Credit Growth and the Financial Crisis: A New Narrative*

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Abstract

A broadly accepted explanation for the 2007-09 financial crisis emphasizes the growth in lending to subprime households during the preceding boom. According to this view, the resulting rise in insolvencies and foreclosures caused the financial crisis, leading to a decline in housing values and a broad contraction in credit. This paper studies the evolution of household borrowing and delinquency between 1999 and 2013, using a large administrative panel of credit file data. Our findings suggest an alternative narrative that challenges the large role of subprime credit. We show that credit growth between 2001 and 2007 is concentrated in the middle and high quartiles of the credit score distribution. Borrowing by individuals with low credit score is virtually constant for all debt categories during the boom. We also find that the rise in defaults during the financial crisis is concentrated in the middle and upper quartiles of the credit score distribution, and the fraction of defaults to the lowest quartile of of the credit score distribution sizably drops during the crisis. We discuss the broader implications of these findings for the role of housing collateral in the propagation of the crisis.

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1 Introduction

A broadly accepted narrative about the 2007-09 financial crisis is based on the findings in Mian and Sufi (2009) and Mian and Sufi (2015a) suggesting that most of the growth in credit during the 2001-2006 boom was concentrated in the subprime segment and most of the new defaults during the 2007-2009 crisis were also concentrated in this segment. The expansion of subprime credit is then viewed as a leading cause for the crisis, having lead to a rise in insolvencies and foreclosures, which caused a contraction of credit supply and a decline in house prices that also otherwise solvent households (see Mian and Sufi (2011), Mian and Sufi (2010), Mian, Sufi, and Trebbi (2011) and Mian, Rao, and Sufi (2013)).

This paper studies the evolution of household borrowing and delinquency between 1999 and 2013, leading up and following the 2007-09 great recession. Our analysis is based on the Federal Reserve Bank of New York Consumer Credit Panel/Equifax data, a large administrative panel of anonymous credit files from the Equifax credit reporting bureau. The data contains information on individual debt holdings, delinquencies, public records and credit scores. We examine the evolution of borrowing and defaults for variety of debt categories during the credit boom and throughout the financial crisis and its aftermath. Our findings suggest an alternative narrative that challenges a large role of subprime credit growth for the crisis. Specifically, we show that credit growth between 2001 and 2007 is concentrated in the middle and high quartiles of the credit score distribution. Credit to individuals with low credit score is virtually constant for all debt categories during the boom. We also find that the rise in defaults during the financial crisis is concentrated in the middle and upper quartiles of the credit score distribution. While low credit score individuals typically have higher default rates than individuals with higher credit scores, during the financial crisis the fraction of defaults to the lowest quartile of of the credit score distribution drops from 40% to 30% for insolvencies,[1] and from 70% to 35% for foreclosures.

Mian and Sufi (2009) and Mian and Sufi (2015a) identify subprime individuals based on their credit score in 1996 and 1997, respectively. We show that this approach implies that most of the credit growth attributed to low credit score individuals captures life cycle demand for borrowing, as well as life cycle effects in the evolution of credit scores. This is because low credit score individuals at any time are disproportionally young. Our approach is based instead on ranking individuals by their 8 quarter lagged credit score. This avoids joint endogeneity of the credit score ranking and borrowing and delinquency behavior, but ensures that the ranking best reflects the borrower's likely ability to repay debt at the time of

[1] Insolvencies occur when individuals are 120 or more late on any payments.

borrowing. Using payroll income data for 2009, we show that the cross sectional dispersion of 8 quarter lagged credit scores is mostly explained by the cross sectional dispersion of labor income, conditional on age.

Our findings confirm and expand those in Adelino, Schoar, and Severino (2015) who show that for mortgages, most of the growth in balances during the boom and the new defaults during the financial crisis are concentrated in the middle of the income distribution. We show that the large contribution of middle and upper credit score and income households to credit growth during the 2001-07 boom applies to all debt categories, and is associated to a stark rise in defaults and foreclosures for these households. The share of defaults to households at the bottom of the credit score distribution, who have low income, falls substantially during the crisis. Taken together, these findings challenge the prevailing view of the financial crisis. Based on this narrative, the rise in credit to subprime borrowers lead to a rise in defaults for this group, especially of housing debt. This lead to a decline in housing values, which then reduced home equity values for otherwise solvent, less risky borrowers, leading them to default on their housing debt.

We also begin to explore the broader implications of our results, focussing particularly on the role of the collateral channel, which is seen as a key driver for the onset and propagation of the financial crisis. There is a large literature on the role of collateral constraints, through housing equity, in the financial crisis. (See for example Berger et al (2015), Guerrieri and Lorenzoni (2011), Kehoe, Midrigan, and Pastorino (2014), Hurst and Stafford (2004), Mian and Sufi (2014), Iacoviello (2004).) According to this view, the value of collateral, by affecting household's ability to borrow, is a key determinant of consumption and its response to fluctuations in income. Therefore, a drop in house prices would determine a tightening of credit conditions and a decline in household borrowing.

We explore this mechanism by evaluating the role of home equity based borrowing between 2001 and 2013. We find that home equity based borrowing contributes only marginally to the growth in household debt during the credit boom, and does not exhibit a substantial contraction during the financial crisis. We also show that the contraction in debt is more severe for non-homeowners, and for non-housing debt for homeowners. These findings challenge the view that the decline in housing values were a key determinant to the contraction in household debt during and the aftermath of the 2007-09 financial crisis.

The paper is organized as follows. Section 2 provides a short description of the data we use for this analysis. Section 3 reports the new evidence on credit growth and default behavior by credit score. Section 4 examines the role of life cycle factors on credit demand and credit scores. Section 5 explores the relation between credit score and income. Section

6 discusses the broader implications for our findings for the collateral channel. Section 7 concludes.

2 Data

We use the Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data (CCP), which is an anonymous longitudinal panel of individuals, comprising a 5% random sample of all individuals who have a credit report with Equifax. The data is on quarterly frequency, starting in 1999:Q1 and ending in 2013:Q3. The data is described in detail in Lee and van der Klaauw (2010). In our analysis, we use a 1% sample for the individual analysis. This includes information for approximately 2.5 million individuals in each quarter. We use the 5% sample for the zip code level analysis.

The data contains over 600 variables,[2] allowing us to track all aspects of individuals' financial liabilities, including bankruptcy and foreclosure, mortgage status, detailed delinquencies, various types of debt, with number of accounts and balances. Apart from the financial information, the data contains individual descriptors such as age, ZIP code and credit score. The variables included in our analysis are described in detail in Appendix A.

3 Credit Growth and Default Behavior

The credit score is perceived as a critical indicator of credit worthiness for borrowers and is widely used by the financial industry. For most unsecured forms of lending, the credit score is the only characteristic that is assessed, jointly with other information available in a borrower's credit report, to award credit.

The credit score is a summary measure intended to predict the risk of default by the borrower. The most widely used measure is the FICO score. We have access to the Equifax Riskscore, which is a proprietary measure designed to capture the likelihood of a consumer becoming 90+ days delinquent within 24 months. The measure uses a numerical range of 280 to 850, where higher scores indicate lower credit risk. It can be accessed by lenders together with the borrower's credit report. Mian and Sufi (2009) and Mian and Sufi (2015a) use the 1996 and 1997 credit score as a measure of creditworthiness.[3] We will show that

[2]For data dictionary, go to `http://www.newyorkfed.org/householdcredit/2013-q3/data/pdf/data_dictionary_HHDC.pdf`.

[3]Specifically, Mian and Sufi (2009) rank MSA zip codes by the fraction of residents with Equifax Riskscore below 660 in 1996. Mian and Sufi (2015a) rank individuals by their Vantage Score, a measure similar to the FICO score. Vantage Score in 1997. For this classification, the subprime cutoff is at the high end of the

this approach tends to attribute higher credit growth to low credit score individuals, as they are disproportionately young, and exhibit subsequent life cycle growth in credit and credit scores.

