998	(3) 1998-2001	(4) 2001-2002	(5) 2002-2004	(6) 2004-2005	(7) 2005-2006	(8) 2006-2007
Income growth, annualized	-0.662**	0.537**	0.517**	0.425	-0.394**	-0.383**	0.103	0.716**
	(0.089)	(0.084)	(0.092)	(0.368)	(0.122)	(0.077)	(0.078)	(0.093)
N	3014	2809	3014	3014	3014	3014	3014	3014
R^2	0.34	0.55	0.27	0.44	0.24	0.39	0.27	0.26

This table presents the correlation across zip codes between mortgage origination for home purchase growth and income growth for different periods of our sample. Income growth and mortgage origination growth are measured for the exact same period for all specifications except the specification reported in column (7). We do not have income data available for 2007; as a result, in column (7) we examine the correlation between mortgage origination growth from 2006 to 2007 and income growth from 2005 to 2006. All specifications include county fixed effects. **,* Coefficient estimate statistically distinct from 0 at the 1% and 5% levels, respectively.

Table IV
Mortgage Credit Expansion in Subprime Zip Codes

	(1)	(2)	(3)	3-square-mile-block fixed effects (4)	(5)	(6)
	Annualized mortgage origination for home purchase growth, 2002 to 2005				Mortgage debt growth, 2002 to 2005	Non-Mortgage debt growth, 2002 to 2005
Fraction of subprime borrowers, 1996	0.460**	0.458**	0.454**	0.431**	0.050**	-0.039**
	(0.033)	(0.033)	(0.035)	(0.079)	(0.015)	(0.013)
Income growth, 2002 to 2005	-0.064	-0.068	-0.084	0.145	0.360**	0.201**
	(0.097)	(0.097)	(0.104)	(0.223)	(0.044)	(0.037)
Establishment growth, 2002 to 2005	0.084	0.096	0.118	-1.898**	0.805**	0.546**
	(0.124)	(0.127)	(0.142)	(0.314)	(0.058)	(0.049)
Employment growth, 2002 to 2005	-0.054	-0.053	-0.041	0.001	-0.040	0.001
	(0.056)	(0.056)	(0.056)	(0.101)	(0.026)	(0.021)
Crime growth, 2002 to 2005		-0.105	-0.012	0.551	0.251*	0.240*
		(0.256)	(0.278)	(0.779)	(0.117)	(0.098)
House price elasticity with respect to income			-0.014**	-0.010		
			(0.005)	(0.009)		
House quantity elasticity with respect to income			-0.001	0.014		
			(0.004)	(0.008)		
Fraction of housing units vacant, 2000			0.371**	0.865**		
			(0.074)	(0.252)		
Fraction of housing stock built last 2 years, 2000			0.363	1.161		
			(0.201)	(0.656)		
Fraction of housing stock built 2 to 5 years ago, 2000			-0.108	0.162		
			(0.078)	(0.246)		
N	2946	2946	2782	2782	2946	2946
R^2	0.42	0.42	0.45	0.94	0.33	0.26

This table presents coefficient estimates from specifications relating the growth in mortgage originations for home purchase in a zip code from 2002 to 2005 to the fraction of subprime borrowers in 1996. Column (5) examines the growth in total mortgage debt, and column (6) examines the growth in non-home consumer debt. The measure of house price elasticity (house quantity elasticity) uses changes in median house value (number of owner occupied housing units) from 1990 to 2000 from the decennial census, and changes in household income from 1991 to 2001 from the IRS. All growth rates are annualized. All specifications include county fixed effects except for the specification reported in column (4), which includes 3 square mile fixed effects. **,* Coefficient estimate statistically distinct from 0 at the 1% and 5% levels, respectively.

Table V
Evidence of a Securitization Channel

Panel A: Secondary mortgage sales and subprime zip codes

	(1)	(2)	(3)	(4)	(5)	(6)
	Change in applicant denial rate 2002-05	Change during 2002-05 in the fraction sold to non-GSE investors	Change during 2002-2005 in the fraction sold to non-GSE investors who are:			
			Affiliates	Commercial Banks	Securitized Pools Of Mortgages	Non-Commercial Bank Fin. Firms
Fraction of subprime borrowers, 1996	-0.094**	0.048**	-0.055**	-0.007*	0.104**	0.077**
	(0.006)	(0.009)	(0.005)	(0.003)	(0.004)	(0.004)
N	2946	2946	2946	2946	2946	2946
R^2	0.58	0.46	0.56	0.46	0.68	0.61

Panel B: Mortgage sales and changes in default rate

	(1)	(2)	(3)	(4)	(5)
	Change in mortgage default rate from 2005 to 2007				
Change during 2002-05 in the fraction sold to non-GSE investors	0.027				
	(0.015)				
Change during 2002-2005 in the fraction sold to non-GSE investors who are:					
Affiliates		-0.247**			
		(0.027)			
Commercial Banks			-0.116*		
			(0.046)		
Securitized Pools of Mortgages				0.360**	
				(0.031)	
Non-commercial Bank Financial Firms					0.314**
					(0.029)
N	2946	2946	2946	2946	2946
R^2	0.39	0.40	0.39	0.41	0.41

Panel A presents coefficient estimates relating the change in the fraction of originated mortgages sold in a zip code from 2002 to 2005 to the share of subprime borrowers as of 1996. Panel B presents estimates relating default rates from 2005 to 2007 to the fraction of loans sold by originators to investors from 2002 to 2005. All specifications include county fixed effects and control variables for income, wage, employment, establishment, and crime growth. **,* Coefficient estimate statistically distinct from 0 at the 1% and 5% levels, respectively.

