Just the facts: An initial analysis of subprime’s role in the housing crisis

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ABSTRACT

Using two large proprietary datasets from New England, this paper establishes some basic facts about the subprime crisis. First, while unaffordable interest-rate resets are often blamed for setting off this crisis, most subprime borrowers who defaulted did so well in advance of their reset dates. Defaults on subprime adjustable-rate mortgages are more sensitive to declining housing prices than are defaults on fixed-rate loans, however, and the data support a number of alternative explanations for this finding. Second, many borrowers with good credit scores took out subprime loans as the housing boom gathered steam. It is hard to construct a prima facie case that these borrowers were inappropriately steered into the subprime market, however, because the loans that these borrowers took out were too risky for prime treatment. Finally, 70% of Massachusetts homes recently lost to foreclosure were originally purchased with prime mortgages. But subprime refinancing is especially prevalent among owners who were likely to have extracted substantial amounts of equity before they defaulted.

1. Introduction

Subprime mortgages lie at the center of recent turmoil in housing and credit markets. Unfortunately, many housing researchers have been prevented from performing formal analyses of the subprime market due to the difficulty of obtaining appropriate data. Proprietary, loan-level data used by Wall Street investment banks and hedge funds often cost more than $100,000, placing these data out of reach for most housing researchers. Moreover, even these loan-level datasets sometimes paint an incomplete picture, because they do not link various mortgages to the same borrower over time. This paper presents some basic facts about the subprime market using two large, micro-level datasets. These data were purchased by the Federal Reserve Bank of Boston and have been used extensively in policy work. Though the datasets cover only Massachusetts (in one case) and southern New England (in another), we will argue that they are quite useful for understanding the subprime crisis in the nation as a whole.

Three sets of facts emerge from our analysis. The first concerns the relationship between the timing of interest-rate resets and the current surge in subprime defaults. The typical subprime loan was an adjustable-rate “hybrid,” meaning that it had a fixed “teaser” interest rate during an initial 2- or 3-year period, after which the loan reset to a floating rate (usually around 6 percentage points above a short-term interbank lending rate). Many commentators have claimed that a wave of unaffordable resets sparked

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the current crisis. Yet the data show that most borrowers who defaulted on subprime adjustable-rate mortgages (ARMs) did so well in advance of their reset dates. Moreover, the data also show that the initial “teaser” rates were not artificially low; in fact, they were quite high. It is possible that some characteristics of subprime ARMs made foreclosures more likely, even though these foreclosures did not occur precisely at the reset dates. In fact, we find that defaults among subprime ARMs are more sensitive to house price declines than defaults on subprime fixed-rate mortgages (FRMs). However, it is hard to know whether the higher sensitivity stems from features of the ARM contracts, or rather from the characteristics of borrowers who were likely to choose ARMs over FRMs.

A second set of facts concerns underwriting standards of subprime loans. Subprime lending began in the mid-1990s as a way for persons with less-than-perfect credit to purchase homes. Several commentators have noted, however, that the average credit score of subprime borrowers grew as the housing boom gathered steam. The commentators have interpreted this pattern as evidence that persons with good credit were “steered” into subprime loans by unscrupulous mortgage brokers. Our data confirm that persons with high credit scores were increasingly likely to take out subprime loans. Yet the data also show that these borrowers could not have obtained these same loans from prime lenders. The subprime loans taken out by “good” borrowers typically had high loan-to-value (LTV) or debt-to-income (DTI) ratios, or they lacked full documentation of borrower incomes and assets. These heightened risk characteristics would have made these loans unattractive to prime lenders, in spite of the borrowers’ high credit scores. Of course, these higher risk characteristics also made the subprime loans very sensitive to the recent decline in housing prices, helping to explain high defaults among subprime mortgages.2

The third set of facts involves the importance of subprime refinancing to foreclosure. Our data show that slightly less than half (45.2%) of recently defaulted Massachusetts mortgages were subprime loans. This share is close to, though somewhat lower than, figures from national analyses. However, one of our datasets allows us to link mortgages taken out by the same owner on the same house. We are therefore able to analyze the purchase mortgage of each foreclosed home, even if the owner refinanced out of his purchase mortgage before defaulting. While ownerships that begin with subprime mortgages are much more likely to default than ownerships beginning with prime mortgages, less than one-third of homes recently lost to foreclosure in Massachusetts were originally purchased with subprime loans. Somewhat surprisingly, many foreclosed homes were purchased before the early 2000s housing boom and had thus accumulated substantial equity. Though we cannot measure cash-out refinancing directly, we provide suggestive evidence that subprime loans were especially popular among homes that had appreciated in price but that were later lost to foreclosure, due in part to a large extraction of equity.