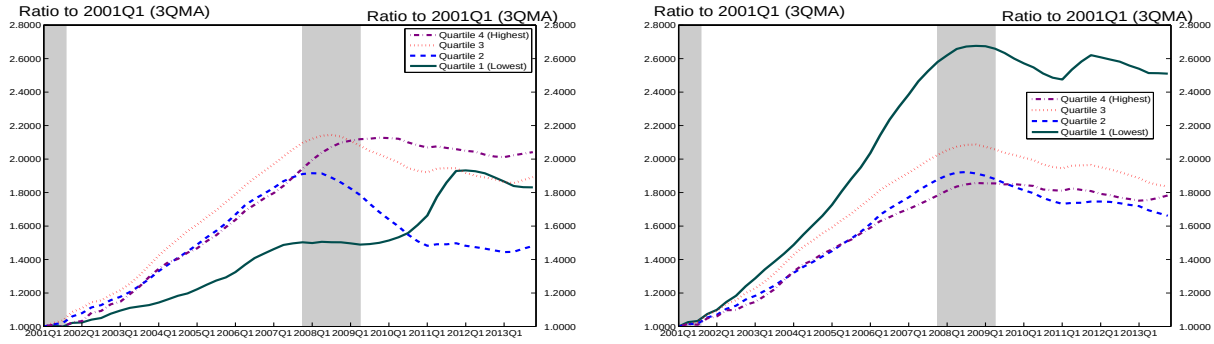
To avoid this problem, we rank individuals by their 8 quarter lagged credit score. This approach prevents joint endogeneity of credit score and borrowing behavior, but at the same time provides a more accurate description of borrowers' default risk as perceived by lenders at the time in which the loans are extended. As we will show in Section 5, the 8 quarter lagged credit score is strongly positively related to income, conditional on age. To compare our findings with the approach adopted by Mian and Sufi (2009) and Mian and Sufi (2015a), we also rank individuals by quartiles of the Equifax Riskscore distribution, 8 quarter lagged and in 1999, the earliest available year in our sample. We will show that the 1999 credit score ranking overstates credit growth for individuals in the first quartile of the distribution for all types of debt, whereas with the 8 quarter lagged credit score ranking, most of the credit growth accrues to individuals with credit scores above the median. Thus, the role of the subprime segment is magnified by the use of initial credit scores to identify subprime individuals.

3.1 Debt Balances

Figure 1 displays the behavior of total debt balances, measured per capita within each credit score quantile. The left panel displays the growth in this variable relative to 2001.Q1 based on the 8 quarter lagged credit score ranking, while the right panel displays the same series for the 1999 credit score ranking. Based on the 8 quarter lagged ranking, per capita aggregate debt balances approximately double for individuals in the *third quartile* of the credit score distribution, they grow by approximately 90% for individuals in the *second and fourth quartile*, while they rise by only 40% for those in the first quartile. By contrast, using the 1999 credit score ranking, individuals in the first quartile exhibit growth in per capita aggregate debt balances of over 170% between 2001.Q1 and 2007.Q3, whereas all other groups display growth rates between 70 and 95%. The figure clearly illustrates that the 1999 ranking exaggerates credit growth for the first quartile, while it reduces it for the fourth quartile. The second and third quartile of the credit score distribution display a similar pattern across both rankings.

A similar discrepancy is evident for mortgage balances and originations. Figure 2 displays per capita mortgage balances for each quartile according to the alternative rankings. Based

second quintile.



(a) 8 quarter lagged Equifax Risk Score

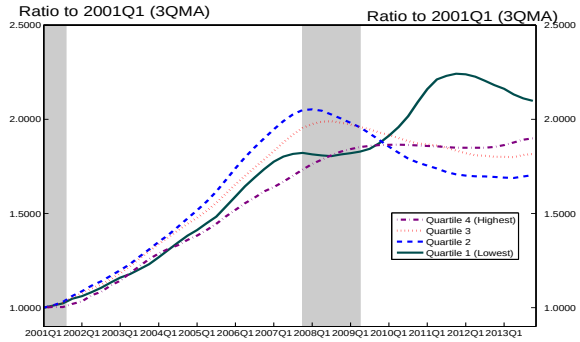
(b) 1999 Equifax Risk Score

Figure 1: Per capita total debt balances by Equifax Riskscore quartile. Ratio to 2001Q1. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

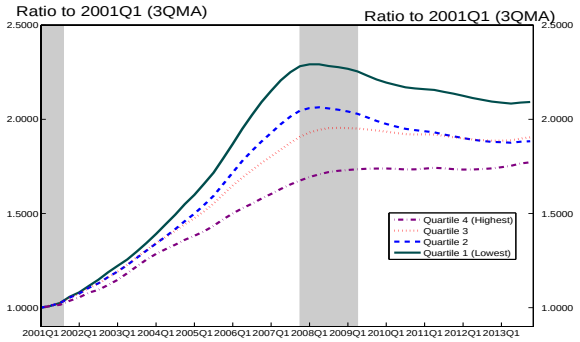
on the 8 quarter lagged ranking, mortgage balances approximately double between 2001.Q1 and the start of the great recession, while they peak at 75% higher in 2006.Q4 for individuals in the first quartile. For individuals in the fourth quartile, per capita mortgage balances also peak at 75% higher at the start of 2009. Using the 1999 credit score ranking, mortgage balances for the first quartile of the distribution grow by 125% between 2001.Q1 and the start of the great recession, 30 percentage points more than the growth for the second quartile over the same period. As for total debt balances, the growth for the second and third quartile is quite similar across the two rankings, while for the fourth quartile the growth with the 1999 ranking is smaller than with the 8 quarter lag ranking.

Figure 3 displays the fraction of individuals with new mortgage originations in the last for quarters for each quartile. Based on the 8 quarter lagged ranking, originations decline for the entire sample period for the first quartile, and decline starting in 2002.Q1 for the second quartile. For the third and fourth quartile, the fraction with new originations peaks in 2004.Q1. Based on the 1999 ranking, originations slightly rise for the first quartile of the distribution between 2001.Q1 and early 2007, while the pattern is quite similar for the other quartiles.

The same patterns and discrepancies across the two credit score rankings are also evident for credit card balances and auto loans. Figure 4 reports per capita credit card balances, as a ratio to their value on 2001.Q1. Once again, the most striking difference between the two rankings can be seen for the first quartile. With the 8 quarter lagged ranking, credit card balances are essentially flat for the entire sample period for the first quartile, while they

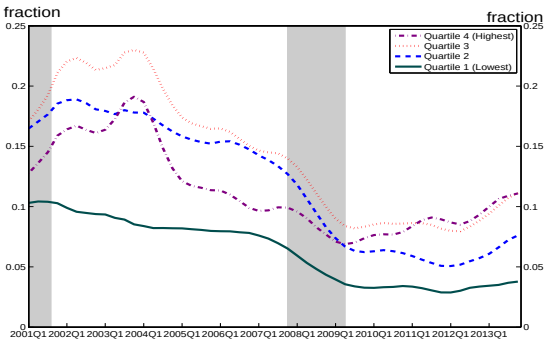


(a) 8 quarter lagged Equifax Risk Score

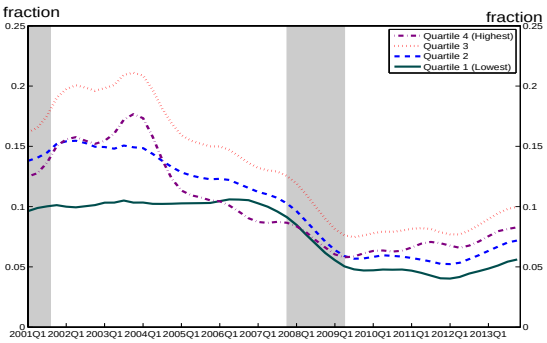


(b) 1999 Equifax Risk Score

Figure 2: Average mortgage balances. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.



(a) 8 quarter lagged Equifax Risk Score

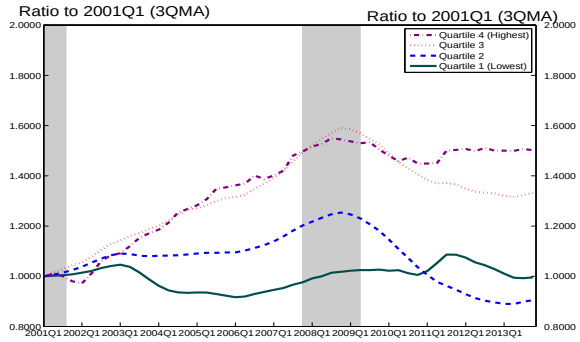


(b) 1999 Equifax Risk Score

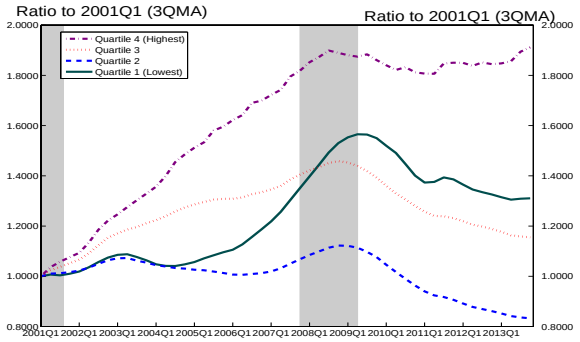
Figure 3: Fraction with new mortgage originations. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

peak at 65% than 2001.Q1 in 2009.Q1 for the 1999 ranking. Credit card balances also grow more with the 1999 ranking for the fourth quartile, while for the second and third quartile the discrepancy across ranking is minor.