Table VI
Mortgage Origination Growth and Mortgage Default Rate Changes
High Housing Supply Elasticity MSAs

	Income growth 2002 to 2005	Change in fraction sold in securitizations 2002 to 2005	Change in fraction to other financial firms 2002 to 2005	Mortgage origination growth 2002 to 2005		Change mortgage default rate 2002 to 2005	
	(1)	(2)	(3)	(4)	(5) With controls	(6)	(7) With controls
Fraction subprime borrowers, 1996	-0.069**	0.100**	0.061**	0.305**	0.413**	0.057**	0.056**
	(0.010)	(0.009)	(0.014)	(0.061)	(0.069)	(0.015)	(0.018)
N	655	655	655	655	655	655	655
R^2	0.17	0.28	0.43	0.10	0.12	0.04	0.05

This table examines relative income growth, securitization patterns, and mortgage origination growth from 2002 to 2005 and the relative change in mortgage default rates from 2005 to 2007 in high subprime borrower share zip codes. The sample is limited to the top decile MSAs by housing supply elasticity as measured by Saiz (2008). The 12 high housing supply elasticity MSAs are: Dayton OH, Fort Wayne IN, Greenville SC, Indianapolis IN, Kansas City MO, Little Rock AR, McAllen TX, Omaha NE, Tulsa OK, and Wichita KS. The control variables in columns (5) and (7) are income growth, employment growth, and business establishment growth from 2002 to 2005. All growth rates are annualized, and all specifications include MSA fixed effects. **,* Coefficient estimate statistically distinct from 0 at the 1% and 5% levels, respectively.

Table VII
Historical House Price Growth and Income Growth Correlations

	Dependent variable: House price growth, annualized							
	(1) 2002-2005	(2) 1991-1998	(3) 1998-2001	(4) 2001-2002	(5) 2002-2004	(6) 2004-2005	(7) 2005-2006	(8) 2006-2007
Income growth, annualized	-0.118**	0.138**	0.070**	0.130**	-0.074**	-0.082**	-0.024*	0.195**
	(0.010)	(0.008)	(0.013)	(0.011)	(0.010)	(0.008)	(0.010)	(0.017)
N	3014	2875	3014	3014	3014	3014	3014	2721
R^2	0.96	0.90	0.87	0.89	0.95	0.95	0.78	0.87

This table presents the correlation across zip codes between house price growth and income growth for different periods of our sample. Income growth and house price growth are measured for the exact same period for all specifications except the specification reported in column (7). We do not have income data available for 2007; as a result, in column (7) we examine the correlation between house price growth from 2006 to 2007 and income growth from 2005 to 2006. All growth rates are annualized, and all specifications include county fixed effects. **,* Coefficient estimate statistically distinct from 0 at the 1% and 5% levels, respectively.

Table A.1
The Mortgage Default Crisis: Basic Facts by MSA

	Increase in Mortgage Default Rate (percentage points) 2005 to 2007			Annualized Mortgage Origination for Home Purchase Growth 2002 to 2005			Annualized Income Growth 2002 to 2005		
	Subprime zip codes	Prime zip codes	Subprime multiple	Subprime zip codes	Prime zip codes	Subprime multiple	Subprime zip codes	Prime zip codes	Subprime multiple
Anaheim, CA	7.1%	2.2%	226.6%	20.8%	2.9%	619.2%	7.1%	11.0%	-35.7%
Atlanta, GA	2.9%	1.1%	166.1%	19.6%	16.4%	19.5%	6.4%	10.2%	-37.3%
Baltimore, MD	1.5%	1.1%	38.9%	32.9%	10.7%	207.7%	4.6%	8.0%	-43.1%
Boston, MA	7.0%	1.4%	414.3%	24.5%	11.4%	113.6%	2.6%	7.5%	-65.7%
Chicago, IL	4.2%	1.7%	149.8%	28.4%	15.3%	85.9%	2.7%	5.4%	-51.2%
Cincinnati, OH	-0.1%	0.5%	-114.8%	13.5%	10.3%	30.8%	1.8%	6.7%	-73.0%
Cleveland, OH	3.6%	1.5%	139.8%	19.1%	7.2%	164.0%	0.8%	5.4%	-84.7%
Columbus, OH	1.9%	-0.1%	2368.9%	4.7%	3.7%	27.5%	0.5%	6.5%	-92.4%
Dallas, TX	1.4%	0.8%	76.6%	12.9%	25.9%	-50.2%	5.6%	12.2%	-54.0%
Denver, CO	1.7%	1.0%	70.5%	14.1%	5.3%	164.8%	4.5%	6.3%	-28.3%
Detroit, MI	6.6%	1.4%	384.8%	23.1%	3.4%	580.1%	-1.8%	1.3%	-234.9%
Edison, NJ	7.0%	1.4%	397.7%	-7.3%	-21.0%	65.0%	3.2%	6.1%	-47.9%
Fort Worth, TX	1.8%	0.9%	87.8%	12.2%	20.5%	-40.6%	4.7%	11.8%	-60.4%
Houston, TX	2.9%	0.7%	301.7%	15.8%	-1.2%	1413.1%	4.5%	13.7%	-67.3%
Indianapolis, IN	2.6%	0.6%	314.4%	10.8%	13.8%	-21.8%	0.7%	6.4%	-89.9%
Kansas City, MO	1.1%	0.9%	23.0%	29.7%	-1.0%	2986.4%	0.9%	8.5%	-89.5%
Los Angeles, CA	7.9%	1.8%	346.5%	34.9%	10.2%	241.7%	4.6%	12.1%	-62.3%
Miami, FL	9.7%	5.7%	70.1%	12.1%	18.2%	-33.7%	5.8%	10.2%	-43.3%
Minneapolis, MN	4.0%	1.5%	159.1%	24.4%	6.8%	257.7%	2.2%	7.2%	-69.8%
Nassau, NY	9.5%	1.8%	432.3%	34.9%	13.8%	153.2%	1.2%	6.7%	-81.8%
New York, NY	6.6%	0.9%	624.4%	37.1%	14.5%	155.1%	4.0%	9.4%	-57.9%
Newark, NJ	8.6%	1.4%	504.5%	41.8%	4.8%	779.6%	1.7%	7.1%	-76.5%
Oakland, CA	9.2%	1.3%	591.7%	39.1%	11.8%	230.9%	3.0%	7.3%	-59.0%
Orlando, FL	6.2%	1.5%	306.2%	33.6%	-2.4%	1475.4%	7.3%	22.4%	-67.4%
Philadelphia, PA	2.0%	0.9%	135.8%	-30.1%	-16.3%	-84.4%	2.7%	7.6%	-64.7%
Phoenix, AZ	8.1%	2.6%	210.9%	37.4%	26.8%	39.8%	8.4%	15.6%	-45.9%
Pittsburgh, PA	-0.9%	1.3%	-171.9%	4.7%	6.8%	-31.1%	1.6%	6.2%	-73.4%
Portland, OR	0.0%	1.1%	-98.2%	32.3%	18.4%	75.0%	9.5%	8.7%	8.5%
Providence, RI	7.8%	2.5%	212.9%	34.4%	7.3%	374.5%	4.4%	6.7%	-34.9%
Riverside, CA	10.8%	6.0%	79.6%	37.6%	25.6%	47.0%	6.4%	13.3%	-51.8%
Sacramento, CA	13.2%	2.7%	385.4%	44.7%	15.9%	182.0%	2.9%	7.3%	-60.7%

