This *preliminary and incomplete* draft is for the Norges Bank's Workshop on Housing and Household Finance.

Assessing the Contribution of Household Leverage to Systemic Risk in the U.S.

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Broad Outline of the Paper

I. Introduction/Motivation

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II. A Perspective on "Dangerous Leverage" Informed by the Mortgage/Housing Boom of the 2000s

➔ *What's the overall perspective our approach to monitoring takes?*
➔ *What kind of data do we need to implement this approach?*

III. Assessing Potential Systemic Vulnerabilities from a Range of Household Credit Market Activity

➔ *What do the potential contributions to systemic vulnerability from the household sector currently look like?*

IV. How to Summarize the Signals from a Range of Household Leverage Indicators

➔ *Is there a convenient way to summarize the signals coming from this wide range of indicators?*
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V. Current Gaps in this Measurement Framework and Future Enhancements

➔ *What can't we currently measure/see/do that materially limits the confidence I have in this monitoring system?*

I. Introduction and Motivation

The economic damage caused by the Financial Crisis and Great Recession has demonstrated the importance of monitoring vulnerabilities in the financial system for banking supervisors and monetary and macroprudential authorities around the world. Mitigating risks to financial stability through macroprudential tools or other policy actions requires assessing systemic vulnerabilities or threats comprehensively and in "real time."

The general monitoring framework envisioned by Adrian, Covitz, and Liang (2015) recognizes that systemic vulnerabilities can take many forms and derive from (or be associated with) a wide range of financial activities. Their broad perspective requires monitoring and assessing leverage in the nonfinancial business and household sectors. They also emphasize the importance of gauging the overall stance of investor risk appetite and its effects on valuation pressures for major asset classes. In addition, they stress carefully assessing the extent and nature of maturity transformation in the financial system and comprehensively tracking leverage and the potential for contagion among systemically important financial firms and other actors. Aikman, et al (2017) develop a specific "quantitative surveillance" approach for the U.S. financial system that, essentially, represents a thorough application of the core ideas and general framework laid out by Adrian, Covitz, and Liang.

In this paper, I will provide a more-detailed perspective on monitoring and assessing potential vulnerabilities in the U.S. financial system specifically associated with leverage and credit risk among American households.[1] The rapid expansion of mortgage credit to households in the 2000s was elemental in the broader build-up of systemic risk that produced the Financial Crisis. And the devastating extent of the Crisis and Great Recession were a direct consequence of the extreme amplification and contagion mechanisms that had built up across the U.S. financial system—highly elevated leverage among large, under-capitalized and highly interconnected firms heavily reliant on short-term funding that was rapidly withdrawn when risks became acute and panic ensued. However, it seems likely that those adverse developments in the U.S. financial system required a substantial volume

[1] This paper reflects my own current thinking rather than any kind of consensus among my colleagues at the Federal Reserve Board.

of primary credit, and residential mortgage debt in the 2000s was, in some sense, the "tinder" upon which amplification mechanisms built throughout the financial system.

I will note from the outset that my perspective on household leverage and its potential to contribute to systemic vulnerabilities shares much in common with that described by Amir Sufi (2014). Thus, one could view the approach I develop below as a particular application of that common perspective, although my approach seems to cover a broader range of credit market activities and indicators than he emphasizes in that paper.

➔ **Need to add a more-detailed discussion of Sufi's perspective, here.**

II. A Perspective on "Dangerous Leverage" Informed by the Mortgage/Housing Boom of the 2000s

As noted, my goal is to provide a perspective and a number of concrete ideas for monitoring and assessing potential contributions to financial system vulnerabilities that could stem from "dangerous" leverage in the household sector.[2] What kinds of leverage, or debt, is likely to prove systemically dangerous? First, exposures to household leverage at key nodes in the financial system—such as the largest or most interconnected financial firms—would need to be substantial. And second that leverage would have to turn out to perform, in the sense of ultimate credit losses, much more poorly than lenders or funding providers had contemplated, priced into loan terms, and provided loss-absorbing equity capital against. Of course, *ex ante*, it is going to be difficult to know with much confidence when imprudent lending and borrowing occurs in worrisome volumes, given limited available data. But analytic difficulties cannot be a reason not to try, and this paper is a concrete attempt to get started and make meaningful progress in the effort.

I think a minimal goal would be to develop a monitoring system at least capable of identifying *potential* sources of systemic risk to the U.S. financial system that might be expected to identify specific areas of activity pertaining to household borrowing and leverage that warrant additional, more "targeted" analysis or research. And, I would hope

[2] In the context of bank capital regulation or the financial analysis of firms, "leverage" is used to refer specifically to balance sheet measures like assets-to-equity or debt-to-equity. In this paper, however, I use the word "leverage" very broadly to cover credit market activities that could result in losses or charge-offs to lenders or investors that put their capital, equity, net worth, or solvency at risk.

that such an approach to monitoring for sources of systemic vulnerabilities, would prove capable of providing sufficient information or signals to convince authorities to deploy macroprudential policy instruments to mitigate unwelcome build-ups of systemic risk.

Where would dangerous household leverage come from?

➔ **Mention a key lesson from the 2000s: For many financial activities, reliance on "market discipline" is overated. Prudent lending and borrowing by highly engaged, forward-looking firms and households with reasonable expectations cannot be assumed, even when the stakes (for borrowers, other market participants, and financial firms) are high. Charles Goodhart's recent Bank Underground post (April 2017) might be helpful.**

In general, I can think of potential systemic risk associated with dangerous household leverage as arising through any of three channels:

➔ **[[[See SG's comments about how some of this discussion could be more clear.]]]**

1. Competitive pressures could lead loan originators and other financial institutions to expand the availability of credit to households at a pace or in forms that might outstrip borrowers' ability to repay those loans.
    a. For example, certain loan originators or other key players at the beginning of the credit supply chain might be earning attractive profits through aggressive credit extension that are only realized to be unprofitable after borrowers fall behind on payments that are proven unaffordable after a period of time.
    b. It is not difficult for me to imagine financial firms feeling considerable pressure to engage in activities seen as profitable for competitors, even if those activities lie beyond a firm's particular experience or expertise.
    c. *Market discipline could prove insufficient to curb overly aggressive credit supply.* **[[[→ Specific citations would be helpful, here. Maybe work in a reference to the credit rating agencies, etc?]]]**
2. Growing optimism about their future prospects or economic conditions could accelerate the demand for credit beyond what borrowers could actually repay, should their expectations turn out to have been overoptimistic.

   a. Judging one's wherewithal to take on debt requires a *forecast* of future economic and financial circumstances, and people are prone to cycles of overoptimism ("animal spirits") and pessimism. **[[[→ Specific citations would be helpful, here.]]]**
   b. Moreover, to the extent that people use information about the economic and financial experiences of family members, friends, and coworkers to form expectations, it is not difficult for me to imagine how cycles of household optimism take hold and accelerate.
3. Highly adverse and unusual economic conditions or other circumstances could result in a drop in borrowers' ability to repay debt, even if those loans appeared to be originated under supply and demand conditions that seemed prudent at the time.
   a. That is, credit market activities could be conditioned on historical tendencies that turn out to understate the severity of realized economic or financial outcomes.
   b. And, naturally, high leverage among households leaves them highly financial vulnerable to adverse developments, including drops in asset values (housing, in particular) or surging interest rates (for variable-rate debt).

Therefore, I view a potentially effective monitoring system as needing to track a wide range of indicators of *credit supply*, an array of indicators of households' *demand for credit*, indicators of credit performance, and measures of balance sheet leverage. The underlying data need to cover as much activity as possible *across the U.S. economy,* be available in *real time*, and permit a more *granular than merely aggregate* analysis of behavior and evolving trends.

- ➔ **Consider working in a bit of the discussion the paper Matt Eichner, Don Kohn, and I wrote, "Financial Statistics for the United States and the Crisis: What Did They Miss, What Did They Get Right, and How Should They Change?" (2015).**
- ➔ **Should work in something from Jonathan Parker's (2014) LEADS ideas in here, too.**

III. Assessing Potential Systemic Vulnerabilities from a Range of Household Credit Market Activity

The most straightforward way for me to flesh out my perspective on the potential contributions to systemic risk from household leverage is to through some data and emphasize key points along the way.

Taking (some) advantage of the micro-data in the Equifax credit records

Figure 1 plots total loan balances for households based on information in credit records from the Federal Reserve Bank of New York's CCP/Equifax database (see Lee and van der Klaauw (2010) for more information).[3] Data for a [few million households] (without any remaining personally identifiable information) are available quarterly beginning in 1999, and the full dataset is updated only about 7 weeks after the end of each quarter. Importantly, from my point of view, the underlying micro-data allow balances to be shown for households with credit scores above 720 (labeled "Prime" in the figure) and for those with scores between 620 and 720 ("Near Prime") and below 620 ("Subprime"). The Equifax data permit separate monitoring for several different categories of debt, as I will show and discuss in a minute. All three lines show sizable run-ups in debt owed by households in the different credit score ranges, with borrowing by prime and near-prime households rising steeply from the early 2000s and borrowing by subprime households ramping up a little later.[4] However, the entire increase in aggregate debt since 2013 has accrued to households in the highest credit score range, as the total amount of debt owed by households with near-prime and subprime scores has been completely flat, on net.