Figure 5 displays the same results for per capita auto loan balances. While rankings present a very pronounced cyclical pattern, the first quartile exhibits much stronger growth during the credit boom.

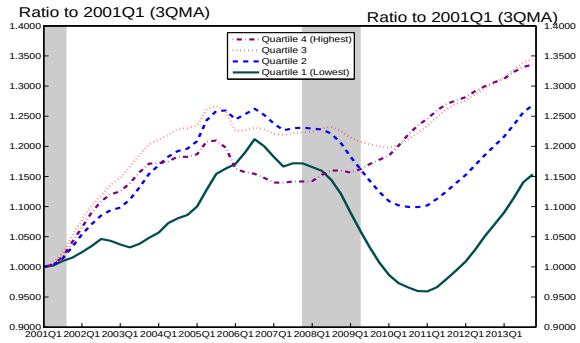


(a) 8 quarter lagged Equifax Risk Score

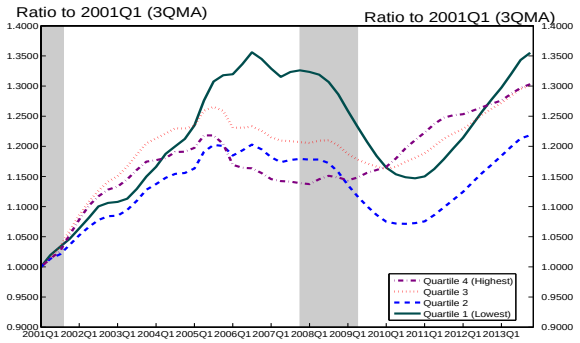


(b) 1999 Equifax Risk Score

Figure 4: Average credit card balances. Ratio to 2001Q1. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.



(a) 8 quarter lagged Equifax Risk Score



(b) 1999 Equifax Risk Score

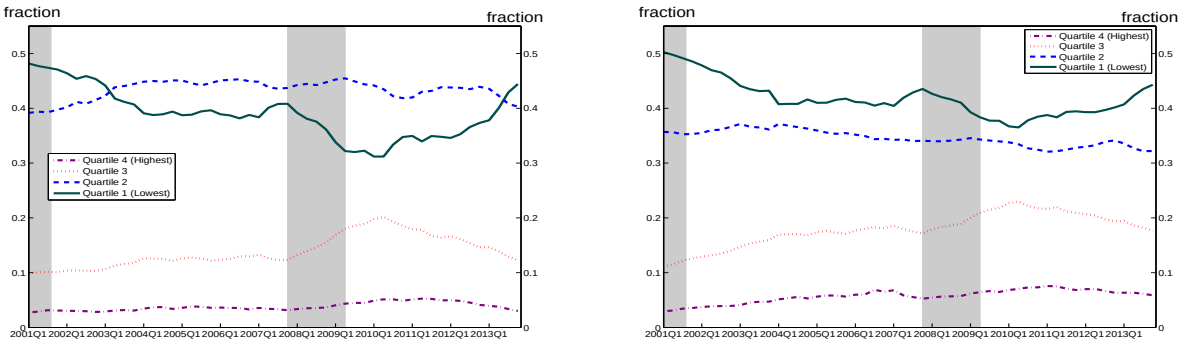
Figure 5: Average automobile loan balances. Ratio to 2001Q1. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

3.2 Defaults

A basic tenet of the common view of the financial crisis is that the growth in credit extended to subprime individuals during the boom led to a rise in defaults for that segment during the crisis. Specifically, this view emphasizes that the rise in foreclosures was concentrated in this segment.

We examine this premise in the next two charts, which present the share of defaults and foreclosure to each quartile for each of the rankings. For both variables, we find that the share of the first quartile declines during the financial crisis, and the decline is more pronounced for the 8 quarter lagged ranking.

Figure 6 presents the share of new insolvencies, defined as instances of accounts with payments 120 days or more late. We find that the share of insolvencies and foreclosures of the first quartile is the highest, reaching about 50%, for both rankings at the beginning of the sample period. It drops during the credit boom period, and after rising briefly in early 2007, drops during the financial crisis. While this pattern prevails for both rankings, the decline during the financial crisis is more pronounced for the 8 quarter lagged ranking, for which the share drops by about 10 percentage points during the great recession. For this ranking, the share of new insolvencies of the first quartile actually drops below the share for the second quartile between 2003 and 2013. The share of new insolvencies to the second quartile is stable throughout the sample period for both rankings. The share to the third quartile, which is close to 10% at the beginning of the sample, grows sharply during the financial crisis, reaching approximately 20% in 2010 for the 8 quarter lag ranking. The pattern is similar but more muted for the 1999 ranking.



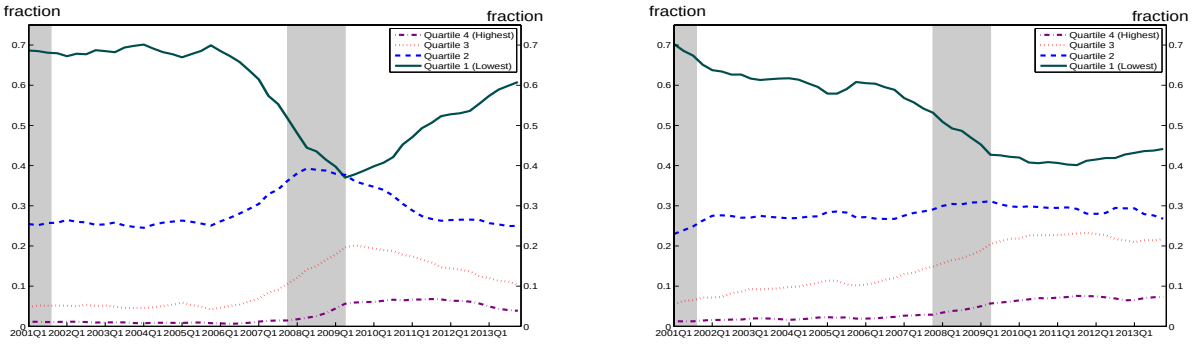
(a) 8 quarter lagged Equifax Risk Score

(b) 1999 Equifax Risk Score

Figure 6: Share of new insolvencies (120 days+late) by credit score quartile. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

Figure 7 presents the share of new foreclosures, which display a pattern of behavior similar to the one new insolvencies, but much starker. For both rankings, the share of new foreclosures for the first quartile is 70% at the beginning of the sample. For the 8 quarter lag ranking, this share is stable until 2007, when it drops sharply, reaching 35% by the end of the 2007-09 recession. This share then rises gradually to 60% by the end of 2013. The sharp decline of the first quartile share during the great recession is matched by an equally stark rise of the share of new foreclosures in the second and third quartiles, which start at 28% and 4%, respectively, at the start of the sample, remain stable until 2006, and then

rise by approximately 15 percentage points between 2009 and the end of 2009. The share of new foreclosures to the fourth quartile, which is less than 1% until 2007, also rises by 5 percentage points during the crisis. With the 1999 ranking, the share of new foreclosures in the first quartile drops gradually until 2006, when it starts a faster decline, reaching 45% at the end of the great recession. The share rises very slowly starting in 2011. The share of the other quartiles are mostly stable until 2007, and then rise permanently. The increase is greatest for the third quartile, for which it rises from 10% in early 2007 to just above 20% in 2009. The age effects which we will discuss in Section 4 likely account for the declining share of foreclosures to the first quartile for the 1999 ranking.



(a) 8 quarter lagged Equifax Risk Score

(b) 1999 Equifax Risk Score

Figure 7: Share of new foreclosures by credit score quartile. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

3.3 Summary

We conclude this section with a brief summary of our findings.