San Antonio, TX	1.5%	0.7%	130.6%	18.0%	21.3%	-15.4%	5.2%	15.4%	-66.4%
San Diego, CA	7.8%	1.1%	639.1%	30.2%	11.8%	157.2%	5.0%	9.0%	-45.0%
San Francisco, CA	3.3%	1.0%	230.7%	25.7%	15.3%	67.7%	7.8%	11.8%	-33.7%
Seattle, WA	2.8%	0.7%	313.8%	21.0%	20.3%	3.3%	3.3%	8.2%	-59.4%
St. Louis MO	4.6%	0.6%	691.0%	31.5%	7.1%	341.3%	0.2%	6.2%	-96.9%
Tampa, FL	4.8%	3.1%	53.1%	44.9%	35.1%	28.0%	7.9%	12.7%	-37.9%
Troy, MI	3.1%	2.1%	49.4%	5.7%	2.9%	96.6%	1.6%	4.6%	-65.1%
Virginia Beach, VA	1.7%	-0.2%	858.7%	27.2%	10.2%	166.9%	5.3%	7.3%	-27.4%
Washington, DC	6.2%	1.5%	308.2%	32.8%	17.9%	83.2%	4.5%	9.6%	-53.6%
AVERAGES	4.8%	1.5%	302.8%	23.3%	10.7%	278.9%	3.9%	9.0%	-62.0%

This table presents information on the change in the mortgage default rate from 2005 to 2007, the annualized growth in mortgage originations for home purchase from 2002 to 2005, and the annualized growth rate in income from 2002 to 2005 for the entire U.S. and broken down by top 40 MSAs by population. Subprime and prime zip codes are defined to be the highest and lowest quartile zip codes based on the fraction of residents with a credit score less than 660 as of 1996.