The paper is organized as follows. Section 2 describes the two main datasets used in our analysis. It also discusses alternative definitions of “subprime” and quantifies the extent of subprime defaults. Section 3 explores the role of interest-rate resets in subprime foreclosures, and compares the performance of subprime ARMs with that of subprime fixed-rate mortgages. Section 4 discusses changes in subprime underwriting standards and the effect that these standards may have had on foreclosure patterns in Massachusetts. Section 5 explores the role of subprime refinances in foreclosures, while Section 6 concludes with a discussion of a crucial outstanding question: whether higher subprime lending in the early 2000s put upward pressure on housing prices.

2. Background and data

2.1. The Warren Group’s Registry of Deeds data

The most fundamental dataset in our research was supplied by The Warren Group, a private Boston firm that has been tracking real estate transactions in New England for more than a century. The Warren Group dataset is a standardized, electronic version of publicly available real estate transaction records filed at Massachusetts Registry of Deeds offices during the past 20 years. The dataset includes the universe of purchase mortgages, refinance mortgages, home equity loans, and purchase deeds transacted in Massachusetts from January 1987 through March 2008. Foreclosure deeds are available starting in 1989. So, for every house purchased in the state during the sample period, we know the location and price of the house, the size of all mortgages associated with the sale,3 and the identity of the mortgage lender, among other variables.

2.1.1. Sales and foreclosures

The Warren Group data allow us to paint a detailed picture of the Massachusetts housing market, both before and after the introduction of subprime lending in the mid-1990s. Fig. 1 presents Massachusetts sales and foreclosures by year, clearly illustrating the state’s two foreclosure waves during the past two decades. The first foreclosure wave occurred in the early 1990s, when the combination of a severe recession and a significant downturn in the housing market resulted in a dramatic increase in foreclosures. In 2006 and 2007, we see evidence of the state’s current foreclosure wave.

1 For example, borrowers might have predicted that they could not have afforded the eventual interest rates after they reset, and defaulted in advance of that date.

2 A natural question is whether the reduced quality of subprime loans is fully responsible for increased defaults among subprime loans originated at the height of the housing boom. Gerardi et al. (forthcoming) investigates this question with a nationwide dataset. They find that subprime loans originated at the end of the boom had worse risk characteristics than those originated earlier, a finding that is corroborated by the results of the current paper as well. But Gerardi et al. (forthcoming) also finds that these changes in risk characteristics are not large enough to explain the astronomical rise in default probabilities among the later vintages of subprime loans.

3 Specifically, we see second mortgages (“piggybacks”) as well any other mortgage secured by the home.
While the absolute number of current foreclosures is approaching early 1990s levels, there are some important qualitative differences across the two foreclosure waves. The early 1990s followed a burst of residential construction in Massachusetts, in which new condominiums were often used as investment vehicles [Jordan, 1992]. When this building boom ended and house prices fell, many of these investment properties ended up in foreclosure. By contrast, residential construction was much more subdued in Massachusetts during the early 2000s boom. The condominium share of foreclosures has been replaced to some extent by foreclosures of multi-family properties, which were built some time ago and which are predominantly located in low-to-moderate income areas.4

Table 1 presents the importance of single-families, condos, and multi-families in the past two foreclosure waves, according to the Warren Group data, along with the share of 1990–2007 purchases attributable to each of the three dwelling types. The share of foreclosures attributable to condominiums has fallen from 33.7% in the earlier wave to only 13.3% recently. By contrast, the share accounted for by multi-families has risen from 20.4% to 28.4%. The bad news for current policymakers is that the negative external effects from multi-family foreclosures are generally more serious than from condo foreclosures. Generally, multi-families are owned by residents of one of the units, with the other residents paying rent. When the owner loses the home, the renters can also be evicted.5

2.1.2. Prices

Our data also allow a careful measurement of housing prices, which have a close theoretical relationship to foreclosures. Standard models of housing finance predict that falling prices make foreclosures more likely by fostering negative equity, which occurs when the outstanding balance on a home mortgage exceeds the market price of the house. Even when the aggregate economy is doing well, individual homeowners often experience life events—such as illness, job loss, or divorce—which cause them to fall behind on their mortgages. When borrowers have positive equity, these adverse life events often prompt profitable sales, or, if the problems are temporary, cash-out refinances. But when equity is negative, borrowers facing adverse life events cannot retire their mortgages with sales at market prices, nor can they tide themselves over with cash-out refinances. Thus, after a sustained decline in housing prices that eliminates home equity, adverse life events often lead to foreclosures.6

In light of the theoretical link between prices and foreclosure, it is important to obtain an estimate of Massachusetts housing prices. Moreover, this estimate should encompass homes typically purchased with subprime mortgages and should not be contaminated by changes in the mix of houses being sold. Repeat-sales indexes, originally suggested by Case and Shiller (1987), attempt to solve problems engendered by a changing sales mix by aggregating price changes on individual homes between sales.7 The Office of Federal Housing Enterprise Oversight (OFHEO) uses the repeat-sales method when constructing its price index for Massachusetts, but this index may not accurately reflect price trends among subprime homes. Purchases that contribute to the OFHEO index must conform to securitization limits set by the government-sponsored housing enterprises, Fannie Mae and Freddie Mac. Because agency-conforming mortgages are generally prime mortgages, the use of a broader price index is important when studying subprime lending.