For monitoring and assessing the potential contribution of household leverage to systemic risk, I think it is quite important to separately track activity for different levels of underlying credit risk; historically, credit scores are constructed to be highly predictive for *average* default rates. **Figure 2** shows estimates of average (serious) delinquency rates in the Equifax data for four different categories of debt (auto loans, credit card balances, mortgages, and student loans) for households with different credit scores.[5] The figure shows

[3] In Figure 1, loan balances are presented in real terms.
[4] Figure 1 plots debt levels using *contemporaneous* credit scores, rather than lagged scores or proxies for scores when that debt was actually *originated*; that timing convention is more useful for considering *recent trends in the series* than assessing *pre-crisis* trends. That is, when loan defaults picked up around 2006 and 2007, many households transitioned into the subprime credit score range, presumably contributing to the "delayed" rise in debt owed by that group.
[5] To construct these rates of serious delinquency (loans 90 days or more past due), I lagged households' credit scores two years, so as to avoid "reverse causation," since falling behind on loan payments will lower a person's credit score.

that borrowers with credit scores above 720 virtually never fall seriously behind on their monthly debt payments, while those with scores below 620 exhibit relatively high delinquency rates for a types of credit.

To me, this strongly suggests that systemic risk monitoring should be focused on the high-credit risk segments of activity. While this might seem an obvious point, I would note that it is also central to Sufi's (2014) perspective. Sufi emphasizes the importance of tracking households whose borrowing tends to be highly elastic with respect to credit availability and that low credit scores are associated with such elasticity.

A second issue for timely assessment of household leverage is that outstanding loan balances, by definition, tend to be slow-moving and, at times, significantly lagging indicators of changing systemic exposures. A more reliable systemic monitoring system would also focus on recent loan *originations*, as those activities provide a better characterization of the current positions of credit demand and supply. Thus, **Figure 3** plots annual time series for a *proxy* of total *new extensions* of credit to households in the three credit score ranges.[6] The figure shows pretty clearly that large volumes of credit were being extended to households in all three credit score buckets from 2003 through 2006; volumes to prime-rated households peaked several years earlier that volumes to near-prime and subprime households. The figure also shows a gradual but fairly steady rise in lending to prime- and near-prime-rated households since 2012 (or so), while originations to subprime households stayed quite low even through the middle of this year.

Figure 4 presents outstanding balances and proxied loan originations for three major categories of household debt --- residential mortgages, credit card balances, and auto loans. The only thing I will mention is that subprime households were able to borrow in the form of auto loans at sizable volumes in recent years, even as access to or take up for mortgage credit and credit card balances has remained tight or light. That said, in recent quarters (the right-most bars), originations of auto loans to subprime borrowers have receded noticeably.

Taking better advantage of the panel aspect in the Equifax micro-data

[6] The Equifax data directly report loan *balances*, rather than *originations*. We proxy *originations* as the change in balances for households whose balances increased over the past year; Bhutta (2015) for a more detailed description and more complete analysis of mortgage market activity in the 2000s.

I wouldn't blame you for being underwhelmed at the novelty of the leverage-by-credit score tabulations in Figures 1, 3, and 4 --- they do not really seem like much of a step forward in systemic monitoring. The Equifax micro-data do allow us to take more nuanced looks at lending to and borrowing by households over time, and **Figure 5** does present a new perspective.

It seems reasonable to me to think of particularly "aggressive" lending to and borrowing by households as more likely to represent riskier or less prudent credit market activity. For example, can a lender really have very high confidence in a borrower's ability to repay debt for payments very much larger than the borrower has faced before? The panel aspect of the credit record data—that is, the ability to observe borrowing *over time at the household level*—allows a novel view on this type of activity.

In particular, Figure 5 plots the incidence of *aggressive lending/borrowing* activity among households in the three credit score ranges, where "aggressive" refers to household loan balances that have grown more than 75 percent over the prior year (subject to moderate dollar-value thresholds for each credit category). The incidence of aggressive lending/borrowing is plotted for the total across all loan categories and separately for mortgages, credit card balances, and auto loans. The top right panel shows evidence of aggressive mortgage borrowing/lending for prime (orange), near-prime (blue), and subprime (black) households over the entire period from the early- through the mid-2000s. Interestingly, for prime-rated households, aggressive mortgage borrowing is estimated to have dropped sharply in 2005 then trended down gradually through 2009. By contrast, by this definition, relatively aggressive mortgage lending to near- and subprime households appears to have continued through much of 2006 or 2007, after which both activities fell precipitously. Also, the credit record data show no material return to aggressive mortgage lending or borrowing for any of the three credit score categories since the Financial Crisis, notwithstanding a considerable recovery in other indicators of housing market activity (not shown), such as total mortgage volumes, home sales, and home prices.

I view these indicators of aggressive lending and borrowing as potentially quite valuable for assessing the contribution of household borrowing to vulnerabilities in the financial system.

More analysis of activity in the residential mortgage market

The overall importance of home mortgage debt in homeowners' balance sheets and its role as a direct funding source for sales of existing homes, an indirect supporter of new home construction, and the key role it played in the financial crisis argues for paying particularly close attention to mortgage lending and borrowing. **Figure 6** provides some additional perspective on the unusually aggressive mortgage lending and borrowing activity during the boom years of the mid-2000s, along with updated estimates of activity through the middle of this year.

The top left panel shows an aggregate index of mortgage credit availability released each month by the Mortgage Bankers Association (monthly since 2013).[7] This index in constructed to be a comprehensive measure of the *supply* of mortgage credit over time across a range of market segments. That is, the index aggregates information about *mortgage credit offers* to consumers, rather than about mortgage credit extended (which would, of course, implicitly include demand information). Taking its construction at face value, the MBA index suggests "ample" availability of mortgage credit in 2004 that expanded aggressively in 2005 and stayed astronomical through early 2007. After several years of stagnant, tight mortgage markets, credit conditions thawed over the course of 2014 and have inched up the past couple of years. Bottom line: The MBA index seems well worth including in a set of systemic risk indicators.

Indeed, although one might be tempted to rely on simpler measures (than the MBA's) of risk among new mortgage borrowers, I am wary of their utility. Consider, for example, time-series measures of household credit scores for newly originated mortgages (the top right panel in Figure 6). Credit scores at the median, the 10th percentile, and even the 1st percentile (in the Equifax credit record data) *did not rise* during the period of mortgage market exuberance in the early- and mid-2000s. Moreover, while these scores did rise after the onset of the financial crisis, they have not indicated a material expansion of credit supply since 2014, like the MBA index does.

Two things (at least) could be going on to "muddle" the signal coming from the distribution of credit scores for new mortgages. First, it is possible that changes over time

[7] Around the ninth or tenth day of each month, the Mortgage Bankers Association releases an estimate of its Mortgage Credit Availability Index for the prior month. These can be found in the "Newsroom" listing of MBA press releases at www.mba.org. Detailed information about the index is available at http://www.mba.org/MortgageCredit.

in the *demand for mortgage credit* are "contaminating" the signal for credit supply. However, given what volumes of mortgage borrowing for near- and subprime families were seen to be doing during the mortgage boom, that would not seem to be a key problem in those years. Second, credit scores are only one important indicator of underlying credit risk for mortgages, and the relative stability of the score distribution for newly originated mortgages was likely masking substantive increases along other key dimensions of risk—dimensions captures in the MBA index.

- ➔ **Mention that "agg mortgage risk indexes" produced by the Urban Institute and AEI also capture a broad range of risk attributes and share general time-series properties with the MBA index.**
- ➔ **Consider showing and discussing the mortgage frontiers developed and estimated by Anenberg et al (2017).**

The bottom two panels of Figure 6—both constructed with credit record data—are indicative of this point[8]. The left-hand panel plots a proxy for the share of newly originated mortgage debt extended to *investors* in residential real estate (as opposed to owner-occupiers)—a key component of the 2000s leverage and housing cycle analyzed by Haughwout et al (2011). That share was relatively low in the early 2000s, began to rise when in the middles stages of the housing market boom of 2003 and 2004, and shot up to astronomical levels with the acceleration in aggressive mortgage lending and home prices from 2005 to early 2007. As you know, lending to home "flippers" was lucrative while housing markets were early in their boom phase but became riskier and riskier over time, as required down payments, negative amortization, and other lending terms loosened and loosened and home prices reached unsustainable levels.

The bottom right panel plots the share of home mortgage borrowers who appear, from their credit records, to have taken out a junior lien, or "piggyback" loan, when obtaining new first-lien mortgage. The figure indicates that piggyback loans became a

[8] It is important to note that the Equifax credit records contain no information about the kinds of "nontraditional" mortgage loan *terms* that were associated with very aggressive lending in the mid-2000s. Mayer, Pence, and Sherlund (2009), for example, emphasize originations without full documentation of borrowers' income or assets, loans with very long amortization schedules, delayed amoritization ("interest-only" loans) or that allowed "negative amortization" for a period of time, loans that carried sizable prepayment penalties, or loans with "teaser" rates of interest early in the repayment term.

prevalent way for homebuyers to obtain very high leverage in a period of aggressive mortgage credit supply. The latest available data show no resurgence in these forms of aggressive mortgage lending through this year, even as sales and prices in most local housing markets continued to rebound.

Why rely on indirect measures of mortgage/housing leverage?

It would be reasonable to wonder why my previous discussion relied on *indirect* measures of leverage—why not focus directly on loan-to-value ratios (LTVs) for new mortgage borrowers? I guess I see two problems with simply tracking LTVs. The first pertains to data availability. Credit records report mortgage debt owed by households comprehensively and large changes in mortgage balances can be associated with new home purchases or cash-out refinancings. But, credit records include no information about home values (they do include geographic information about households' residence), so no reliable estimates of new borrowers' LTVs.

The second problem with reliable LTV-tracking is a conceptual one emphasized by Sufi (2014) and demonstrated by the orange line in **Figure 7**. As you know, mortgage credit is a very important source of funding for home purchases and research has shown that the boom'/bust cycles in mortgage credit availability tends to significantly affect *prices* of housing transactions (see, for example, Mian and Sufi, 2011, or Favara and Imbs, 2015). Consequently, LTVs derived from *market values* based on transaction prices can send unreliable signals about borrowers' leverage and, thus, embedded credit risk.