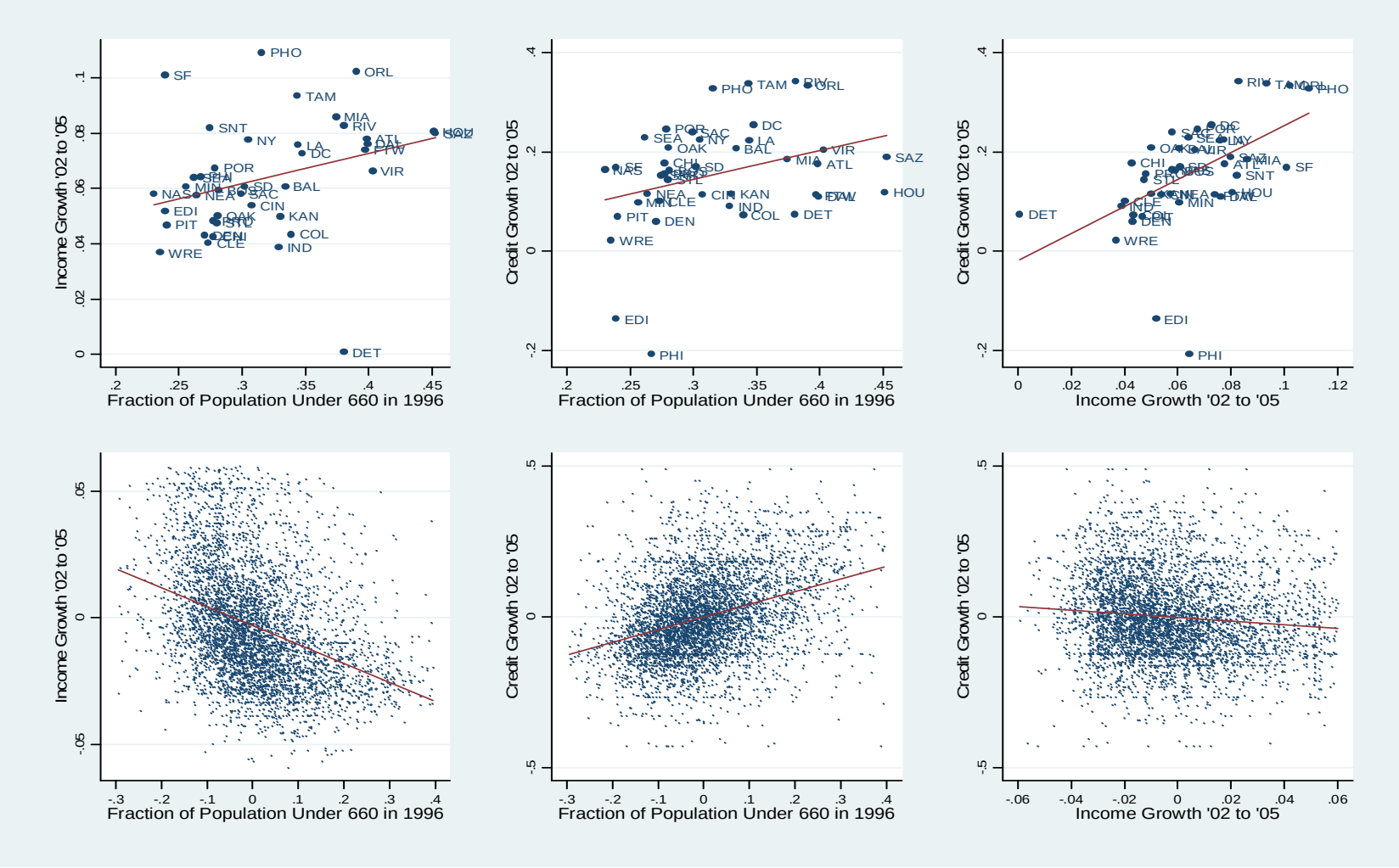

Figure I

Income Growth, Mortgage Credit Growth, and Subprime Population: Between and Within MSA Correlations

This figure presents correlations between income growth, mortgage credit growth, and the fraction of the population with a credit score under 660. The top panels present between MSA correlations for the top 40 MSAs by population, and the bottom panels utilize zip code level data to show the within MSA correlations for the top 40 MSAs. The bottom panels present data that are deviated from MSA level means.

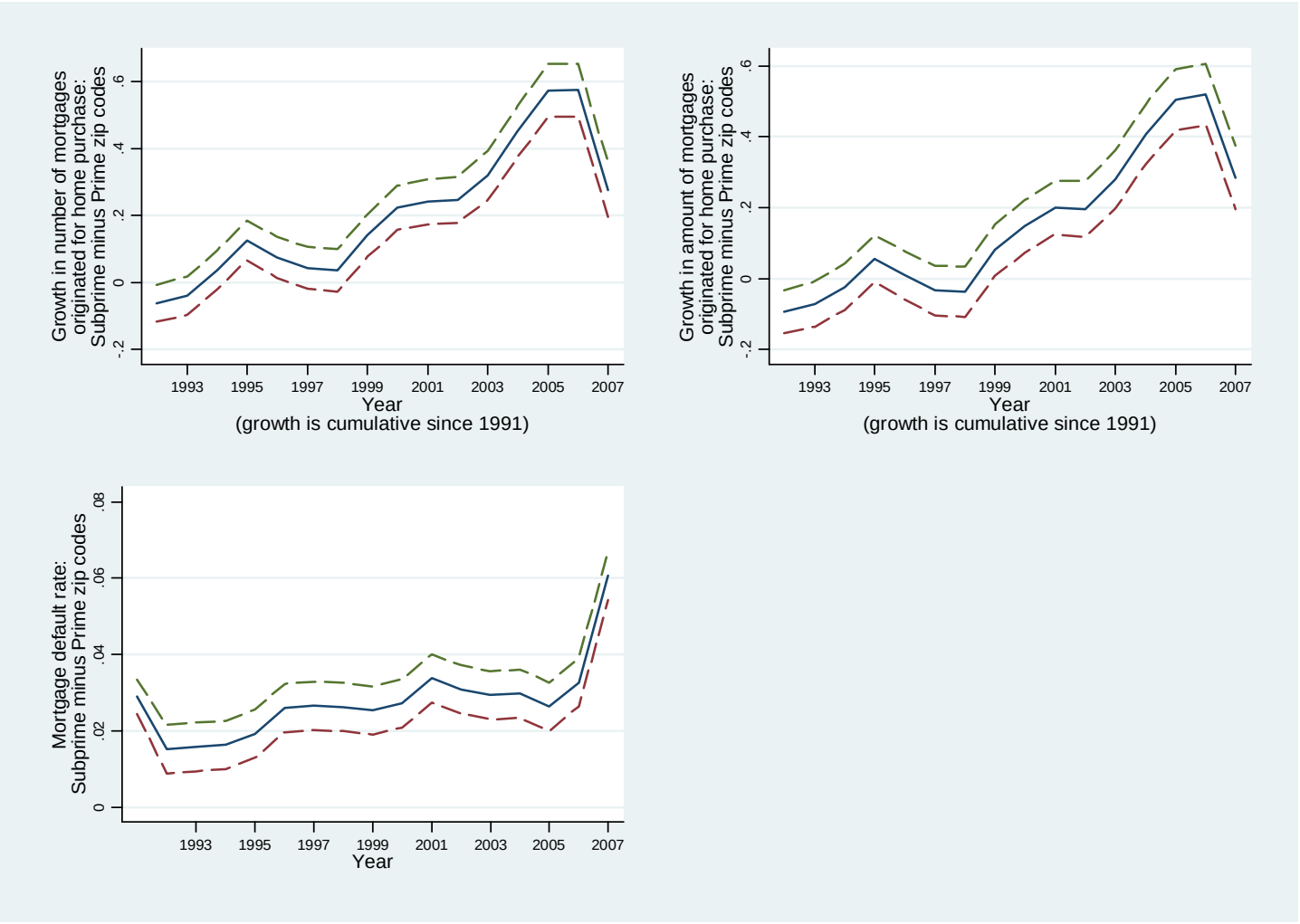

Figure II
Mortgage Credit Growth and Default Rates: Subprime Relative to Prime Zip Codes

This figure plots the growth in the number (top left panel) and amount (top right panel) of originated mortgages and the mortgage default rate (bottom left panel) for subprime relative to prime zip codes in the same county. Subprime and prime zip codes are defined to be the highest and lowest quartile zip codes based on the fraction of residents with a credit score below 660 in 1991.