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4 Multi-family dwellings, meaning properties containing between two and four separate units, accounted for 23.0% of the total housing units in Massachusetts as of 2000 (U.S. Census Bureau, 2005). This percentage is the second highest in the nation (followed only by Rhode Island’s 25.2%) and far exceeds the national average of 9.1%. The iconic multi-family dwelling in Massachusetts is the “triple-decker,” which consists of three units, one of which is typically occupied by the owner while the other two are rented out.

5 Like the speculative condominiums of the early 1990s, purchases of multi-family dwellings in the early 2000s often had an “investment” quality to them, because multi-family purchasers sometimes qualified for purchase mortgages based on the rents they hoped to receive, even if the new owners planned to live in one of the units themselves. This strategy can turn out poorly if rental income is more volatile than the new owners had hoped.

6 This line of thinking is akin to the “double trigger” theory of foreclosure, which holds that foreclosures occur when an owner has negative equity and suffers an adverse life event. We argue elsewhere (Foote et al., 2008) that while the double-trigger explanation essentially gets the facts right, it can be made more theoretically robust by recognizing the roles that credit-constraints and heterogeneity in time-discount rates play in explaining foreclosures at the individual level.

7 A drawback to our repeat sales measure is that it is impossible to know which houses have undergone major renovations in the Warren Group data, and which therefore should be excluded from the repeat sales calculations. We excluded any home that had risen in value by more than 50% for repeat sales within 1 year, and by more than 100% for repeat sales within 3 years, figuring that such a large price increase could only be explained by a renovation. In practice, the precise cutoff that we used to exclude renovations made little difference to our final results. See Appendix A of Gerardi et al. (2007) for details.
Fortunately, the Warren Group data allow us to match individual homes across sales, so we are able to construct a repeat-sales index that uses all properties in the state. Fig. 2 graphs our repeat-sales price index along with the OFHEO index for Massachusetts. Gratifyingly, the two indexes are in close agreement during periods of overlap. Additionally, as is implied by theory, both indexes imply that periods of high foreclosures (as shown in Fig. 1) are also periods of low or negative price appreciation. Our index, however, shows larger price declines during the two housing downturns of the past two decades. This pattern suggests that homes financed with non-conforming mortgages suffered larger price declines during these downturns.\(^8\) More to the point of this paper, the pattern suggests that subprime properties were not spared the declines. Thus, the link in housing prices during the past few years; if any-
suggests that subprime properties were not spared the de-
cline in housing prices during the past few years; if any-

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Year & All ownerships & Ownerships that default \\
 & \# & Mean & Median & \# & Mean & Median \\
\hline
1990 & 44,545 & 0.79 & 0.80 & 2495 & 0.87 & 0.90 \\
1991 & 45,436 & 0.80 & 0.80 & 1218 & 0.90 & 0.95 \\
1992 & 53,807 & 0.81 & 0.80 & 913 & 0.91 & 0.95 \\
1993 & 61,004 & 0.82 & 0.85 & 906 & 0.92 & 0.95 \\
1994 & 66,568 & 0.83 & 0.88 & 931 & 0.92 & 0.95 \\
1995 & 60,762 & 0.83 & 0.88 & 850 & 0.94 & 0.97 \\
1996 & 69,718 & 0.83 & 0.88 & 831 & 0.94 & 0.98 \\
1997 & 74,350 & 0.83 & 0.86 & 822 & 0.93 & 0.97 \\
1998 & 85,947 & 0.83 & 0.85 & 715 & 0.92 & 0.95 \\
1999 & 86,895 & 0.83 & 0.85 & 769 & 0.92 & 0.95 \\
2000 & 78,045 & 0.82 & 0.85 & 776 & 0.92 & 0.95 \\
2001 & 77,645 & 0.82 & 0.87 & 896 & 0.92 & 0.95 \\
2002 & 81,337 & 0.82 & 0.85 & 822 & 0.92 & 0.95 \\
2003 & 86,966 & 0.82 & 0.85 & 1072 & 0.92 & 0.95 \\
2004 & 95,890 & 0.82 & 0.87 & 1875 & 0.94 & 0.98 \\
2005 & 94,539 & 0.83 & 0.90 & 2291 & 0.95 & 1.00 \\
2006 & 79,142 & 0.84 & 0.90 & 1291 & 0.96 & 1.00 \\
2007 & 67,127 & 0.84 & 0.90 & 59 & 0.94 & 1.00 \\
\hline
\end{tabular}
\caption{Initial loan-to-value ratios, by year of purchase.}
\end{table}

Fig. 2. Repeat-Sales Index Constructed with Warren Group Data and OFHEO price index for Massachusetts.