During the housing and mortgage market boom of the early- and mid-2000s, economy-wide estimates of mortgage loan-to-value ratios based on transaction ("market") prices of homes were *gradually declining*—by more than 20 percent between 1999 and the end of 2005 (the orange line). Even though homeowners were taking on greater and greater volumes of mortgage debt over that period, transaction prices were rising fast enough to add equity to the overall household balance sheet (thus, the falling transaction-based LTV). When the transaction prices of homes plunged during the market bust the resulting LTV soared almost 70 percent (from an index value of about 78 in Figure 7 to about 132 in late 2011). Home values based on transaction prices, therefore, provide quite a warped view of the evolution of *actual* homeowner leverage during this pronounced boom/bust cycle.

The blue line in Figure 7 portrays a more plausible/reliable narrative. It shows steady homeowner LTVs in the early stages of the cycle (1999 to 2003, say), then a substantial increase in leverage from 2004 through 2006—to levels not seen, nationwide, [since the 1970s ????] (the historical data are not plotted, here). The blue line also shows *declining homeowner leverage*, year-after-year, from 2009 through the about the middle of 2016 (where it has since essentially stayed over the past year), reflecting the combination of very low aggregate net mortgage borrowing in those years and moderate but steady increases in estimated "fundamental" home values.

But, what are these *fundamental home values* embedded in the blue line in Figure 7? They are home values, aggregated across the nation as a whole, that would be predicted by an econometric model based on the usual, historical ("long run") relationship between prices of transacted owner-occupied homes and market rents. In other words, as has been documented elsewhere, the U.S. housing market boom was characterized, in virtually every major market and across the country as a whole, by an historically unusual rate of price appreciation for transacted homes relative to increases in prevailing market rents for geographically proximate rental properties (see, for example, Davis et al, 2008, or Campbell et al, 2009).

The blue line at the top of Figure 7, then, is an estimated LTV using homeowners' aggregate outstanding mortgage balances in the numerator and *fundamental* values of their owned homes derived from prevailing market rents and usual (acyclical) econometric relationships. While, of course, the econometric model could prove to be unreliable, this novel approach to leverage about the most important component of households' balance sheet positions seems much more likely to yield useful inference for assessing systemic risk from residential mortgages than the transaction-price-based approach.

On the geographic distribution of mortgage debt growth in the boom and recently

As is probably quite clear by now, the key challenges to reliably monitoring and assessing the potential contribution of household leverage to systemic vulnerability stem from incomplete data; for example, households' credit records contain no information about employment, income, or household financial assets. Consequently, much of the literature has drawn inference from variation in mortgage and housing market outcomes across geographically disparate markets, where levels and changes in income, employment, and

asset values are known to differ materially (for example, Mian and Sufi, 2009 and 2011). → **This paragraph needs a lot of work.**

The left panel of Figure 8 presents scatterplots of household debt growth (from the Equifax data) and wage growth (from the Bureau of Labor Statistics's Quarterly Census of Employment and Wages for the largest 100 counties in the United States. Each observation is the [average rate of change] of these series in a county for one of three time periods—"baseline", 1999:Q1-2001:Q1 (blue); "mortgage/housing boom," 2004:Q4-2006:Q4 (orange); and "recent/housing recovery", 2014:Q3-2016:Q4 (gray). The orange scatter shows almost no geographic correlation between debt growth and wage growth during the mortgage and housing market boom period—variation in debt growth across large counties (the y-axis) was huge relative to variation in wage growth, and there is no apparent difference in the distribution of wage growth for counties with slow versus high debt growth[9]. This pattern is quite consistent with the findings emphasized by Mian and Sufi (2009) in their thorough analysis.

Data for the recent period (the gray dots) also show very little correlation between local growth of debt and wages, but the scatterplot is much tighter than in the boom period: In recent years, none of the 100 largest counties in the country have experienced very large debt growth, even though the distribution of wage growth across counties lies slightly to the right (higher growth) in recent years than during the mortgage/housing boom period.

The panel to the right looks at the geographic correlation between debt growth and changes in house prices for the same three time periods. Here, the orange dots—representing the mortgage/housing boom period of the mid-2000s—show a positive correlation, as counties with slower growth of house prices experienced slower (though still fairly rapid) of household debt and as those with the fastest growth of debt tended to also experience the faster home price appreciation. Still, the orange dots are scattered widely in the plot, so the positive correlation is not very strong. Since 2014—as housing markets across the country were generally rebounding at a solid pace and home prices were rising noticeably in most places—there has been no correlation to speak of between home price appreciation and household debt growth: The gray dots are scattered across a fairly wide

[9] In these 100 counties, mortgage credit is the overwhelming source of growth in total household debt that is plotted (on a per capita basis) in Figure 8.

range along the x-axis (home price appreciation) but spread only across a narrow range along the y-axis (debt growth), and, on average, household debt has contracted (in per capita terms) in about 90 of 100 largest counties in the country. This strongly suggests that mortgage credit has *not* been fueling the somewhat surprising pace of home price appreciation evident in many local markets since 2014.

Alternative indicators of borrowers' ability or difficulty in making their mortgage payments

Naturally, an assessment of potentially systemic credit risk would benefit from reliable, *early* indications of borrowers facing difficulty making their loan payments. The Equifax/CCP include "payment status" for every type of credit in borrowers' records. However, Figure 9 plots several delinquency rates for mortgage borrowers with different credit risk attributes and shows their information content is not as timely as one would prefer. The top left panel plots delinquency rates (30 or more days past due or severe derogatory) on existing mortgage balances for prime, near-prime, and subprime borrowers. The numerator of this rate is the total amount of balances in a delinquent state for each credit score group, while the denominator is simply the overall amount of the group's mortgage balances. This "stock" measure of delinquency is bound to be a slow-moving or "lagging" indicator, although it did eventually accurately portray the substantial difficulties near-prime and subprime borrowers faced after the home prices collapsed.

The other three panels of Figure 9 are attempts to identify much earlier warning signs. The upper right panel plots the rates at which mortgages of different types *transition* from "current" payment status to "30 days past due," on the logic that an increase in such transitions would portend a rising wave of loan defaults. However, the blue line in that figure was surprisingly flat through the end of 2006, although that transition rate did virtually double over the course of 2007. It is also noteworthy that this transition rate for mortgage delinquencies had returned to a normal, low level by 2011, even as the stock of outstanding delinquencies (top left) continued to be at an historically highly elevated level through the middle of this year.

The lower two panels provide two other potential "early warning" indicators based on mortgage borrowers' delinquency status—so-called "early payment" delinquencies. These are the fraction of loans used to purchase owner-occupied properties that became delinquent *within 12 months of origination*, which would seem to be a plausible measure of

the imprudence embedded in recent credit underwriting practices. After all, 12 months would be a relatively short period of time for a family's financial circumstances to deteriorate from "credit-worthy" so considerably. Indeed, the black and blue lines in the left-hand panel show that early payment delinquencies *fell during the Great Recession* (2009 and 2010)—even as unemployment climbed across the country and households experienced considerable financial distress. This is indicative of a material tightening in mortgage underwriting that quickly took hold around the onset of the financial crisis.

Looking at the pre-crisis data, the fact that the early payment delinquency rate (EPD) peaked about 2 years before the delinquency rate on outstanding mortgage balances is a useful sign. But, unfortunately, the warning signal from this particular EPD indicator would probably have been too muted to garner sufficient concern that the mortgage boom was about to bust. The black line in the left shows a rise in the early payment delinquency rate in 2006, but the rate probably did not reach an eye-popping level until later in 2007. Of course, that timing is not very different than what Mayer, Pence, and Sherlund (2009)—whom I would credit with the idea of focusing on EPD—showed (Figure 2 on page 41 of their paper).

Tracking balance sheet leverage using county-level data

As mentioned, ideally, we would have access to timely (comprehensive) information about borrowers' income and assets as well as their debt obligations, but such data are not currently available (to me, anyway). Crude proxies can be constructed, however, by aggregating household debt outstanding in the Equifax/CCP up to the county level, then tracking its ratio to county-level wages available (quarterly, with a moderate time lag) in the Quarterly Census of Employment and Wages (QCEW) produced by the Bureau of Labor Statistics.

The top left panel of Figure 10 shows how household debt-wage income (DTI) has evolved since 1999 for counties near the bottom of the distribution of DTI (blue), at the median of DTI (orange), and near the high end of DTI (black).[10] The figure shows a

[10] In the finance industry, the abbreviation "DTI" (for "debt-to-income") is used in reference to the ratio of a family's *monthly required debt payments* to its (gross) income; I am using the term more literally to refer to the ratio of a family's *outstanding debt balances* to its (gross) wage income. So, in Figure 10, in the first quarter of 2017, the median county in our dataset had outstanding mortgage and consumer loan balances amounting to 1.5 times its wage income.

substantial rise in household indebtedness through the mid-2000s in counties that were already most indebted at the onset—the black line rose from just over 2.0 in 1999 to nearly 4.0 ten years later. These counties' DTIs have subsequently moved back down to about 2.8 by early this year, close to the level last seen in 2003. The evolution of DTIs over the past 20 years was similar, but slightly more moderate, for counties near the median level of indebtedness (orange), while counties with relatively low levels of household debt experienced a much shallower credit cycle.