- The 1999 credit score ranking overstates credit growth for low credit scores during the boom. This observation applies to aggregate debt balances, mortgage balances and originations, credit card balances, and auto loans.
- Using our preferred 8 quarter lagged credit score ranking, most credit growth during boom is concentrated in 3rd quartile of the credit score distribution.
- The rise in new insolvencies and foreclosures during the great recession is concentrated in the 2nd and 3rd quartile of the credit score distribution, for both rankings, but the rise is more pronounced for the 8 quarter lagged ranking.

- The share of new insolvencies and foreclosures to the 1st quartile drops sharply during crisis. Again, this pattern is more pronounced for the 8 quarter lagged ranking.

4 The Role of Age

We now explain why ranking individuals by their credit score 15 years prior, as in Mian and Sufi (2009) and Mian and Sufi (2015a) amplifies credit growth for low credit score individuals. Specifically, we will show that low credit score individuals are disproportionately young. The young experience future credit growth, as well as income and credit score growth, due to the life cycle. Moreover, their credit score at time of borrowing is considerably higher than when young. Using a 4-12 quarter lagged credit score provides a better assessment of a borrower's default risk, as it closely related to income at time of borrowing.

We begin by showing that low credit score individuals are disproportionately young. Figure 9 displays the fraction of individuals in each credit score quartile in 1999 by age. We consider 5 age groups. For the youngest group, age 25-34, the fraction in the first quartile is 36%, the fraction in the second quartile is 25%, the fraction in the third quartile is 18%, and the fraction in the fourth quartile is 6%. The distribution gradually shifts to higher quartiles for the older age groups. For 45-54 year olds, the fraction in each quartile are roughly equal. For the oldest age group, 65 or older, the fraction in the first quartile is 8%, while the fraction in the fourth quartile is 38%. This distribution is very stable over time.

Given their relatively young age, and correspondingly short credit history, low credit score individuals in 1999 exhibit credit score growth over time. This is illustrated in figure 9, which plots the ratio of the current and 1999 credit score over the sample period by 1999 credit score quartile. For individuals in the first credit score quartile in 1999, their credit score grows by more than 10% between 2001 and the end of 2013. The credit score grows by about 2% for individuals in the second quartile, and is essentially flat for the other 1999 credit score quartiles.

To explore the role of age on credit score and credit growth in more detail, we adopt a regression approach.

4.1 Age Effects: Regression Analysis

To more precisely assess the relation between age, credit score and credit growth, we regress the Equifax Riscore in each quarter on age fixed effects, time effects and state fixed effects. We include state effects due to the sizable cross state variation in important regulation

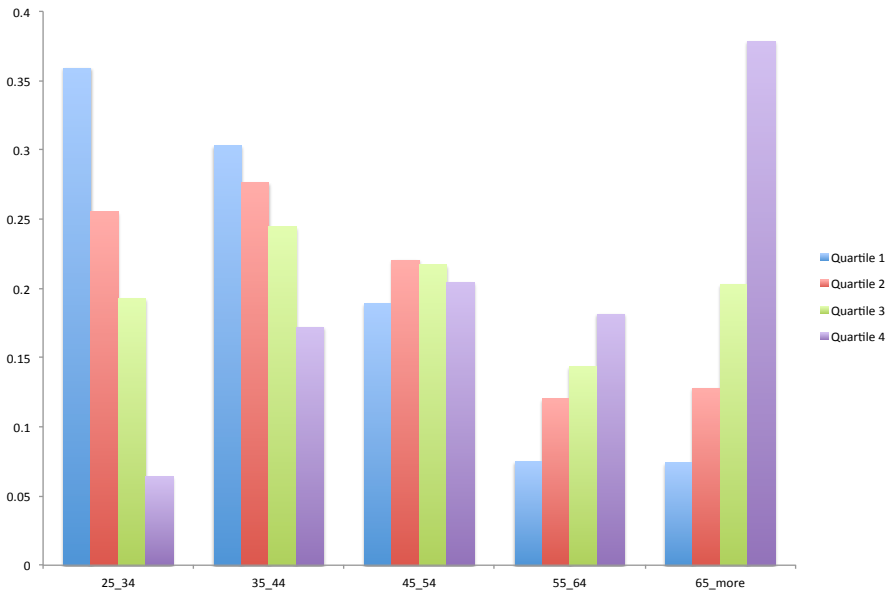


Figure 8: Fraction in each age bin in 1999 by Equifax Riskscore quartile in 1999. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

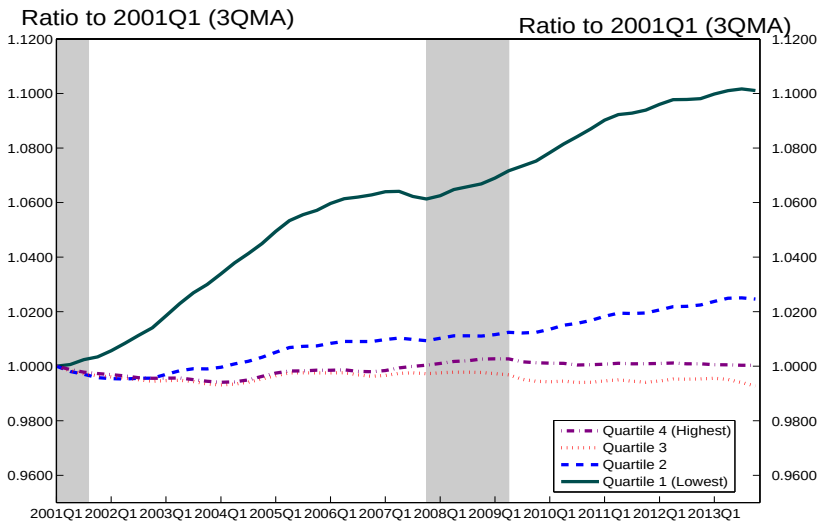


Figure 9: Current credit score as ratio to 1999, by Equifax Riskscore quartile in 1999. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

regarding foreclosure, health insurance and other factors, which could affect the incidence of financial distress and credit scores.

Figure 10 plots the estimated age effects between age 20 and 85. The growth in credit score as a function of age is strongest between age 25 and 40, and weakest after age 65.

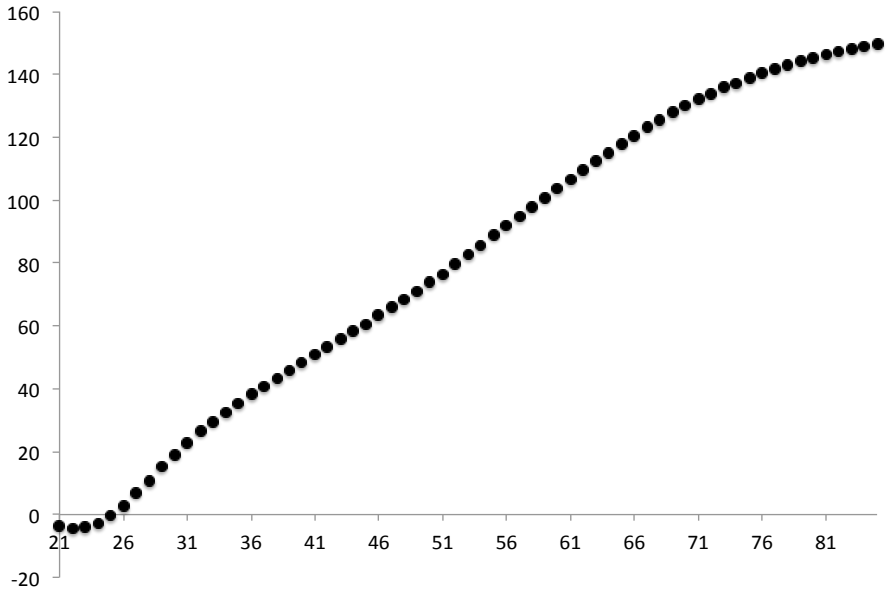


Figure 10: Equifax Riskscore. Estimated age effects. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

We adopt the same approach to evaluate the relation between age and debt balances, regressing them on age fixed effects, time effects and state fixed effects. Figure 11 plots the age effects of this regression for aggregate debt balances, home debt balances, credit card balances and auto loan balances. There is a striking life cycle pattern in all these measures. Credit card balances (right axis) peak at 3,000$ at age 55, whereas auto loans reach a peak of approximately 2,000$ at age 32. Home balances do no start rising until age 25, then peak just above 40,000$ at age 42. The behavior of total debt balances largely reflects the behavior of home balances.