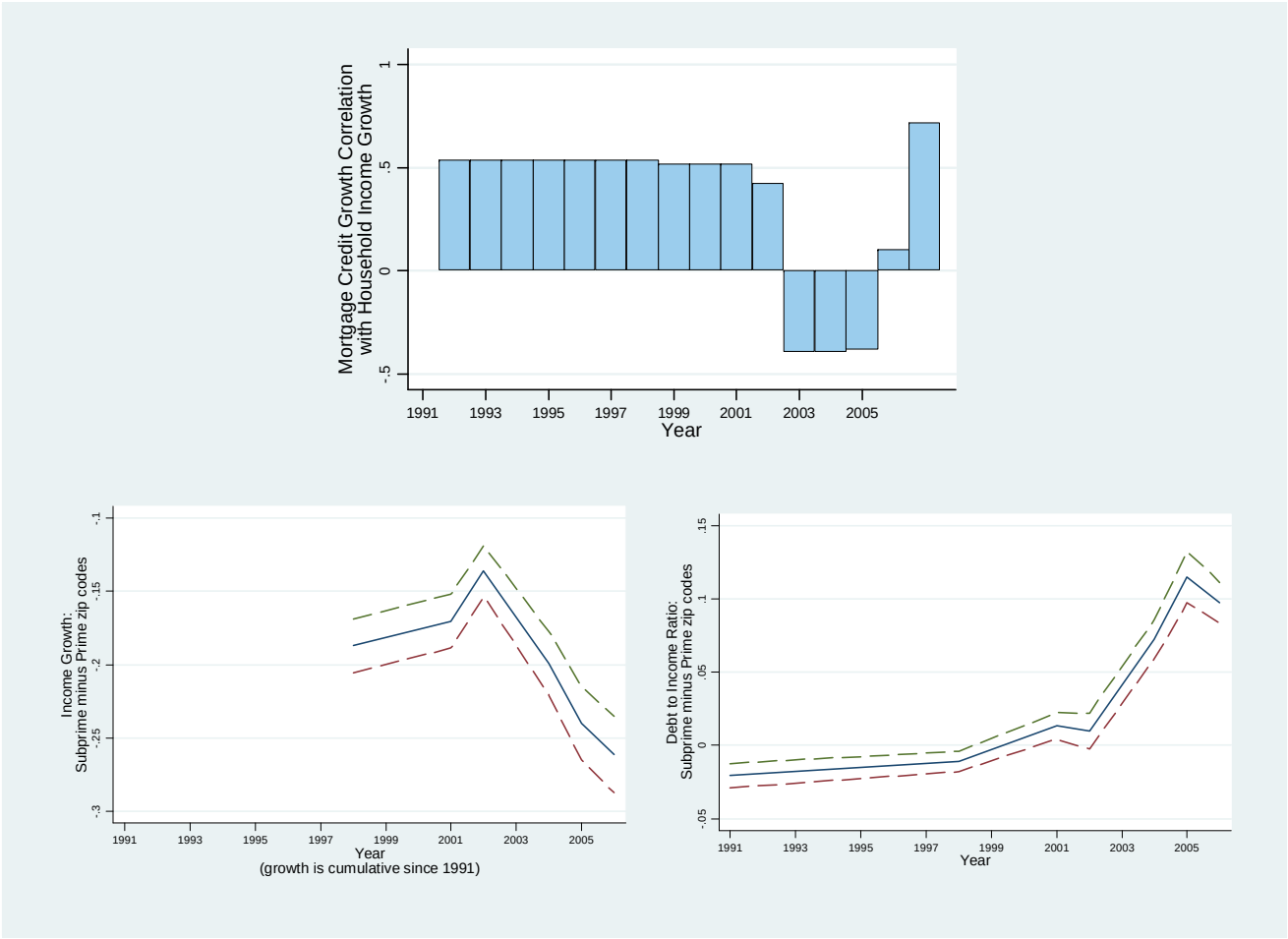

Figure III
Mortgage Credit Growth and Income Growth Over Time

The top panel in this figure plots the correlation across zip codes between income growth and mortgage credit growth over time, after deviating from county means. The bottom left plots the relative income growth for subprime relative to prime zip codes in the same county, and the bottom right plots the relative debt to income ratio for subprime relative to prime zip codes in the same county. The debt to income ratio is defined as total originated mortgages for home purchase in a zip code scaled by the total income of the zip code. Subprime and prime zip codes are defined to be the highest and lowest quartile zip codes based on the fraction of residents with a credit score below 660 in 1991.