2.1.3. “Ownership experiences” and LTV ratios

In addition to matching individual homes across sales, we are also able to match individual mortgages for a single homeowner during the time he owned a specific house, a period that we term an ownership experience. By constructing ownership experiences, we can carry variables generated at the time of purchase through all of the periods that the owner lives in the home, even if he refinances out of the initial purchase mortgage. An example of such a variable is the homeowner’s initial LTV ratio, which correlates with eventual foreclosure probabilities. Table 2 presents LTV ratios for the complete sample of Massachusetts ownership experiences, as well as for those ownerships that end in foreclosure. The first lesson from the table is that average purchase LTVs have risen over time, from 79% in 1990 to 84% in 2007. (The increase is even greater if one tracks median LTV rather than mean LTV.) A second takeaway from Table 2 is the well-known regularity that high-LTV ownership experiences are more likely to end in default. Average LTVs among defaulting ownership experiences are generally 8–12 percentage points higher than the LTV for the typical ownership experience.

The ability to construct complete ownership experiences makes the Warren Group dataset uniquely valuable for housing research. However, the dataset does have some important shortcomings. The most significant is a lack of information on interest rates. Massachusetts law does not require interest rates on fixed-rate loans to be recorded at deed registries. For ARMs, interest rates are included in special riders to the main transaction records, but the Warren Group has not yet transcribed this information electronically (with some exceptions discussed below). Another disadvantage of the Warren Group dataset is that it does not tell us when any particular mortgage is paid off, or discharged. The lack of discharge information prevents us from calculating the amount of cash-out refinancing at various points.\(^9\) Finally, the Warren Group dataset does not include any demographic information about borrowers, such as income, race, or previous credit history.

2.2. LoanPerformance (LP) data

Most of our information on interest rates and other detailed mortgage characteristics comes from the First-

\ \^8\ We also compared our index to the S&P/Case–Shiller price index for Boston. This index includes homes purchased with both conforming and non-conforming mortgages, but only for the Boston area. The S&P/Case–Shiller price index also showed larger price declines during the housing downturns of the early 1990s and the mid-to-late 2000s.

\ \^9\ Obviously, if a new mortgage is used to pay off an old one, then the amount of cash left over for the homeowner will be much smaller than if the old mortgage remains on the books. Therefore, calculating the amount of equity taken out of the house with any degree of accuracy requires us to know when and if a particular mortgage is discharged. Discharges are officially registered at Massachusetts deeds offices and we are currently looking into ways of adding them to the Warren Group data. An obvious case where discharges can be inferred is when we have the data to do have is when a house is sold, in which case all outstanding mortgages are discharged.
American LoanPerformance company (LP). This firm collects information on individual loans that have been packaged into non-agency, mortgage-backed securities (MBS) and sold to investors in the secondary mortgage market. We refer to two separate LP datasets in our research. The first is a loan-level dataset that the Boston Fed purchased from LP in mid-2007. This dataset covers Massachusetts, Connecticut, and Rhode Island from 1992 through August 2007. Elsewhere in this paper, we will refer to summary statistics generated by a nationwide LP dataset that was purchased by the Board of Governors of the Federal Reserve System in Washington, D.C., and used by research economists there.

The major strength of the LP dataset is its extensive loan-level information on interest rates and other lending terms. It also contains information regarding the type of MBS each loan was packaged into—subprime, Alt-A, or prime. In addition, the LP dataset also includes information on borrowers. For approximately 97% of the loans in our sample we know the borrower’s FICO score. This calculation includes the amount of the monthly mortgage payment divided by the borrower’s monthly income, while for virtually every loan in our sample we know the combined LTV ratio implied by the size of the loan and the value of the house. A major shortcoming of the LP dataset is the inability to create complete ownership experiences by matching loans made to the same borrower on the same house. Also, the LP dataset has only limited information on borrowers. Like the Warren Group dataset, the LP dataset does not include demographic information such as race, education, or gender.

2.3. Defining the subprime market

A paper discussing facts about the subprime market obviously needs a definition of “subprime” lending, but there is no single way to define the subprime market. One description could be based on the characteristics of borrowers. A subprime borrower could be someone who has missed a mortgage payment during the past year or two, who has filed for bankruptcy in the past few years, or who has a low FICO score for other reasons. However, as we will see, many borrowers with good credit scores also made use of the subprime market, especially at the height of the housing boom. Alternatively, a subprime definition could be based on lenders. Many lenders typically, but not exclusively, originated loans to subprime borrowers, generally with high fees and interest rates. Yet these same lenders also made loans to prime borrowers. Finally, we can construct a subprime designation using information on characteristics of the loans. For example, we could define a subprime loan to be a mortgage that was packaged into a subprime MBS.