4.2 Counterfactuals

To further illustrate the role of the life cycle for credit demand, we construct a series of counterfactuals. These calculations are intended to remove life cycle effects on credit growth by assigning to individuals in each 1999 age bin, the debt balances of individuals who are in that same age bin at any given quarter. For example, a 26 year old in 1999 will be attributed the debt balances of current 26-year-olds in all quarters.

Specifically, we consider the following age bins: $1 = [25, 34)$, $2 = [35, 44)$, $3 = [45, 54)$,

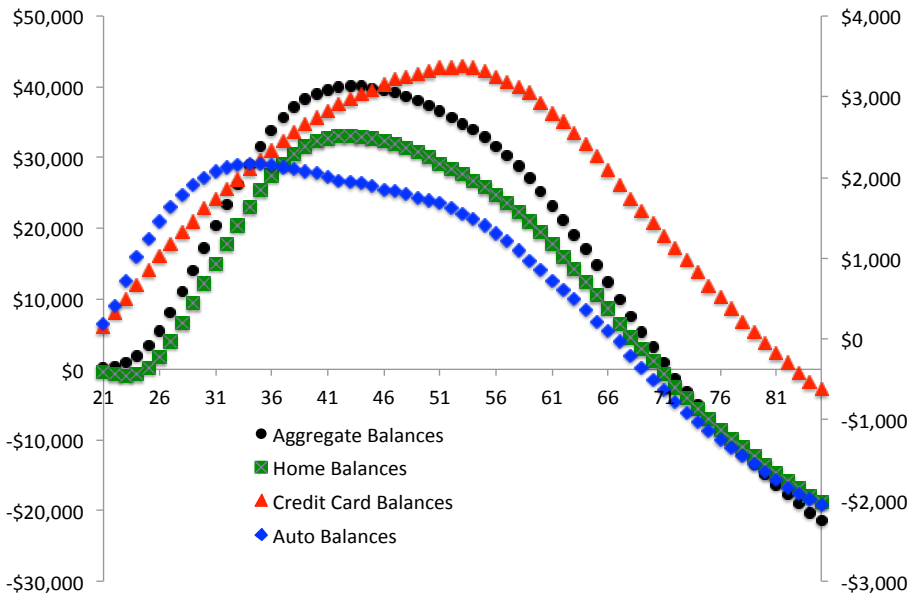


Figure 11: Debt balances. Estimated age effects. Credit card and auto loan balances on righ axis. Home debt and aggregate balances on left axis. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

$4 = [55, 64)$ and $5 = [65, ...)$. Let $\pi^{i,j_{1999}}$ be the fraction of individuals in age bin i and Equifax Riskscore quartile $j = 1, 2, 3, 4$ in 1999, and $\overline{x}_t^{i_{1999}}$ be the average value of a variable x for individuals in age bin i in quarter t. We compute $\overline{x}_t^{i_{1999}}$ the average value of the variable at t for individuals in age bin i in 1999. This measure forces individuals to continue to behave according to their age in 1999 in all future time periods. Since age is kept constant, this counterfactual eliminates life cycle effects.

The results are displayed in figure 12. We find that 25-34 year olds in 1999 experience *more* debt growth than current 25-34 year olds, whereas 45-54 and 65+ year olds in 1999 experience *less* debt growth now than current 45-64. The 35-44 year olds in 1999 experience very similar debt growth to the current 35-44 year olds. The gap between total debt balances for individuals currently in each age group and those in that age group in 1999 measures the component of credit demand due to life cycle considerations. For example, in 2007.Q1, total debt balances for 25-34 year olds in 1999 would have been approximately 25,000$ lower if their age had remained constant. By contrast, for 55-64 year olds in 1999, per capita total debt balances would have been approximately 30,000$ higher in 2007.Q1 if they had not aged.

To quantify the role of life cycle borrowing by 1999 credit score quartile, we compute the same counterfactual by credit score. Let $x_t^{i,j_{1999}}$ be the average value of a variable x for

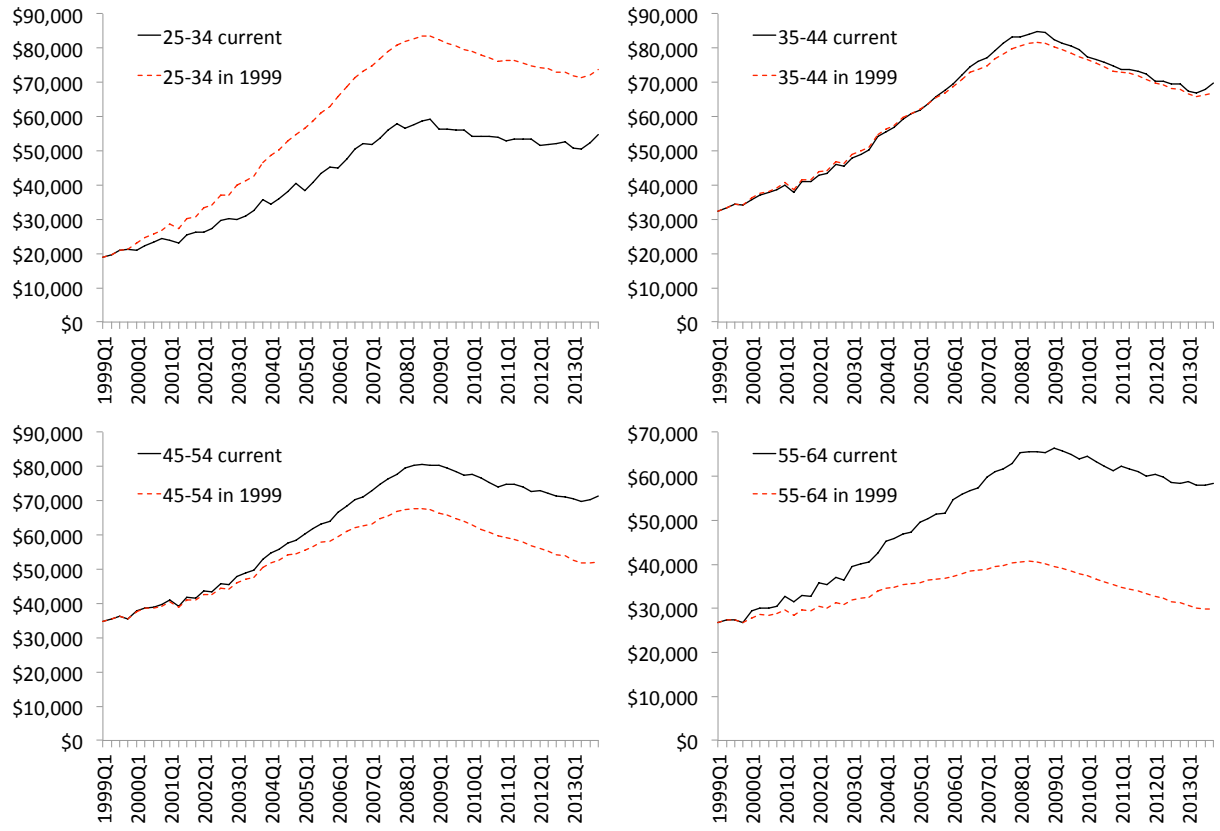


Figure 12: Total debt balances by current age, and by age in 1999. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

individuals in age bin i and Equifax Riskscore quartile $j = 1, 2, 3, 4$ in 1999 at quarter t. Additionally, let $\overline{x}_t^{j_{1999}}$ be the average value of variable x in quarter t for credit score quartile j in 1999:

$$\overline{x}_t^{j_{1999}} = \sum_i \pi^{i,j_{1999}} \times x_t^{i,j_{1999}}, \tag{1}$$

Using $\overline{x}_t^i$ the average value of a variable x for individuals in age bin i in quarter t, we compute the counterfactual value of that variable for Equifax Riskscore quartile $j = 1, 2, 3, 4$ in 1999 as follows:

$$\hat{x}_t^{j_{1999}} = \sum_i \pi^{i,j_{1999}} \times \overline{x}_t^i. \tag{2}$$

We compare these counterfactual debt balances to actual debt balances by 1999 and 8Q lagged credit score quartile. If there is no difference between the counterfactual series and the series for 8 quarter lagged ranking, then all the discrepancy between the 1999 ranking and the 8 quarter lagged is due to life-cycle effects. Figure 13 displays the results. Consistent

with the previous counterfactual and with the age distribution by 1999 credit score quartile, removing life cycle effects decreases debt growth for the 1st quartile of the 1999 credit score ranking, and increases debt growth for the 4th quartile of the 1999 credit score ranking. For the first quartile, the impact of life cycle borrowing is greatest at the height of the credit boom and during the crisis and its aftermath. The gap between actual and counterfactual per capita total debt balances is over 50%, suggesting that approximately half of the difference in debt growth between the 1999 and 8 quarter lagged credit score ranking is due to life cycle effects. For the 4th quartile, total debt balances would have been approximately twice as large absent aging from 2007 onward, and the life cycle considerations explain virtually all the gap between the 1999 and 8 quarter lagged credit score ranking. Life cycle effects are also sizable for the second quartile of the 1999 credit score distribution, they account for about 25% of total debt balances between 2007 and 2009 and explain most of the discrepancy with the 8 quarter lagged credit score ranking for that period.