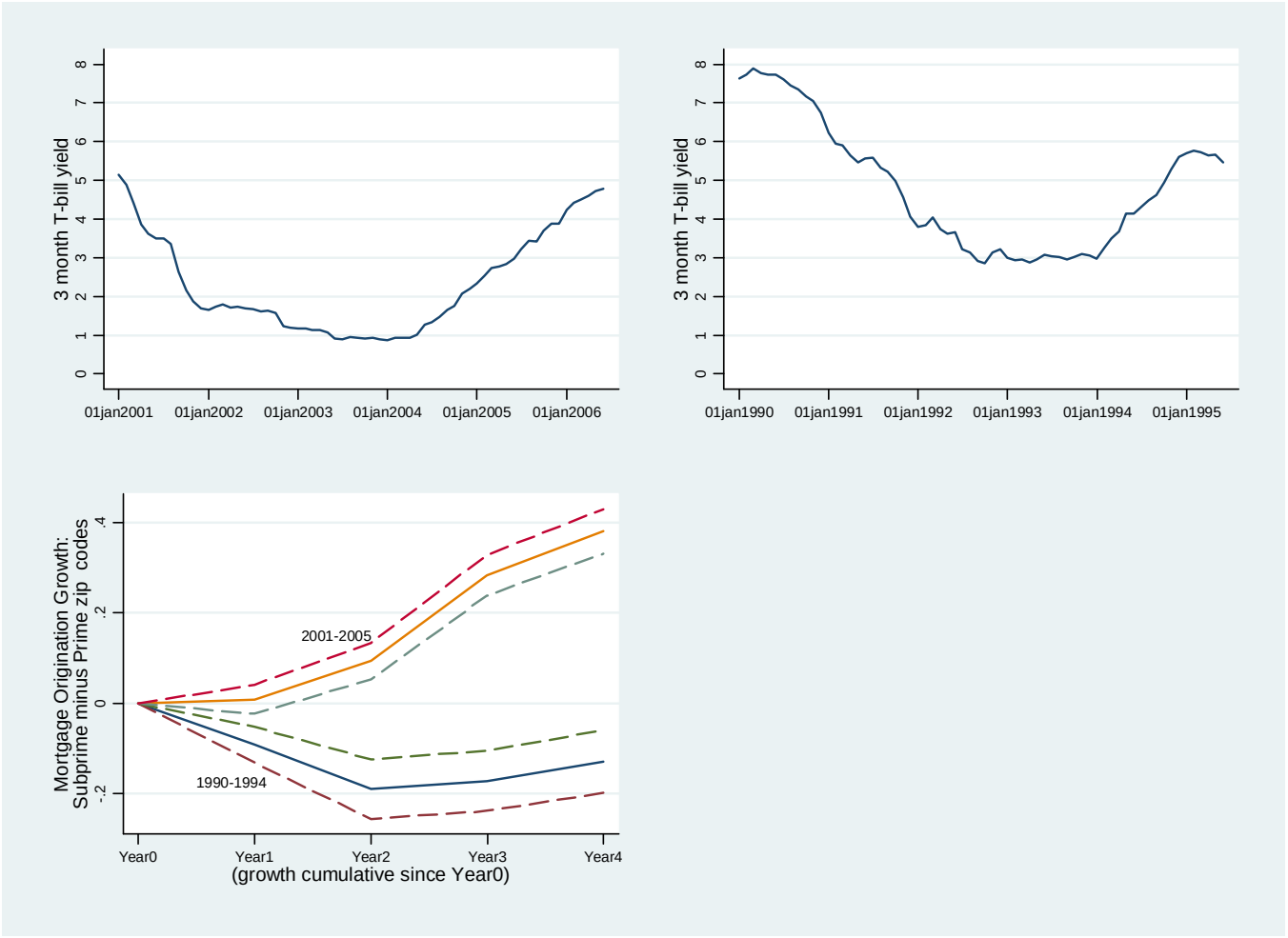

Figure IV

Relative Mortgage Origination Growth for Subprime Zip Codes: Falling Interest Rate Periods

The top left and right panels show the evolution of the 3-month Treasury bill yield during the 5 year period from 1990 to 1994 and 2001 to 2005, respectively. The bottom panel shows the growth in the amount of originated mortgages for subprime relative to prime zip codes in the same county for these two 5 year periods. Subprime and prime zip codes are defined to be the highest and lowest quartile zip codes based on the fraction of residents with a credit score below 660 as of the first year of the respective 5 year period.