The availability of different information in our two main datasets leads to different definitions of the subprime market. The Warren Group dataset does not contain mortgage interest rates or credit scores, so we use the identity of the lender to characterize individual mortgages as subprime or prime. Our list of subprime lenders comes from the Department of Housing and Urban Development (HUD), which has maintained a list of predominantly subprime lenders since 1993. HUD bases this list on characteristics of lenders’ business models that are generally associated with subprime lending. By standardizing this list across years and matching it to the lender variable in the Warren Group dataset, we can designate loans in this dataset as subprime or prime. A drawback of this approach is that subprime lenders sometimes make prime loans. To get a sense of the misclassification that the use of the HUD list is likely to generate, we checked our subprime classification against interest rates in a small subsample of ARMs that the Warren Group had recorded electronically. The results were encouraging. Of the mortgages in the Warren Group data that were identified as subprime from the HUD list, and for which interest rate information is available, approximately 93% had an initial rate of at least 200 basis points above an equivalent prime mortgage rate, or had an associated margin of at least 300 basis points above the typical benchmark interest rate used for determining subprime rates.

Table 3 presents the total share of subprime mortgages in the Warren Group data using the HUD-list definition. The table suggests that the subprime share in Massachusetts is comparable to, though somewhat lower than, the subprime...
Table 3
Subprime shares (in percent) for Massachusetts mortgages by origination year.

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<tbody>
<tr>
<td>Allmortgages</td>
<td>4.4</td>
<td>5.7</td>
<td>4.4</td>
<td>4.4</td>
<td>5.3</td>
<td>9.2</td>
<td>11.7</td>
<td>10.3</td>
<td>3.6</td>
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<tr>
<td>Purchasemortgages</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>4.0</td>
<td>7.0</td>
<td>10.1</td>
<td>14.8</td>
<td>13.1</td>
<td>3.1</td>
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<tr>
<td>By house type</td>
<td></td>
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</tr>
<tr>
<td>Single-family purchase</td>
<td>2.3</td>
<td>2.3</td>
<td>2.6</td>
<td>3.5</td>
<td>5.9</td>
<td>8.6</td>
<td>13.2</td>
<td>11.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Condominium purchase</td>
<td>2.2</td>
<td>2.1</td>
<td>2.2</td>
<td>2.5</td>
<td>4.3</td>
<td>6.0</td>
<td>10.7</td>
<td>10.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Multi-family purchase</td>
<td>4.2</td>
<td>4.6</td>
<td>6.4</td>
<td>9.4</td>
<td>18.0</td>
<td>26.4</td>
<td>32.6</td>
<td>28.6</td>
<td>5.8</td>
</tr>
</tbody>
</table>

18 The Mayer and Pence data quoted in this paragraph come from their Fig. 1b found on page 22.
19 For a borrower with a small downpayment, the purchase of an expensive multi-family property would require a mortgage with a high-LTV ratio. As we will discuss, such a mortgage may have been unattractive to prime lenders.

share for the nation as a whole. Mayer and Pence (2008) construct a series of subprime shares using the HUD list and nationwide data collected as part of the Home Mortgage Disclosure Act (HMDA) for 1998–2005. They find that the subprime share of all originations fluctuates between about 8% and 12% from 1998 through 2003. In 2004 and 2005, the national subprime share rises sharply, reaching about 18% in those 2 years. Table 3 shows that this general pattern is also found in the Massachusetts data, though our series is about 5–7 percentage points lower than the national data. For national purchase mortgages, Mayer and Pence find a similar time-series pattern, with this share rising in 2004 and 2005 to about 15% and 18%, respectively. Our data also show a purchase-share peak in these years, though again the Massachusetts data are a few percentage points lower. The lower rows of Table 3 disaggregate the subprime share of purchase mortgages in the Warren Group data for each of the three types of residences. The table shows that subprime purchases were especially popular among multi-family homes at the height of the housing boom, with the subprime fraction of multi-family purchases reaching 32.6% in 2005. This high share is not surprising, because multi-family homes are typically located in low-to-moderate income areas and are often more costly (taking all housing units together) than the purchase of just one housing unit in a single-family home. The bottom line of this analysis is that subprime lending is likely to be somewhat less important in Massachusetts than for the nation as a whole, while the particular pattern of subprime lending is affected to some extent by the prevalence of multi-family homes in the state. But the time-series pattern of subprime lending in Massachusetts is qualitatively similar to that for the entire country.