The right-hand panel of Figure 10 presents a different tabulation of the county-level data. In particular, it shows the evolution of DTIs for counties in different parts of the U.S. *wage distribution*—low-wage counties are in black, median-wage counties in orange, and high-wage counties in blue. While all three lines rose to a similar extent during the mortgage/housing boom phase (through the mid-2000s), the "deleveraging" phase has brought about a somewhat larger decrease in DTIs for counties in the middle (orange) and upper end (blue) of the national wage distribution. Indeed, in the first quarter of 2017, DTIs in low-wage counties were still as high as they had reached in late 2007, suggesting considerable remaining financial fragility in these places.

Two more indicators—one for credit demand, another for credit supply

Figure 11 presents two final sets of indicators of household leverage conditions—indicators of the demand for credit for households with different credit scores are plotted to the left, while a specific set of indicators of the supply of credit is shown to the right. The credit demand indicator is the volume of new applications for credit that appear in the Equifax/CCP credit records (plotted on a per capita basis).[11] While this seems like a plausible indicator to monitor, it is by no means likely to be a "pure" measure of credit *demand*. Rather, households are almost surely more likely to apply for credit if they suspect—perhaps, based on the experiences of their family, friends, coworkers, or other sources—their application to be more likely to be accepted. The left-hand panel of Figure 11 shows that for households with near-prime (blue) and subprime (black) credit scores, credit application rates fluctuated in a fairly narrow, high range from 2000 through 2007, then plunged with the onset of the Financial Crisis and Great Recession in 2008 and 2009. For

[11] Applications are proxied a credit *inquiry* having been recorded in a household's credit history.

both sets of households, credit application rates again fluctuated in a fairly narrow range from 2010 through mid-2017—suggesting tepid demand for credit, on the whole.

As an indicator of credit supply, the right-hand panel plots a "success rate" for recent credit applications, measured as the fraction of households whose credit records shows a new account having opened in the past year among those households whose records showed at least one credit inquiry during that timeframe. Interpreting this indicator is a little tricky because the Equifax/CCP data do not identify what *type* of credit a household has applied for (inquired about), although we can observe what types of new credit accounts were actually opened. That said, some cyclicality is evident in this indicator of credit supply—particularly for borrowers with subprime credit scores (the black line) and near-prime scores (blue). Interestingly, unlike most of the indicators I have presented, the success rate on credit applications for subprime and near-prime households has *fully recovered* in recent years following the sharp contraction that occurred around the onset of the Financial Crisis and during the Great Recession. The credit panel data indicate that, in recent years, subprime and near-prime borrowers have seen their credit inquiries translate into new auto loans and credit card accounts at high rates. These patterns are broadly consistent with the substantial rise in the indicator of "aggressive" auto and credit card lending/borrowing for subprime and near-prime households seen in Figure 5 (bottom two panels) that would be indicative of a material easing in the supply of these types of credit.

IV. How to Summarize the Signals from a Range of Household Leverage Indicators

Having developed a reasonably broad set of indicators to illuminate many particular aspects of credit market activity associated with household leverage that could contribute importantly to systemic risk, it seems reasonable to consider how to aggregate or summarize the signals from that information set. I borrow the concept of a "ribbon heatmap" that my coauthors and I developed for a much broader analysis of systemic risk for the U.S. financial system (Aikman et al, 2017).

My construct for this analysis of household leverage is depicted in Figure 12. It uses information from ten of the indicators previously discussed, which are described at the bottom of the figure and have been aggregated to form an overall index that is plotted as

the top row of the color-coded "ribbon." The aggregate index is the simple average of values for the ten indicators listed in the other color-coded rows of the figure.[12] As can be seen beneath the "heatmap," each of the ten indicators has been rescaled to take values between 0 and 1, and those values have been coded to a color wheel that runs from indigo (values near 0) to yellow (values near 0.5) to dark red (values near 1). The graphical representation permits a fairly efficient reporting for quite a large amount of data—quarterly readings from 2000:Q1 through 2017:Q2 of ten leverage indicators and an overall aggregate index. (More than 700 values are represented in the chart). Finally, values for the aggregate index and the ten indicators for the most recent quarter and one year earliers are reported in the two columns to the right of the heatmap.

Methods used to construct the heatmap

Two particularly important judgments were made to construct this chart. First, among all of the available information about varying aspects of household leverage and credit market activity discussed, which small set of indicators should be the focus of the heatmap? Second, how should each selected indicator be translated to the (0.1) interval for color-coding?

In the end, I selected 7 of the indicators discussed above that pertain to *mortgage* activity, leverage, and home values and 3 of the indicators from the set associated with *non-mortgage* credit. The relatively heavy focus on households' mortgage-related activity can be justified by its relative importance in the composition of overall household liabilities and its critical role in the run-up to the U.S. financial crisis. Indeed, it is probably fair to criticize my choice of indicators as possibly being over-influenced by credit market activities that played such a large role in the 2000s experience. I selected the indicator of housing overvaluation based on deviations from historical relationships between home prices and rents, county-level DTI at the 90th percentile of the distribution, the dollar volume of mortgage originations for subprime and near-prime households, the incidence of "rapid borrowing" among subprime and near-prime households, the estimated investor share of new mortgage extensions, and early payment delinquency rates for purchase and non-

[12] This average of the 10 indicators has been rescaled so that, for example, values exceeding 0.8 convey an "elevated" contribution of household leverage to systemic risk and values near 0.5 convey a "moderate" stance.

purchase mortgages. For non-mortgage credit, I selected the volume of new loan extensions to subprime and near-prime households, the incidence of rapid borrowing by subprime and near-prime households, and the apparent "success rate" for credit applications by subprime borrowers. You can see from the ten ribbons in the heatmap that these indicators are only moderately correlated with one another—particular in the pre-crisis period—which I think is a desirable feature of the set.

Developing a useful algorithm for translating the ten disparate series to the (0,1) interval for color-coding and interpretation also required more art than science. I first considered using percentiles from each indicator's available time-series distribution for the translation but quickly recognized a significant problem with such a "nonparametric" approach: The difficulty is that the available time-series are simply too short, and too much of the sample is associated with either the "boom" phase of the credit cycle (with presumably "notable" or "elevated" systemic risk) or its long "bust" phase. (That is, the available sample has far too few observations from what should be the fat middle of the distribution.)

Consequently, I decided to take a much more judgmental approach to the translation algorithm. For each indicator, I selected 6 threshold values corresponding to translated values of 0.0, 0.2, 0.4, 0.6, 0.8, and 1.0, so that values near those thresholds would be plotted as deep blue, royal blue, blue-green, green-yellow, light red, and dark red. These colors, in turn, could be associated with contributions to systemic risk that could be considered "extremely subdued," "low," "moderate," "notable," or "elevated." Then, for each indicator, I linearly interpolated between the threshold values to compute translated series. For example, if at time period *t,* indicator *k* was observed to take a value of 44 ($x_t^k = 44$) which fell between this indicator's third and fourth threshold values of 38 and 46, the translated value ($\tilde{x}_t^k$) would be calculated as follows:

$$\tilde{x}_t^k = 0.40 + 0.20 \cdot \left[\frac{44 - 38}{46 - 38}\right] = 0.40 + 0.15 = 0.55$$

and would appear as yellow in the heatmap, indicating a "moderate" contribution of this indicator at that time to the overall systemic risk index.[13]

[13] In this equation, 0.40 is the translated value associated with the 3rd threshold, and 0.20 is the distance between the translated values at the 3rd and 4th thresholds.

Results from the heatmap

As noted, the top ribbon of the heatmap plots quarterly values from 2000:Q1 through 2017:Q2 of the aggregate index covering the ten indicators of household leverage. From 2000 to 2004, this overall index is coded in various shades of orange and light red, indicating a trend of notable and building vulnerabilities from household leverage during that time. Early in this time period, the indicators of non-mortgage credit (the bottom three ribbons) were contributing the most to the notable level of the overall index, but as non-mortgage lending and borrowing was cooling off from 2002 through 2005, indicators of risky housing and mortgage activity were generally rising to elevated levels. And, by the third quarter of 2005, the range of indicators portrayed sufficiently aggressive mortgage lending and borrowing that the overall index had crossed the 0.80 threshold, suggesting an elevated contribution to systemic risk. However, aggressive activity in the mortgage market continued to pick up in subsequent quarters and the overall index reached its peak (darkest red) in the second half of 2007.

With the bust in housing markets around the country, as well as the onset of the Financial Crisis and Great Depression, lenders and borrowers abruptly disengaged from risky credit market activity, and several of the indicators plunged into blue territory. Thus, even as indicators for overall indebtedness of subprime and near-prime households (no. 2 in the list) and "fundamental" mortgage loan-to-home value ratios (no. 1) remained at highly elevated levels for several years, the aggregate index of systemic risk stayed in a low range from 2009 through 2013. The index ratcheted up in 2014 and early 2015, but has been close to 0.40—suggesting a low-to-moderate level of systemic risk—since the third quarter of 2015. Over the past year or so, the success rate for credit applications by subprime borrowers (no. 10) has been very high (above 0.90), but most of the other nine indicators have continued to signal low to moderate contributions to systemic risk.

V. Current Gaps in this Measurement Framework and Future Enhancements

To be added. . . .