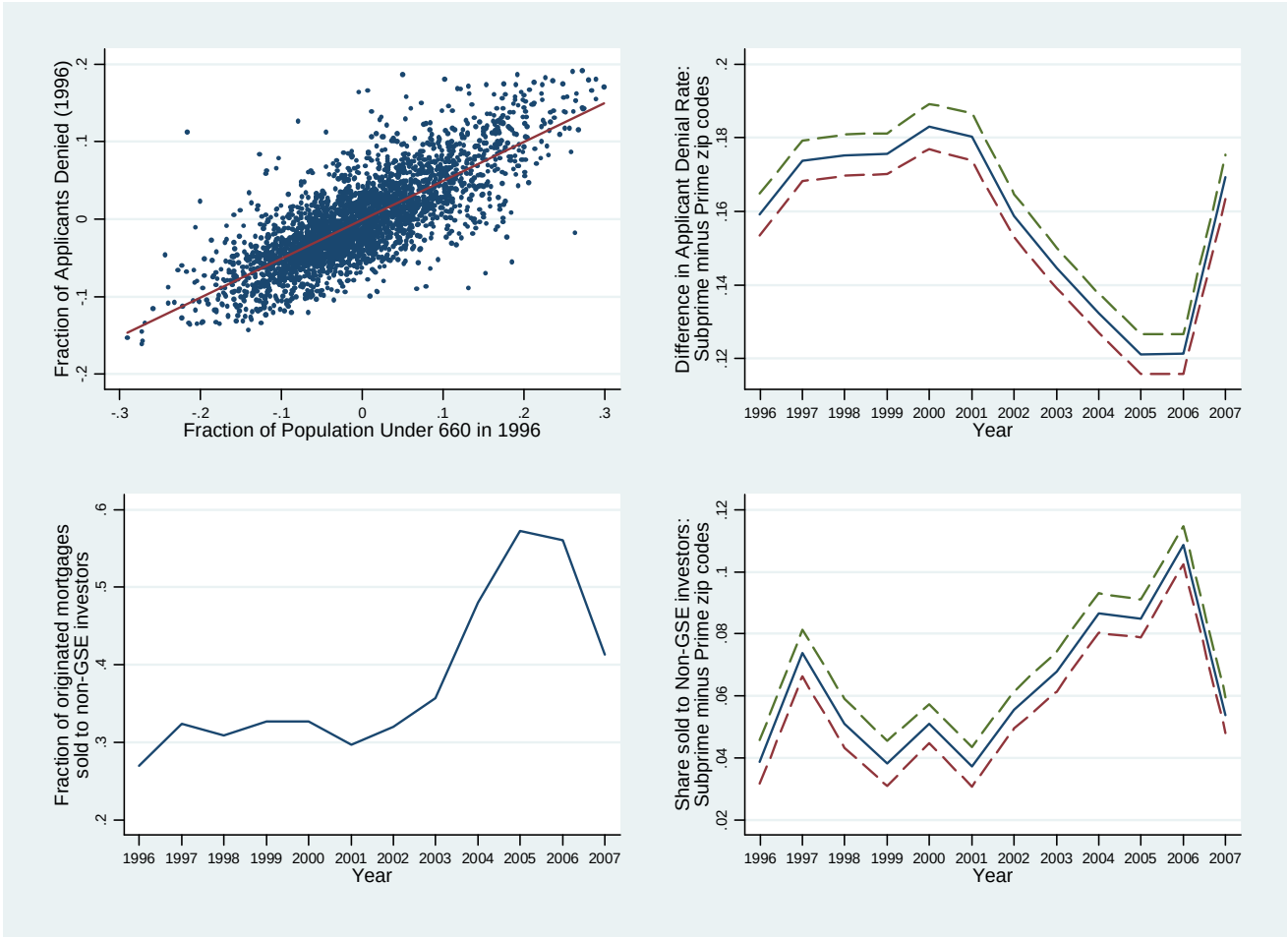

Figure V
Relaxation in Borrower Credit Constraints

The top left panel shows the correlation across zip codes between the mortgage application denial rate and the fraction of residents with a credit score below 660, both as of 1996. The data are deviated from county means. The top right panel shows the denial rate for mortgage applications for prime relative to subprime zip codes in the same county. The bottom left panel shows the fraction of all originated mortgages for home purchase that are sold to non-GSE investors, and the bottom right panel shows the relative fraction sold to non-GSE investors for subprime versus prime zip codes in the same county. Subprime and prime zip codes are defined to be the highest and lowest quartile zip codes based on the fraction of residents with a credit score below 660 as of 1996.