In the LP data, creating the subprime loan designation is conceptually easier. Subprime mortgages are those that were securitized into a subprime MBS (as opposed to prime or Alt-A). No restriction is made on the FICO score of the borrower. Also note that, unlike the Warren Group dataset, the subprime definition is not based on the originator of the mortgage, but rather the type of security into which the mortgage was grouped in the secondary market. Fig. 3 illustrates the evolution of borrower and loan characteristics among subprime loans in the LP dataset. Because much of the discussion below will focus on differences between subprime ARMs and FRMs, we present data for these two types of loans separately. Panel A shows that average FICO scores generally improved over the sample period; we will have more to say on this topic below. Panel B shows that LTV ratios were generally rising during the housing boom, especially for ARMs. By 2006, the average LTV ratio for subprime ARMs was in excess of 90%, with the average LTV for FRMs very close to that level. Panel C shows that DTI ratios were in excess of 40% for both types of loans by the end of the sample period. Finally, the last panel shows that the fraction of fully documented loans declined for both types of loans after 2000, though this decline was more consistent among ARMs than FRMs. All in all, most of the risk characteristics of subprime loans deteriorated over the sample period, with the notable exception of FICO scores.

2.4. Quantifying subprime defaults

We next turn to the quantitative importance of subprime defaults, using the universe of Massachusetts mortgages in the Warren Group data. The first column of Table 4 shows the percentage of defaulted mortgages from 2006–2007 that were originated by subprime lenders. This fraction ranges from more than half for multi-family homes to slightly more than 40% for single-families and condos. Across all types of homes, the fraction is 45.2%, a number that is close to, but somewhat lower than, subprime fractions found in nationwide studies. For example, Nothaft (2008) found that around 52–56 percentage of defaulted mortgages during this period were subprime. The discrepancy of approximately 10 percentage points may reflect differences in the Massachusetts housing market relative to the rest of the country, or differences in the way that the two studies define subprime mortgages. Because the Warren Group data allows us to link mortgages within the same ownership experiences, we can also ask how many foreclosed homes were originally purchased with subprime mortgages. These fractions, reported in the second column of the table, range from a low of about one quarter for single-family homes to a high of 43% for multi-families. The overall share, across all three types of homes, is 30%.

One implication of Table 4 is that many prime purchasers refinanced into subprime loans before defaulting. This is seen by noting that the subprime share of defaulted mortgages in the first column is larger than the subprime shares among purchase mortgages of foreclosed homes in the second column. The last section of the paper investigates this type of refinancing activity in detail. A second takeaway from Table 4 is that subprime purchases default
more often than prime purchases. Although the share of subprime purchase mortgages peaked at slightly less than 15% (Table 3), about 30% of recently foreclosed homes were purchased with subprime mortgages (Table 4).

Fig. 4 explores foreclosure propensities of various homes in detail, by presenting cumulative default hazards disaggregated by subprime-purchase status, type of house and purchase year.20 A comparison of the two rows in the figure reveals that subprime purchases are more likely to default, no matter what the type of house or purchase-year cohort. (Note the different vertical scales across the two rows.) For prime single-families and condos purchased in 2005–2006, the cumulative default hazard reached about 1.3% at the end of 2007. For the same types of homes purchased with subprime mortgages, the corresponding hazard was 11.9%. A large discrepancy in foreclosure rates also exists for multi-family homes. The cumulative hazard for multi-families purchased with subprime mortgages in 2005–2006 reached nearly 25% by the end of 2007. The corresponding hazard for prime multi-families was about 8%.

The next two sections of the paper evaluate some potential explanations for high subprime default probabilities related to interest rates and underwriting standards. But at this point, it is useful to point out that Fig. 4 is consistent with the theoretical link between falling prices and foreclosures discussed earlier.21 The figure shows that homes purchased late in the housing boom are more likely to default than homes purchased earlier, and that this pattern is true for both prime and subprime purchases. One explanation for this pattern is that homes purchased early in the boom are more likely to have amassed positive equity before house prices fell, whether or not they were purchased with prime or subprime loans. Of course, the fact that falling prices played a role in defaults does not mean that other potential factors were unimportant for subprime loans. In the next section, we investigate the role of one such factor: interest-rate resets on subprime hybrid ARMs.

3. The role of subprime ARMs and interest-rate resets

Many of the policy proposals that were initially advanced to address the housing crisis involved interest-rate resets among subprime hybrid ARMs.22 This section

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20 A cumulative default hazard is a measure of how many foreclosures are likely to have occurred among a group of homes purchased in some year, as a function of how much time has elapsed since the purchases took place. The cumulative default hazard takes into account the fact that some homeownerships are “right-censored” with respect to foreclosure. That is, in every period, some homeownerships end in a sale rather than foreclosure, and therefore drop out of the pool of potential foreclosures for the next period. As a result, a cumulative default hazard is not strictly the probability that a given house purchased in some period will be foreclosed some time later.

21 Gerardi et al. (2007) estimate a formal duration model of default using the Warren Group data. The explanatory variables in their model include LTV ratio at purchase, type of residence, cumulative price appreciation since purchase, and subprime-purchase status. The paper finds a strong (negative) role for cumulative appreciation in defaults for both prime and subprime purchases. Consistent with Fig. 4, the paper also shows that subprime purchases are about six times more likely to default than prime purchases, all else equal.