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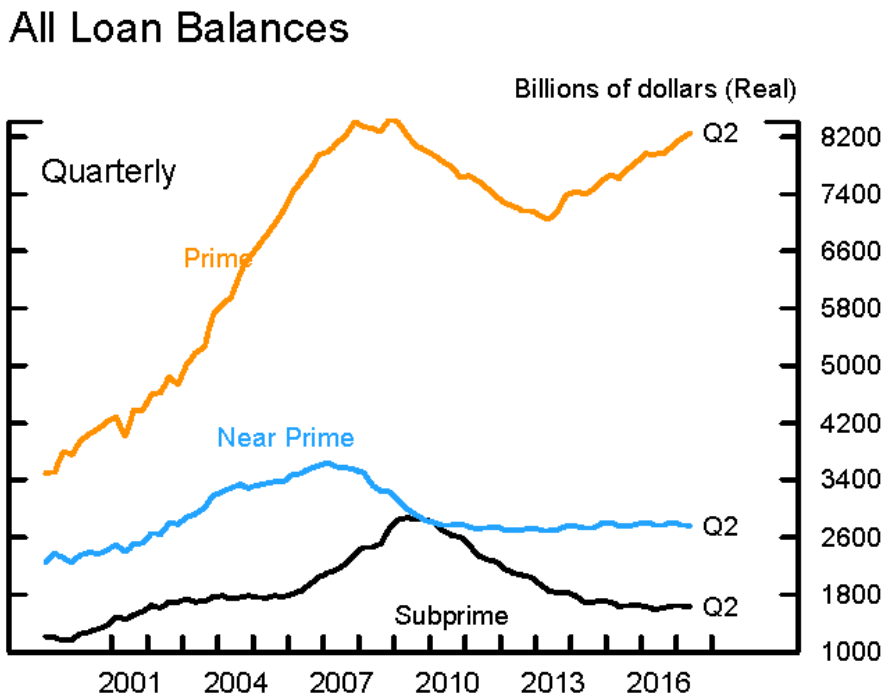
Figure 1. Debt Owed by American Households



Source: FRBNY CCP/Equifax
Note: Near prime between 620 and 719, prime greater than 719; scores measured contemporaneously.
Student loan balances prior to 2004 were estimated.

Figure 2. Rates of Serious Delinquency (90 Days+) for Major Household Loan Categories

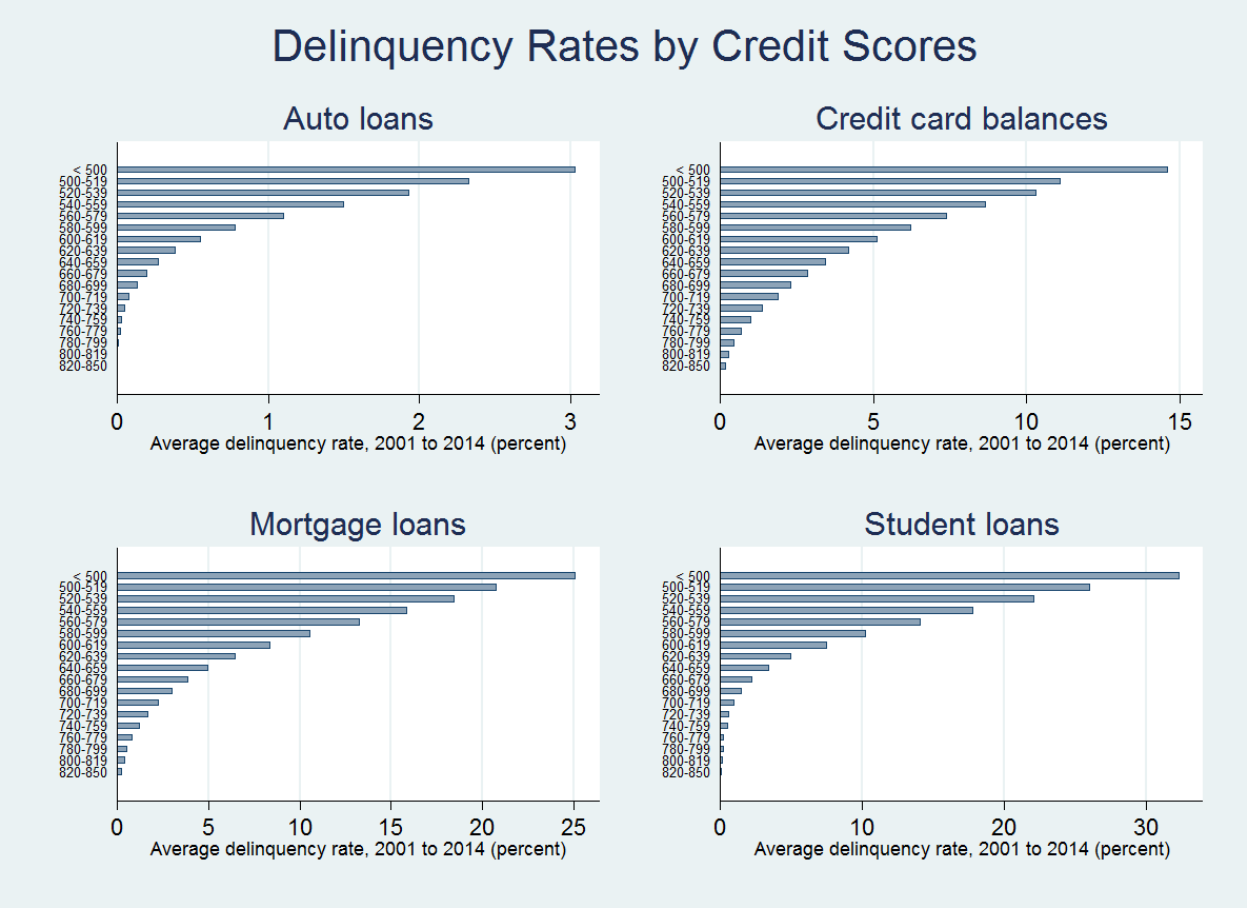


Figure 3. Proxy for Loans Originated to American Households (All Types of Loans)

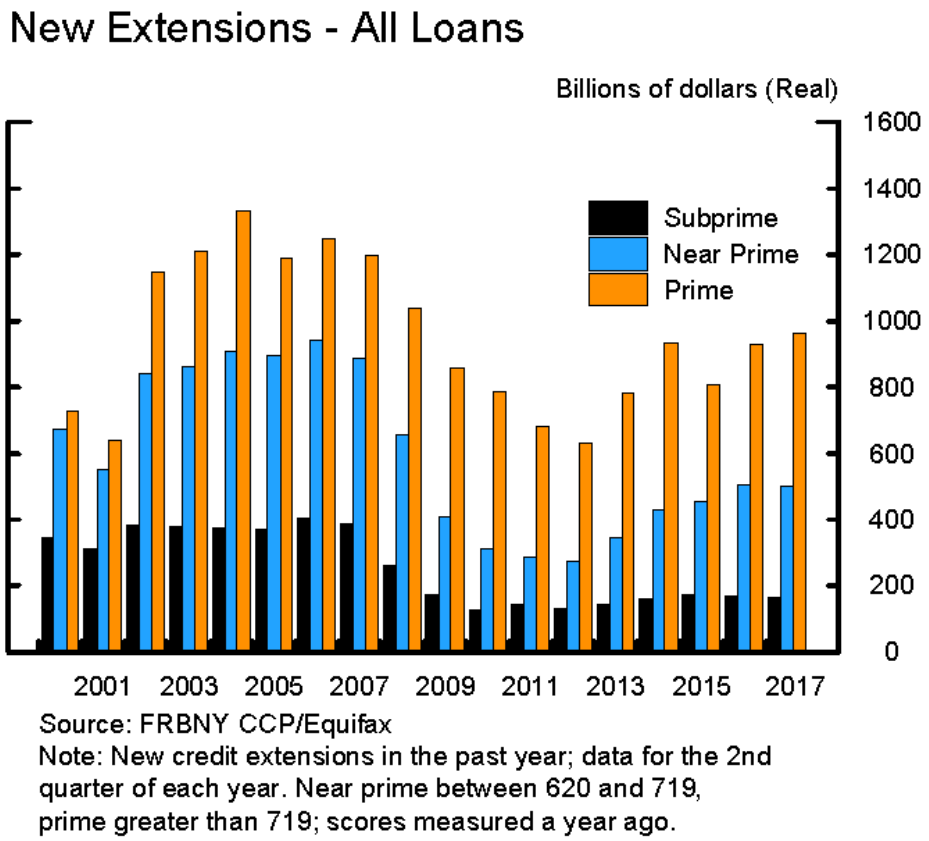
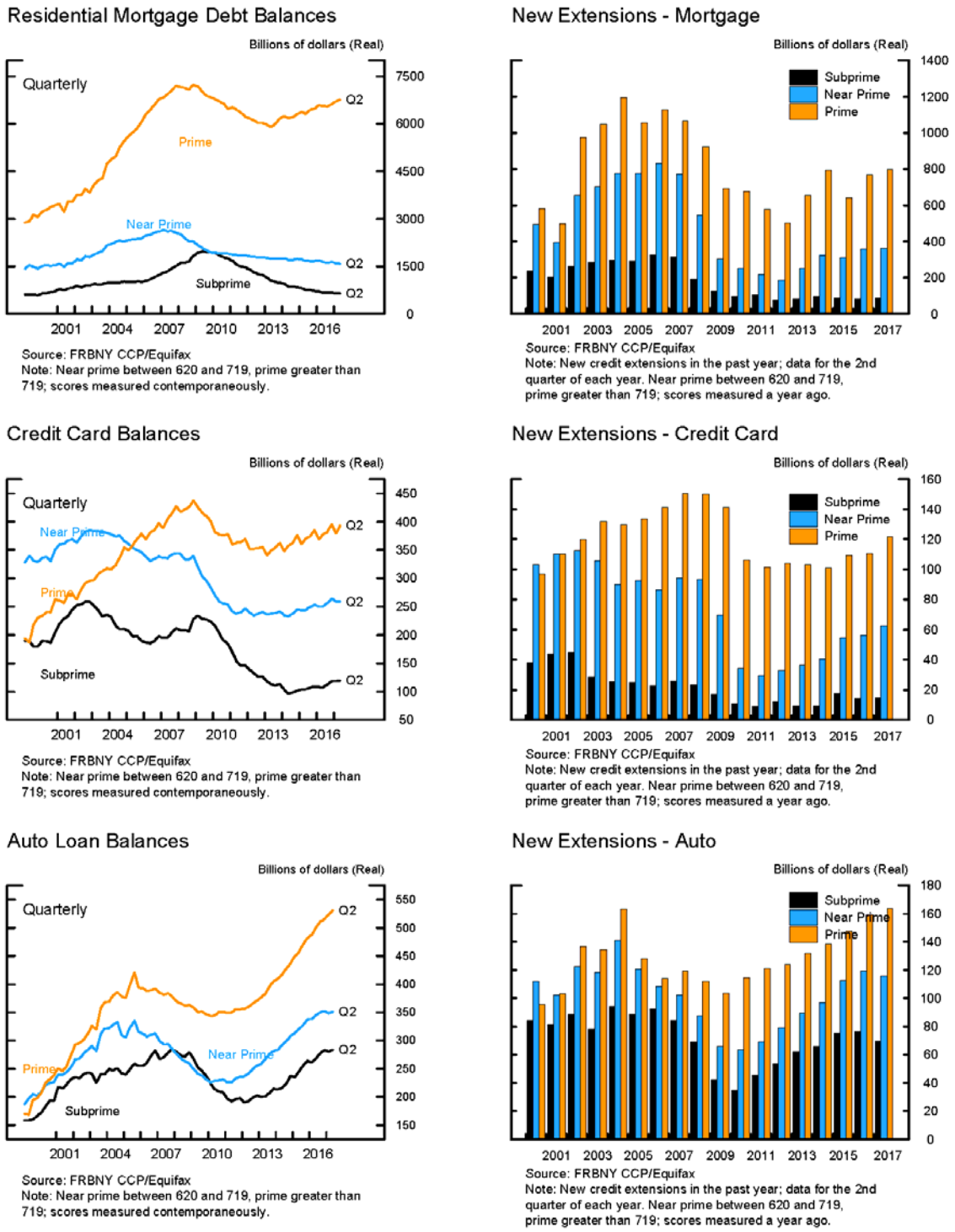