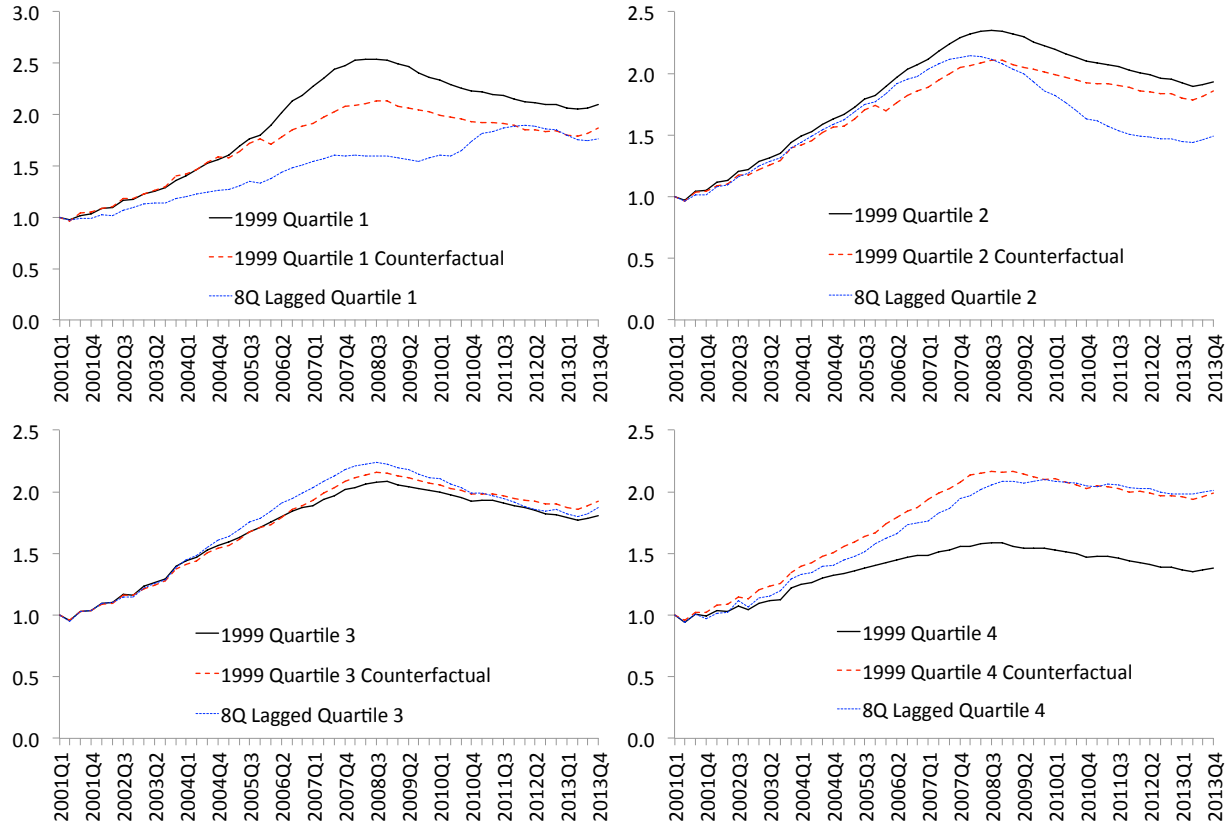


Figure 13: Total debt balances. Actual and counterfactual by 1999 Equifax Riskscore quartile. Actual by 8Q lagged Equifax Riskscore quartile. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

Taken together, these results suggest that life cycle effects in borrowing are very strong and sizably effect debt growth for individuals at the extreme of the 1999 credit distribution. There are especially important for individuals in the first quartile of the credit score distribution in 1999, for whom most of the subsequent credit growth is due exclusively to these life cycle considerations.

5 Credit Score and Income

The rationale behind using a recent credit score to rank individuals is twofold. First, this measure better reflects their perceived default risk at the time of borrowing. In addition, it is closely related to individual's current labor income. In this section, we estimate the relation between 8 quarter lagged credit score and income. The Equifax Consumer Credit Panel does not provide individual income. However, for 2009, we have access to Equifax Worknumber payroll data, linked to the Equifax credit files. The income data, which is from a large payroll verification firm, is available for a subsample of over 11,000 individuals in the credit panel, and it is nationally representative. We construct a total labor income measure using information on pay rate and pay frequency. Detailed information on the construction of this measure and on other features of these data are provided in Appendix B.

Table 1 displays the distribution of 8 quarter lagged credit score and total income for the Worknumber data. Median labor income is 39,520$, while the median credit score is 700.

Table 1: Distribution of credit score and labor income in 2009

Percentile	10%	25%	50%	75%	90%	Mean	St. Dev.
Riskscore	519	602	700	775	808	680	112
Income	16,640	22,880	39,520	64,100	99,840	49,728	35,057

Credit score is the 8 quarter lagged Equifax Riskscore. Labor income is Equifax Worknumber total annual labor income. Source: Authors' calculations based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

To evaluate the relation between income and credit score, we regress the 8 quarter lagged credit score on income, income square, age, age square, state fixed effects and time effects.[4] The estimated coefficients on income are highly significant, and suggest that the variation

[4]Since the credit score is bounded above, we use a truncated regression approach. Additionally, standard errors are clustered at the state level.

in credit scores largely accounted for by variation in income, conditional on age. A change from the 25th to 75th percentile of the income distribution raises the 8 quarter lagged credit score by 120 points. This amounts to 69% of the change from 25th to 75th percentile of the credit score distribution.

This strong relation between credit score and income, conditional on age, suggests that the probability of default in the next 4 quarters is also closely to income. This is not surprising, as current income is the source for principal and interest payments on outstanding debt for most borrowers.

6 Broader Implications: Role of Collateral Channel

Our results pose a challenge for the prevailing narrative that the main precursor of the run-up in defaults during the financial crisis was the rise in sub-prime lending, which caused house prices to drop (Mian and Sufi (2009), Mian and Sufi (2015b)). According to this view, the subsequent drop in house prices induced a broad contraction in aggregate demand, propagating the shock originated in the sub-prime segment to the overall economy. Instead, our analysis suggest that a sharp rise in credit the preceded the crisis was driven by prime borrowers who exhibit unprecedentedly high rates of default during the crisis. These new findings raise new questions on the determinants of the financial crisis and the policies necessary to cure it and prevent future episodes.

The collateral value of real estate has generated a sizable related literature focussing on the role of home borrowing in household credit. Specifically, this research emphasizes that a decline in house prices would be associated in a contraction of the supply of credit, through the reduction in the value of collateral (Iacoviello (2004), Guerrieri and Lorenzoni (2011), Kehoe, Midrigan, and Pastorino (2014)). Our results so far also cast doubt on this collateral channel, since we find very similar patterns across all debt categories, including those ones not collateralized by housing equity and unsecured debt, such as auto loans and credit card debt.

We now provide further evidence specifically on the role of the collateral channel for the behavior of household credit during the boom, and especially in the aftermath of the 2007-09 financial crisis. We show that home-equity loans, such as HELOCs and other non-mortgage home debt, constitute a very small fraction of total debt balances and play a small role in the variation of household credit around the financial crisis. We then show that the contraction of total home debt during and after the financial crisis is smaller than for other debt categories. Lastly, we distinguish between homeowners and non-homeowners in our

sample.[5] We show that the borrowing by non-homeowners exhibits a slower growth in the boom, but a much sharper contraction in the recession. For homeowners, the contraction in non-home related debt during the crisis is much more severe than the decline in home debt. This evidence, while still suggestive, is consistent with borrowing behavior during and after the crisis driven by an aggregate shock other the decline in housing values, though possibly correlated with this decline.