22 In December 2007, the White House announced the voluntary Hope Now initiative, in which lenders agreed to suspend interest-rate resets for 5 years for borrowers who could afford their mortgages only at their initial interest rates. Resets are also a component of the government’s new FHA Secure program, announced in August 2007. This program initially allowed borrowers who were delinquent on their mortgages to qualify for new FHA loans, but only if these delinquencies resulted from previous interest-rate resets. In April 2008, the program was extended to borrowers who had missed a limited number of payments either before or after their resets.
describes the general lending model that gave rise to the hybrid ARM. We then assess the link between the timing of interest-rate resets on these mortgages and defaults. We conclude with a comparison of the sensitivity of ARMs and FRMs to declines in housing prices and a puzzle related to how these mortgages were priced.

### 3.1. The subprime business model

Proponents of the centrality of resets in the current crisis based their view on the following logic. Subprime hybrid ARMs offered borrowers extremely low “teaser” rates for some initial period (usually 2 or 3 years) but then these mortgages “exploded” to high rates thereafter. Lenders found such loans attractive because of the high post-reset interest rates. Borrowers found them attractive because of the teaser, but later regretted their decisions when they found themselves paying high post-reset interest rates. Is this an accurate description of the subprime lending model? No.

First, there was never something like a low “teaser” rate on the typical subprime ARM. Table 5 presents summary statistics from the Board of Governor’s LP dataset on “2/28” mortgages originated from 2004 to 2007. This type of 30-year mortgage is by far the most common type of subprime ARM. The “2” in the 2/28 designation indicates that the interest rate is fixed for the loan’s first 2 years. For the remaining 28 years, the interest rate adjusts every 6 months until the mortgage is paid off. Almost all 2/28s were fully amortized, meaning that the borrower repays some of the principal with every monthly payment. Table 5 illustrates the calculation, showing both the average margin and the average fully indexed rates. When the 2004 cohort of mortgages reset in 2006, the 6-month LIBOR 2 years after origination is assumed to be 3.0% (the April 2008 value) to allow comparison with other cohorts.

Table 4

<table>
<thead>
<tr>
<th>Type</th>
<th>Subprime fraction of defaulted mortgages</th>
<th>Fraction of defaulted ownerships purchased with subprime mortgages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family</td>
<td>42.2%</td>
<td>24.3%</td>
</tr>
<tr>
<td>Condominium</td>
<td>40.1%</td>
<td>27.3%</td>
</tr>
<tr>
<td>Multi-family</td>
<td>53.3%</td>
<td>43.0%</td>
</tr>
<tr>
<td>All</td>
<td>45.2%</td>
<td>30.0%</td>
</tr>
</tbody>
</table>

Table 5
Interest rates for subprime 2/28 mortgages, by year of origination.

<table>
<thead>
<tr>
<th>Year of origination</th>
<th>Initial (pre-reset) interest rate</th>
<th>1-year prime ARM rate</th>
<th>Margin of fully indexed (post-reset) rate over benchmark rate</th>
<th>Fully indexed interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>7.3</td>
<td>3.9</td>
<td>6.1</td>
<td>11.5</td>
</tr>
<tr>
<td>2005</td>
<td>7.5</td>
<td>4.5</td>
<td>5.9</td>
<td>10.5</td>
</tr>
<tr>
<td>2006</td>
<td>8.5</td>
<td>5.5</td>
<td>6.1</td>
<td>9.1</td>
</tr>
<tr>
<td>2007</td>
<td>8.6</td>
<td>5.7</td>
<td>6.1</td>
<td>9.1</td>
</tr>
</tbody>
</table>

Note: The 2006 and 2007 cohorts of mortgages reset in 2008 and 2009. For these mortgages, the 6-month LIBOR 2 years after origination is assumed to be 3.0% (the April 2008 value) to allow comparison with other cohorts.
averaged about 11.5%. Similar numbers hold for the 2005 loans, which reset in 2007.

A comparison of the first and last columns of Table 5 shows that the fully indexed interest rates were about 3–4 percentage points higher than initial rates for mortgages originated in 2004 and 2005. This would lead to a monthly payment increase, or “payment shock,” of about 25%. While sizable, this payment shock is small compared to, say, payment shocks in the credit card market, where interest rates can easily increase by a factor of five when teaser rates expire. In addition, a simple comparison of pre- and post-reset interest rates on 2/28 mortgages typically overstates the payment shocks experienced by people who bought homes with subprime mortgages. During the height of the housing boom, many subprime purchasers also used second mortgages (“piggybacks”) when they bought homes, because they did not make downpayments of at least 20%. These second mortgages had high interest rates and short amortization schedules, so they accounted for a disproportionate share of a borrower’s monthly house payment. Moreover, these mortgages were almost always fixed-rate loans, so they were not affected when the interest rate adjusted on the main subprime loan. The presence of second mortgages therefore limited the percentage increase in a borrower’s house payment that was caused by the interest-rate reset of the main 2/28 mortgage. Specifically, a reset on a 2/28 mortgage only affected about 60% of the typical borrower’s monthly payment.23