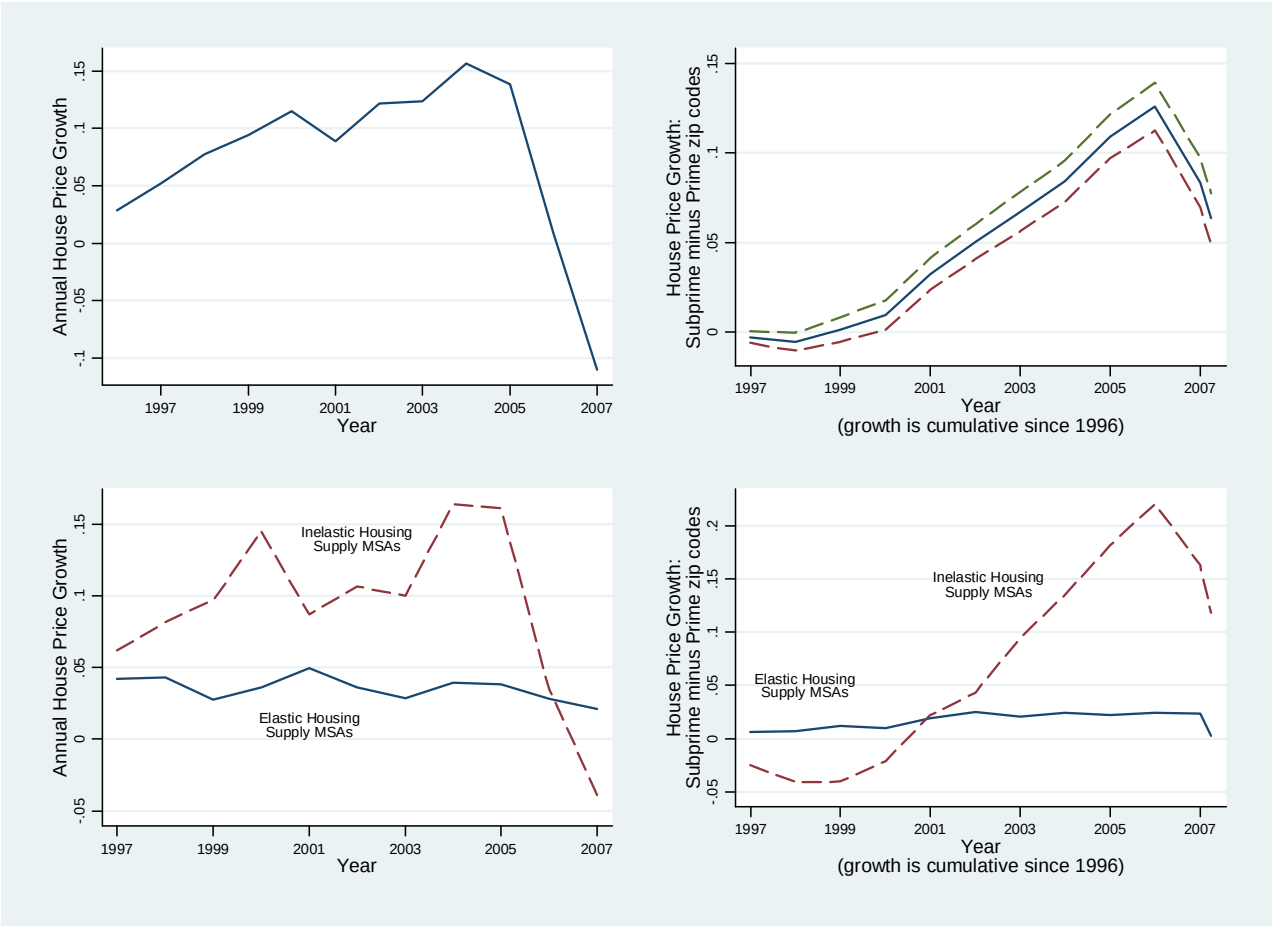

Figure VI
House Price Growth

The top left panel shows average annual house price growth across zip codes. The top right panel shows relative house price growth for subprime versus prime zip codes in the same county. The bottom left panel shows average annual house price growth for the top decile and bottom decile housing supply elasticity MSAs based on the elasticity measures of Saiz (2008). The bottom right panel shows relative house price growth for subprime versus prime zip codes in the same MSA for elastic and inelastic MSAs. Subprime and prime zip codes are defined to be the highest and lowest quartile zip codes based on the fraction of residents with a credit score below 660 as of 1996.

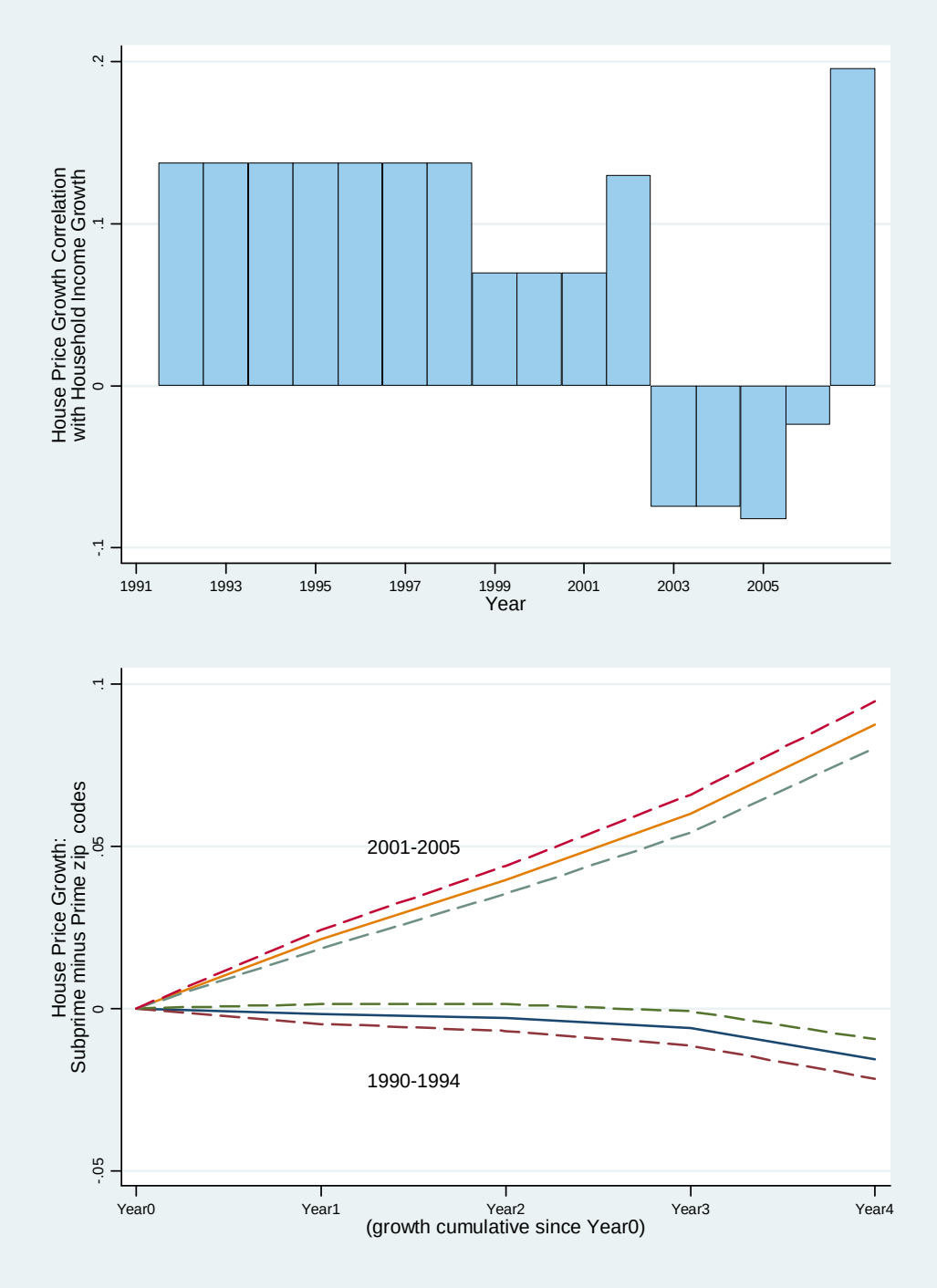

Figure VII
House Price Growth: Historical Evidence

The top panel in this figure plots the correlation across zip codes between income growth and house price growth over time, after deviating from county means. The bottom panel shows house price growth for subprime relative to prime zip codes in the same county during the 5 year periods from 1990 to 1994 and 2001 to 2005. Subprime and prime zip codes are defined to be the highest and lowest quartile zip codes based on the fraction of residents with a credit score below 660 as of the first year of the respective 5 year period.