Figure 4. Outstanding Balances and Loan Originations for Major Categories of Household Debt



Note: New extensions measure the aggregate change in balances among individuals who increased their balance over the past year. For 'all loans', new extensions come from individuals who had an increase in their total debt balance, excluding student loans. For credit cards, new extensions come from individuals who increase their total card balance, regardless of whether their total available credit changed.

Figure 5. Indicators of "Aggressive" Lending/Borrowing for Major Categories of Household Debt

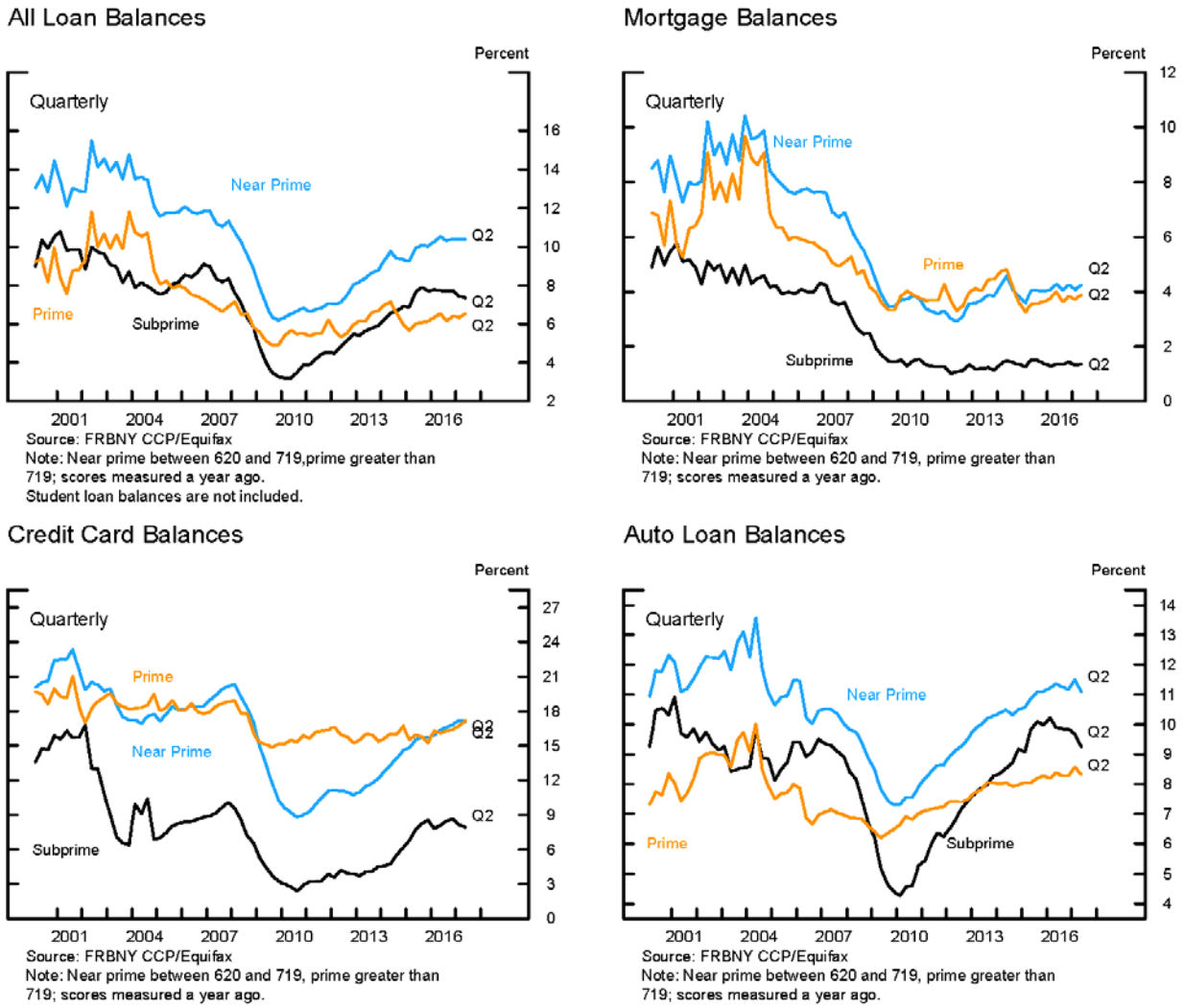


Figure 6. Indicators of "Aggressive" Mortgage Lending and Borrowing

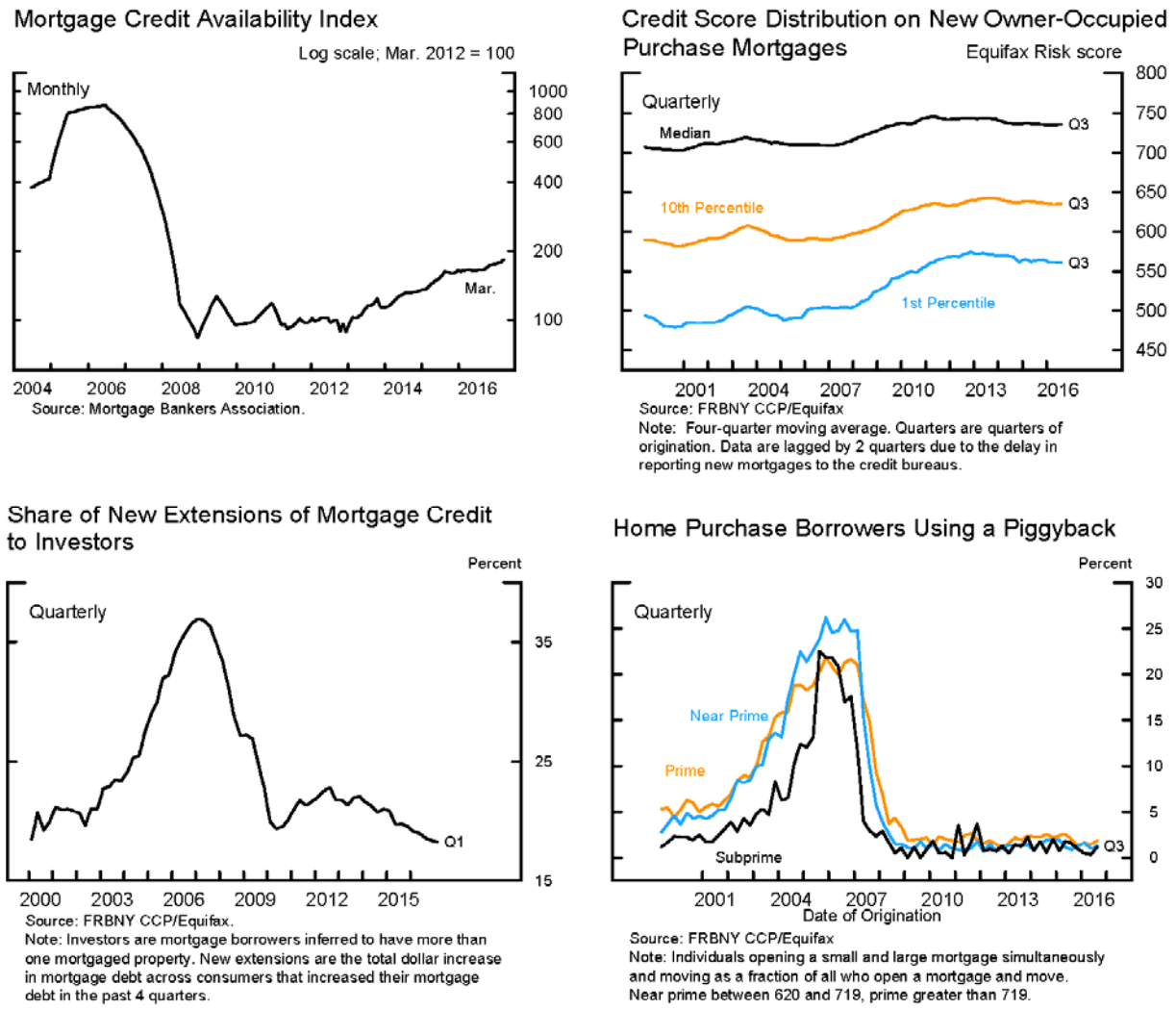
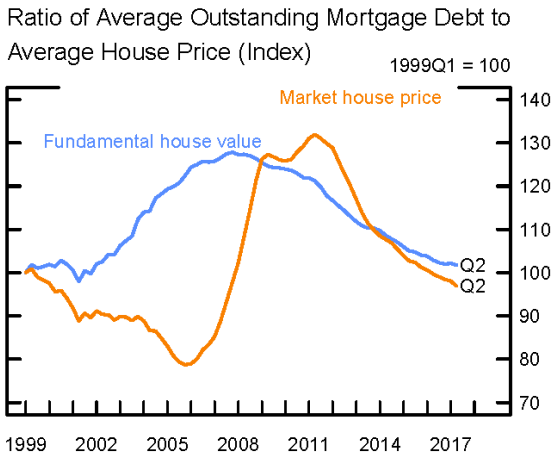
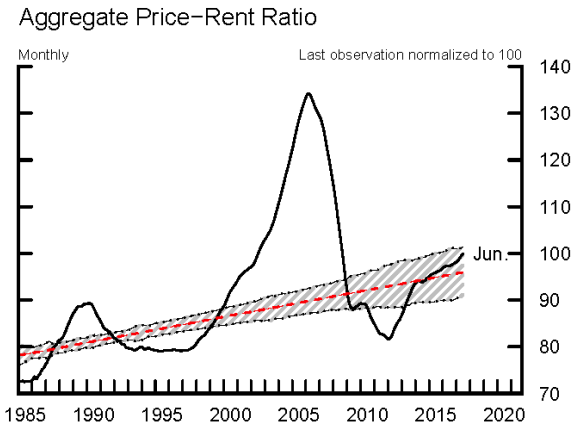