6.1 Debt Composition

We begin by studying the composition of household debt holdings at different points in time. We consider 2001, the first year of analysis; 2008, which marks the peak of the credit boom; and finally 2013, the last year in our sample. Figure 14 presents the composition of total balances in these three years. First, HELOCs and home installment loans are the two smallest components of aggregate balances, followed by credit card, auto loans and then the biggest component–mortgages. Second, the percentage contribution of each of these types of debt remained fairly constant during the credit contraction period (between 2008 and 2013), with the contribution of credit card debt (and home installment loans, although those loans are extremely small) falling most noticeably and the contribution of mortgage debt rising slightly. This implies that all types of debt fell during the recession, with credit card debt falling the most, and mortgage debt falling least.

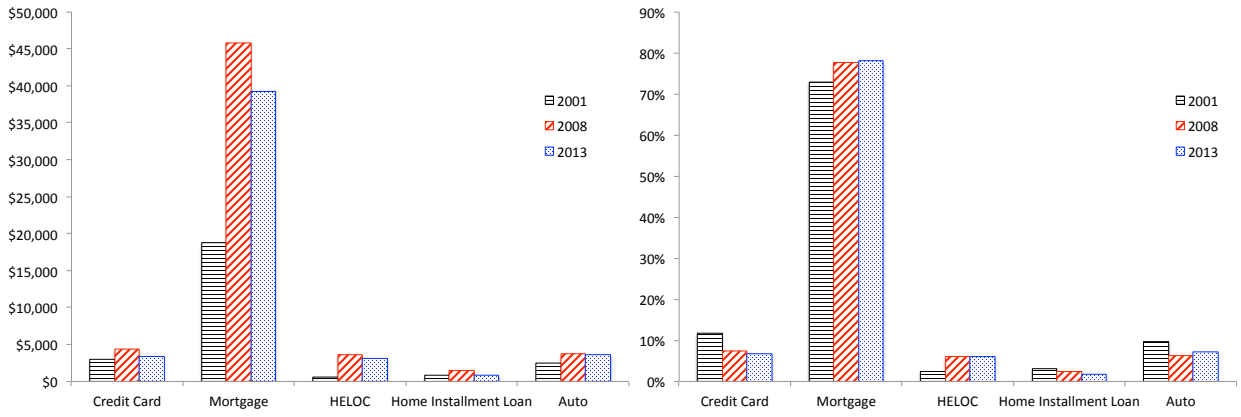


Figure 14: Composition of total debt balances in selected years: values (left panel) and percent contribution (right panel). Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

[5]Our definition of homeownership is based on the presence of outstanding real estate debt holdings on an individual's record. We discuss this definition in more detail below.

Home Equity Loans We now further investigate the behavior of home-equity based debt, compared to other debt categories. Specifically, we compare total balances, total balances net of home-equity lines, which exclude HELOCs and other home-equity lines of credit, and total balances without all real estate debt, a category which additionally excludes mortgage balances.

Figure 15 presents the time series of total balances and total balances net of home equity loans (i.e. HELOCs and home equity lines of credit). First, home equity loans contribute only marginally to the dynamics of total debt balances, as total balances with and without home equity loans are almost identical (left panel). In particular, since the start of the contraction in aggregate credit in 2008Q3, total debt with and without home lines contract at virtually the same pace, which is inconsistent with the notion that the contraction in household debt was driven by the decline in home equity loans. We also investigate the role of real estate debt in its entirety. Figure 16 presents the results. Mortgage debt clearly played a crucial role in the rise of total balances between 2001 and 2008 (left panel). However, the drop in balances starting from the peak of debt (2008Q3) was significantly faster for non-home debt than for real estate debt (right panel). Non-home balances dropped by 17% of the 2008 level by 2011Q1, while overall balances dropped by only 9%.

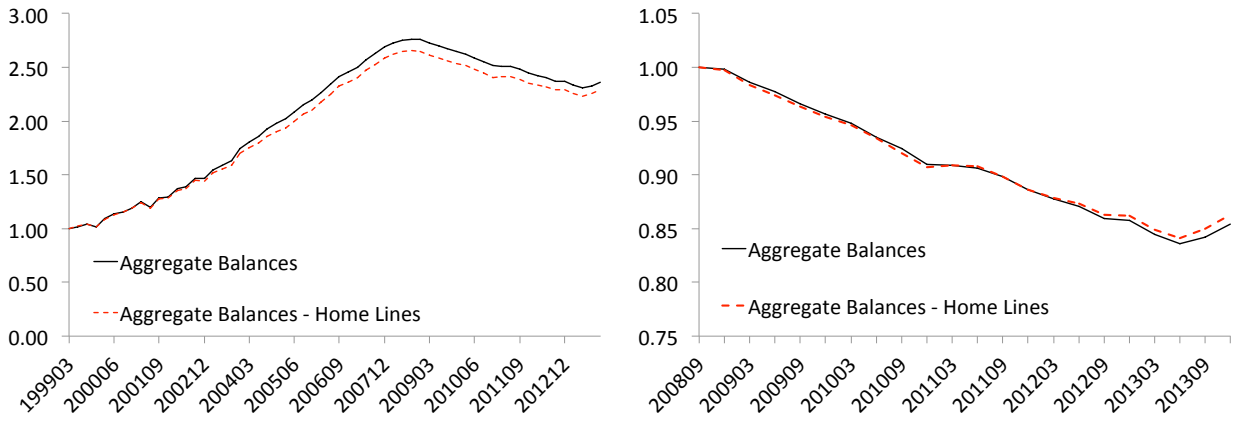


Figure 15: Total debt balances with and without home equity loans (HELOCs and home equity lines of credit) during the credit boom (left panel) and bust (right panel). Series rescaled by own value in first quarter. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

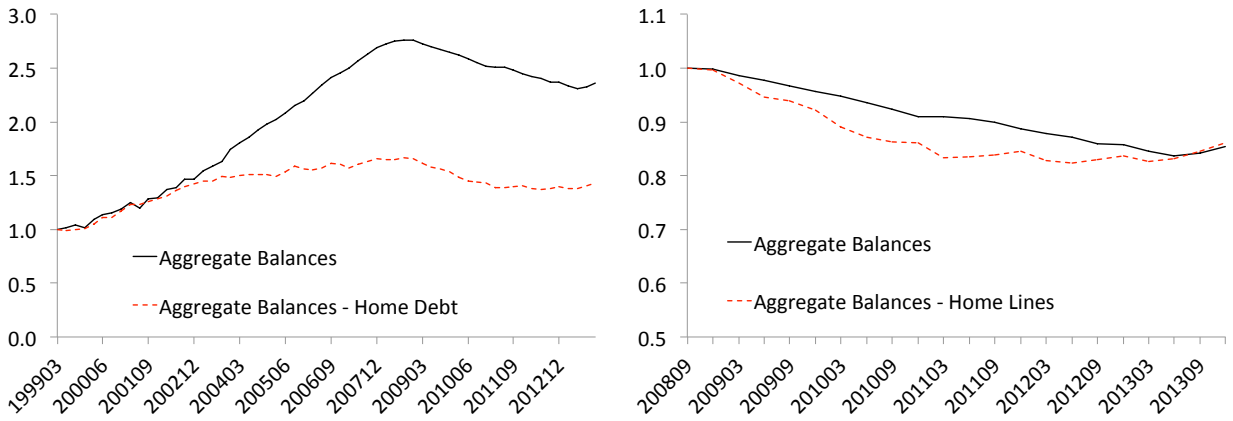


Figure 16: Total debt balances with and without home equity loans (HELOCs, home equity lines of credit and mortgages) during the credit boom (left panel) and bust (right panel). Series rescaled by own value in first quarter. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

6.2 Homeowners versus Non-homeowners

Our next set of results pertains to the behavior of homeowners and non-homeowners. We identify homeowners in our sample by the presence of any real estate debt (mortgage, HELOC, home equity line of credit) on their record in the last 4 quarters. Hence, we capture all individuals who borrow against real estate in any way, but not include individuals who own a home but do not borrow against it. Our definition is dictated by the nature of our data, and clearly does not capture all homeowners.However, we don't think this limitation is particularly significant for our analysis, since home owners who have no active real estate loans, who fall into our non-homeowner category, are likely to be older or in high income and wealth brackets, and thus probably not face binding borrowing constraints.Given this, we view our homeownership classification as adequate for exploring the link between decline in housing values and contraction in borrowing during and after the financial crisis.