Figure 7. Alternative Measures of Homeowners' Mortgage Loan-to-Value Ratios and Ratio of Home Prices to Property Rents



Source: FRBNY CCP/Equifax, CoreLogic, and BLS.
Note: Through the cycle index corrects for housing overvaluation as predicted by an econometric model based on market rents and other factors.



Note: Chart shows the log of the price−rent ratio. Shaded area shows 95−percent confidence interval for the long−run trend, which is estimated using data from 1978−2001 and includes the effect of carrying costs on the expected price−rent ratio.
Source: For prices, CoreLogic. For rents, BLS.

Figure 8. Correlation between Mortgage Debt Growth and Growth of Wages and Home Prices in Major Local Markets

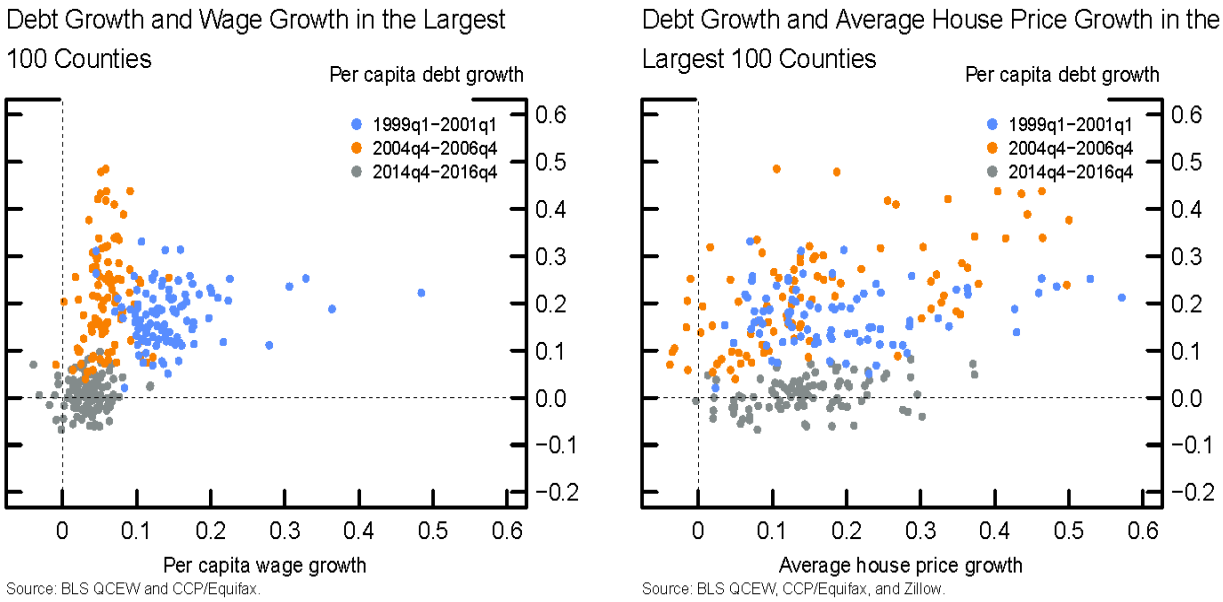


Figure 9. Indicators of Mortgage Borrowers' Difficulty in Making Payments

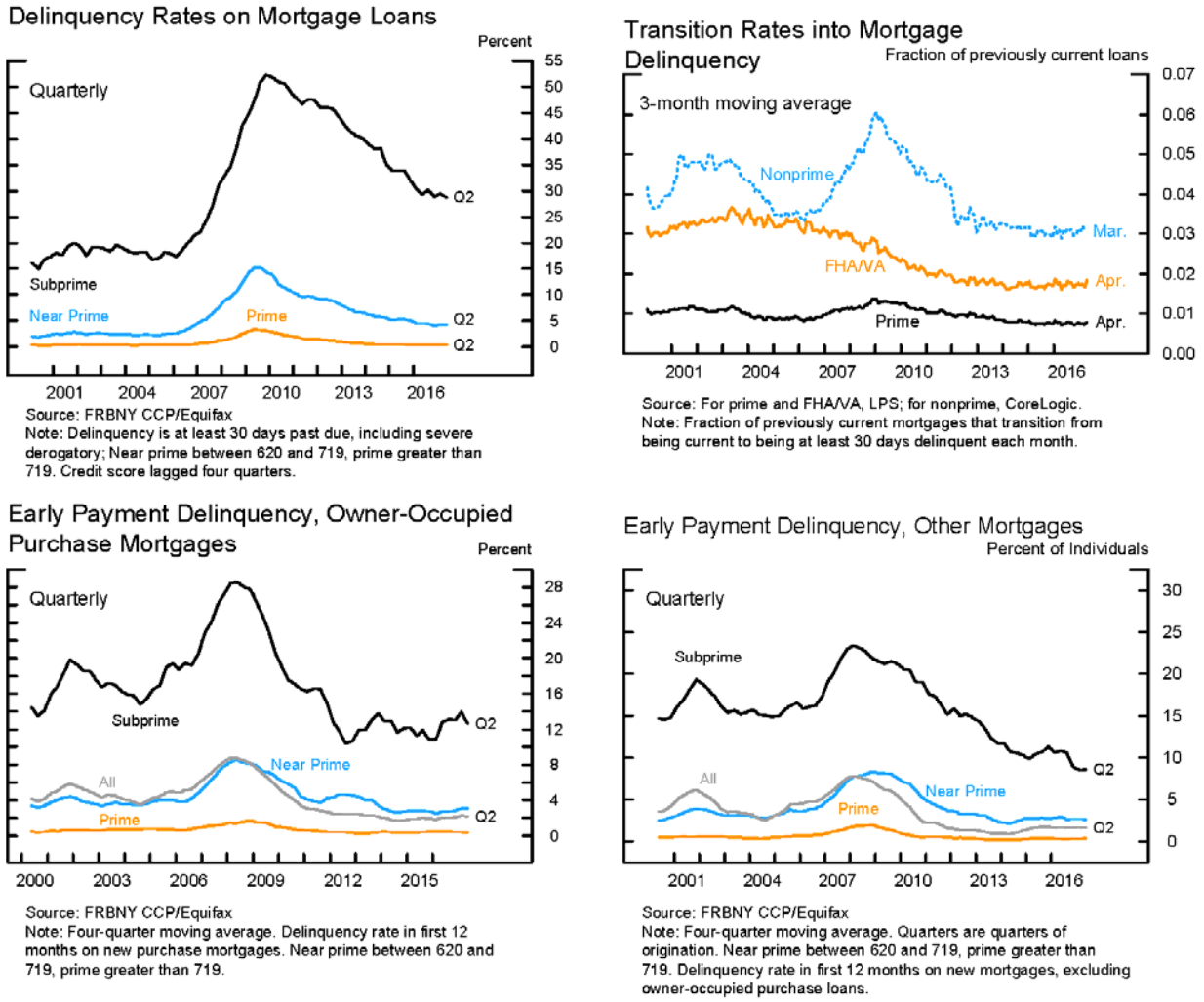
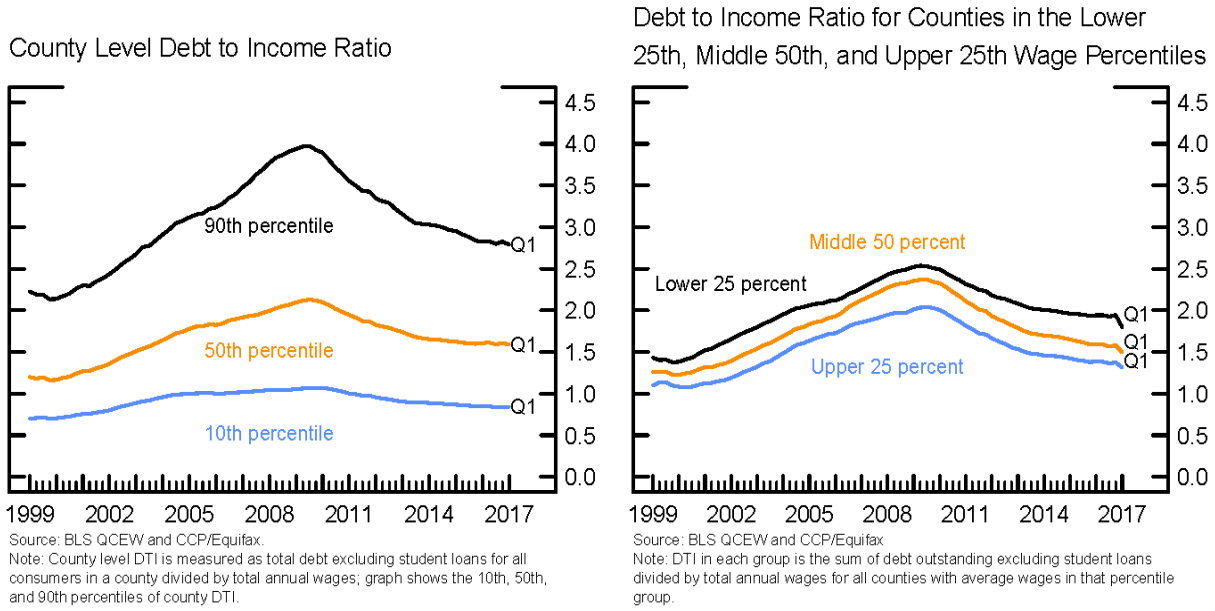


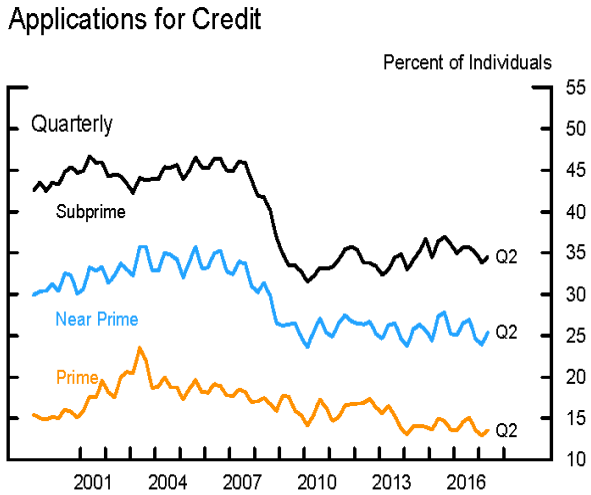
Figure 10. Debt in Relation to Household Income at the County Level



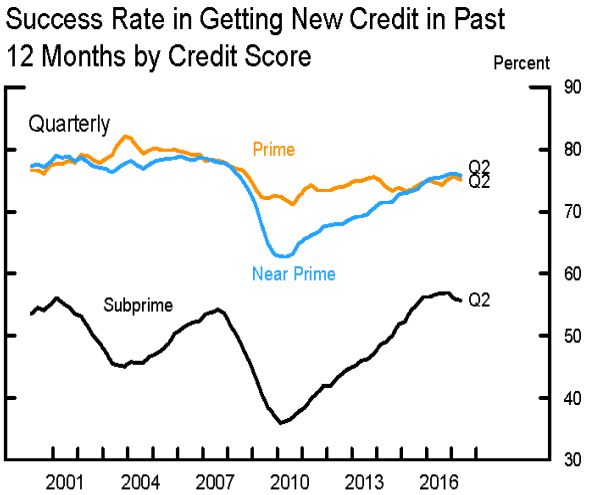
Source: BLS QCEW and CCP/Equifax.
Note: County level DTI is measured as total debt excluding student loans for all consumers in a county divided by total annual wages; graph shows the 10th, 50th, and 90th percentiles of county DTI.

Source: BLS QCEW and CCP/Equifax
Note: DTI in each group is the sum of debt outstanding excluding student loans divided by total annual wages for all counties with average wages in that percentile group.

Figure 11. Indicators of the Overall Demand for and Supply of Credit to Households

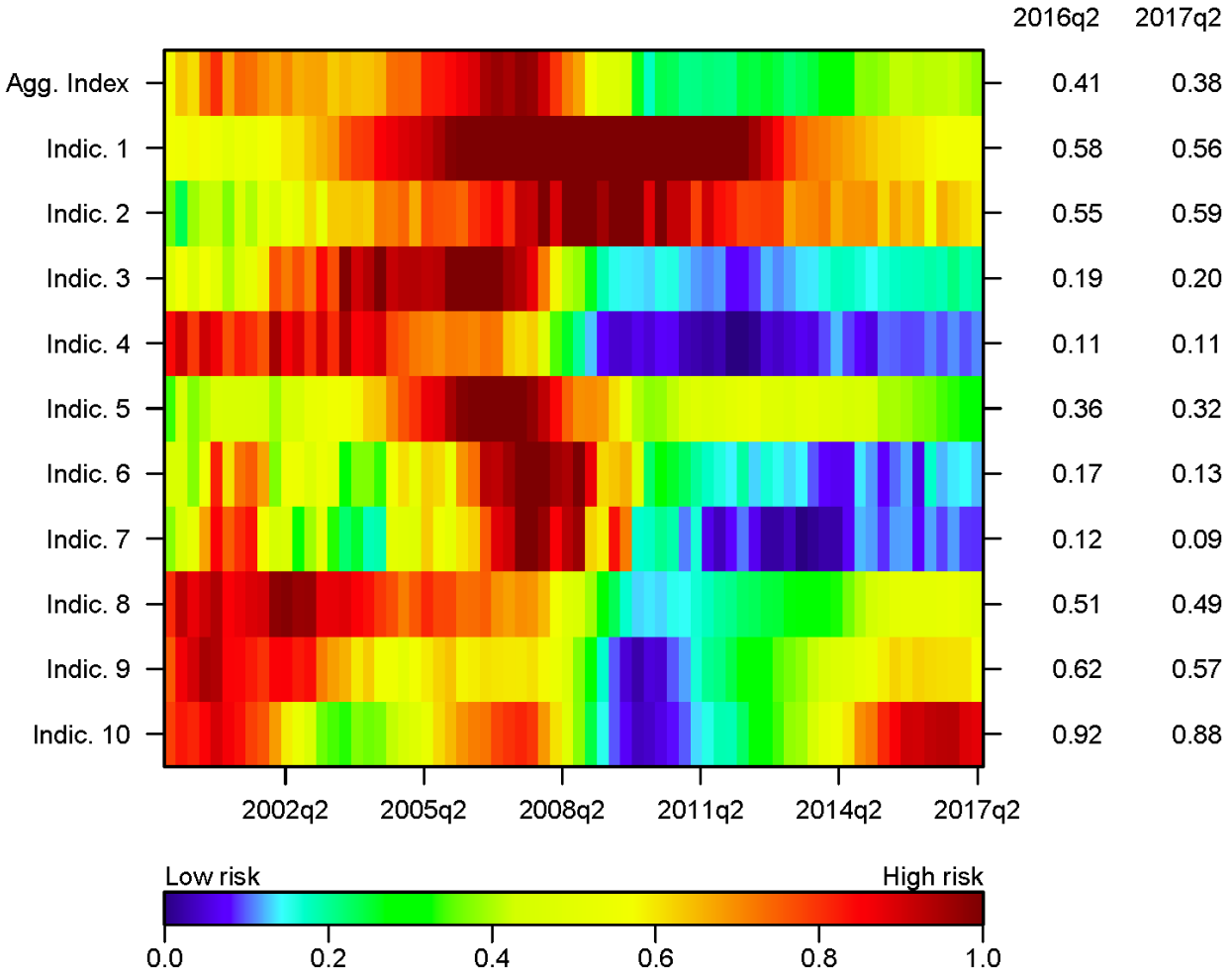


Source: FRBNY CCP/Equifax.
Note: Share of individuals with one or more credit record inquiries in the past three months; Near prime between 620 and 719, prime greater than 719.



Source: FRBNY CCP/Equifax
Note: Fraction opening a new account in past 12 months given at least one inquiry in past 12 months. Credit score is from 12 months ago.

Figure 12. Heatmap to Summarize a Range of Household Leverage Indicators



List of Indicators:

1. Index of average mortgage LTV based on "fundamental" housing values (or, if higher, current market value of homes; Figure 7, top left panel)
2. County-level debt-to-income at the 90th percentile of the distribution (Figure 10, top left panel)
3. Volume of mortgages extended to subprime or near-prime borrowers (Figure 4, top right panel)
4. Incidence of "aggressive" mortgage lending to/borrowing by subprime and near-prime households (Figure 5, top right panel)
5. Investor share of new mortgage extensions (Figure 6, bottom left panel)
6. Early payment delinquency rate for home-purchase mortgages (Figure 9, bottom left panel)
7. Early payment delinquency rate for non-purchase mortgages (Figure 9, bottom right panel)
8. Volume of non-mortgage credit extended to subprime and near-prime borrowers (Figure 4, middle and bottom right panels)
9. Incidence of "aggressive" non-mortgage lending to/borrowing by subprime and near-prime households (Figure 5, bottom left and right panels)
10. Success rate on credit applications for subprime borrowers (Figure 11, bottom right panel)