Our findings suggest that the decline in household borrowing during and in the aftermath of the financial crisis was not driven by a decline in real estate debt. As shown in figure 17, total debt balances, while homeowners homeowners experienced a much larger rise in total debt balances, the decline in total debt balances from the peak of 2008Q3 was significantly bigger for non-homeowners. This finding is consistent with mortgages driving the rise in debt during the boom, but falling very slowly during the crisis, as shown in figure 16. The magnitude in the gap in the change in total debt balances between homeowners and non homeowners is very sizable. By 2011Q1, non homeowner total debt balances dropped by

more than 16%, compared to less than 6% for homeowners. This pattern holds for all types of debt as well. Figure 18 shows the behavior of credit card balances, which by definition are not collateralized. Credit card borrowing grows less but falls more for non homeowners when compared to homeowners in our sample.

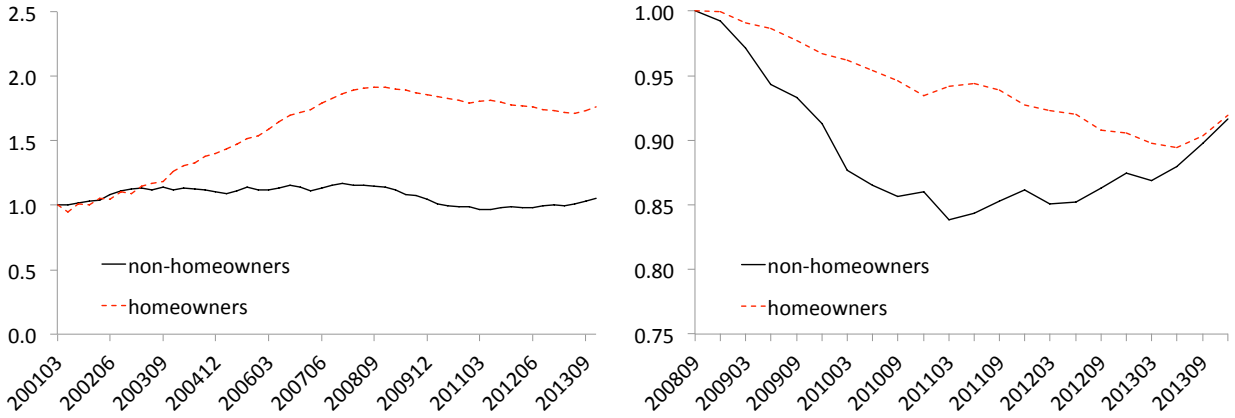


Figure 17: Total debt balances by homeownership status during the credit boom (left panel) and bust (right panel). Series rescaled by own value in first quarter. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

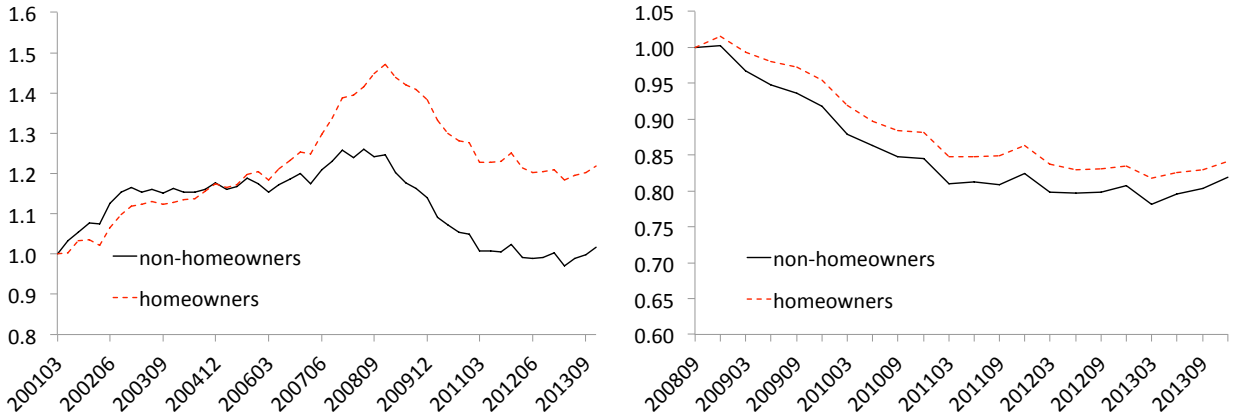


Figure 18: Credit card balances by homeownership status during the credit boom (left panel) and bust (right panel). Series rescaled by own value in first quarter. Source: Authors' calculation based on Federal Reserve Bank of New York's Consumer Credit Panel/Equifax Data.

7 Interpretation and Ongoing Work

Our analysis challenges the prevailing view of the 2007-09 financial crisis, which emphasizes the growth of subprime credit during the boom and the role of a decline in the value of real estate collateral during the crisis. We show that most of the growth in credit during the 2001-2007 boom is concentrated in the prime segment, and this segment is also responsible for the growth in defaults and foreclosures during the crisis. We also present evidence strongly suggesting that forces other than house price dynamics were behind the household credit cycle during the great recession. Aggregated data points to several robust findings. First, while all debt categories exhibit a strong boom-bust pattern, this pattern is much more pronounced for non-housing debt. Second, non homeowners exhibited a much larger decline in debt balances when compared to homeowners during and after the recession.

Our findings call for a deeper analysis is needed to understand the causes of the sizable reduction in household credit which took place during and after the financial crisis. In ongoing work, we are studying the patterns of geographical variation in the evolution of debt balances by categories, in order to provide a more definitive evidence on the mechanism behind the variation in household credit.

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A Consumer Credit Panel Data and Variables

We briefly describe the construction of each variable in the analysis.

Insolvent: An individual is insolvent if they have at least one loan in their CCP report in that quarter that is 120+ days past due, severely derogatory, or bankrupt (crtr_attr16, crtr_attr17, or crtr_attr18), while not having any loans that are 30, 60, or 90 days past due (crtr_attr13, crtr_attr14, or crtr_attr15). Also, at least one of crtr_attr13, crtr_attr14, or crtr_attr15 must be non-missing, and the individual must not be in a state of bankruptcy.

Foreclosure: There are two scenarios in which an individual is marked as being in the state of foreclosure. First, if the individual forecloses on a home (that is, if cma_attr3905 switches from off ("0") to on ("1" or "7")), then that individual is marked as being in a state of foreclosure for seven years after the date of their foreclosure. Second, if the individual enters the dataset for the first time while under foreclosure (which almost exclusively occurs at the datasets 1999 Q1 truncation), that individual is marked as being in the state of foreclosure until the flag (which is supposed to stay on for seven years after the date of the foreclosure) turns off.

B Income Data

In this section, we describe the supplementary payroll data used for the income imputation procedure. This data is merged with our credit panel data, allowing us to map individuals' incomes for 2009 to their credit files.

The Equifax Workforce Solutions data provided by Equifax is a nationally-representative random sample of individuals containing employment and payroll verification information provided directly from the employers. The information provided for each employee includes the last three years of total income, the date of first hire, tenure, and for the current year status (part time/full time), weekly hours, pay rate and pay frequency.

Income Measure Description There are various income measures provided in the Worknumber dataset. For each year of data available variables are given for the total 12-month base, bonus, overtime, and commission compensation in year t, $t-1$, and $t-2$. This information however is only available for a little over $\frac{1}{3}$ of the sample. The other measure of income, which is widely available across the sample, is rate of pay and pay frequency. We therefore impute total income using a simple *rate* $\times$ *frequency* approach to account for the lack of representation found in the sample regarding the total 12-month income variables. This yields about 11,000 observations for 2009. The sample of records is nationally representative, both in terms of geographical and age distribution.

Comparison with the CPS To gauge the accuracy of the imputed income measure in our data, we performed a simple comparison with the income levels reported in the Consumer Population Survey. We present results based on income quintiles below.

Table 2: Income Distribution Comparison by Quintile

Calculation	Dataset	1	2	3	4	5
Mean	CPS	11058.67	24791.32	36584.61	51872.45	110192.2
	Worknumber	17078.07	26565.46	39589.76	58510.22	117260.1
Median	CPS	12000	25000	36000	50000	85000
	Worknumber	16640	27040	39520	57512	99990

Source: IPUMS, Equifax Worknumber. Worknumber income calculations made using proxied income from pay periods and pay rate. CPS income calculations made using total wage and salary income.