Finally, subprime lenders anticipated that most borrowers would refinace their mortgages before or shortly after their interest-rate resets. Table 6 presents data on the disposition of subprime 2/28s in the Boston Fed’s LP dataset.24 For the years 2001–2005, the disposition is measured as of 27 months after origination, which is 3 months past the reset date. The first row shows that only 22.3% of subprime 2/28s originated in 2001 were still active 3 months after origination. About two-thirds of the original 2001 pool (66%) had already been refinanced, with the remainder either in foreclosure or seriously delinquent. The refinanced shares for the 2002 and 2003 mortgages are even higher, 74.1% and 74.6%, respectively. Clearly, most subprime borrowers did not spend much time paying on mortgages that had reached their reset dates. Lenders would have understood this and would not have relied on high post-reset payments to construct a profitable business model.

### Table 6

<table>
<thead>
<tr>
<th>Year of origination</th>
<th>Percent active</th>
<th>Percent refinanced</th>
<th>Percent foreclosed</th>
<th>Percent 60–90 days delinquent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001 24 months after origination</td>
<td>22.3</td>
<td>66.0</td>
<td>8.4</td>
<td>3.3</td>
<td>100</td>
</tr>
<tr>
<td>2002 24 months after origination</td>
<td>15.8</td>
<td>74.1</td>
<td>6.5</td>
<td>3.6</td>
<td>100</td>
</tr>
<tr>
<td>2003 24 months after origination</td>
<td>15.5</td>
<td>74.6</td>
<td>6.2</td>
<td>3.7</td>
<td>100</td>
</tr>
<tr>
<td>2004 24 months after origination</td>
<td>17.9</td>
<td>68.0</td>
<td>10.5</td>
<td>3.7</td>
<td>100</td>
</tr>
<tr>
<td>2005 24 months after origination</td>
<td>23.4</td>
<td>53.5</td>
<td>20.2</td>
<td>3.0</td>
<td>100</td>
</tr>
<tr>
<td>2006 24 months after origination</td>
<td>42.4</td>
<td>27.1</td>
<td>28.3</td>
<td>2.2</td>
<td>100</td>
</tr>
<tr>
<td>2007 24 months after origination</td>
<td>65.5</td>
<td>12.3</td>
<td>21.5</td>
<td>0.7</td>
<td>100</td>
</tr>
</tbody>
</table>

### 3.2. Subprime foreclosures and the timing of interest-rate resets

As we move down the rows in Table 6 the increase in foreclosures among later vintages of mortgages becomes apparent. Data for the 2006 and 2007 2/28s reflects their status as of March 2008, not after 27 months, because mortgages made in these years have generally not been in existence for a full 27 months. Even with this shorter horizon, however, foreclosure rates for the 2006 and 2007 mortgages are much higher than those of other years. Fully 28.3% of 2/28s originated in 2006 are in foreclosure. The 2007 vintage is not far behind at 21.5%.

A closer look at the data shows little or no relationship subprime defaults and reset dates. Fig. 5 displays monthly default probabilities for three yearly vintages of subprime 2/28s, again from the Boston Fed’s LP dataset. Default probabilities typically rise rapidly until the loans are about 12 months old, then decline gradually thereafter. If mortgage resets were a direct cause of foreclosure—or at least an important precipitating factor—then we would expect to see spikes in default rates at or shortly after 24 months. Yet for the two vintages originated more than two years ago (2002 and 2005), no such spikes appear. Indeed, if a vertical line were not placed on the figure at 24 months, it would be difficult to notice anything special about this
month. The most salient feature of Fig. 5 is the large increase in default probabilities for the later vintages that took place before the reset occurred. For the 2006 vintage, default probabilities are about four times higher than the 2002 cohort, even though the 2006 loans had not yet reset at the time that the figure was created. The increase in defaults for the 2005 cohort is also substantial in its pre-reset period.

3.3. The effect of falling prices on subprime ARMs and FRMs

The previous results suggest that the timing of resets has little or no relationship to the timing of defaults. But this finding does not rule out the possibility that characteristics of subprime ARMs made them more likely to default. In particular, the data show that defaults among subprime ARMs were more sensitive to declines in housing prices than were defaults on subprime FRMs.

Using the Boston Fed’s LP dataset, Fig. 6 graphs the estimated 24-month foreclosure probability of adjustable-rate and fixed-rate subprime mortgages, as a function of cumulative price appreciation during the first 12 months of the loan. In Panel A, no controls are included for risk characteristics of individual borrowers. By contrast, Panel B controls for FICO scores, LTVs, the presence of second mortgages, and documentation status. In both panels, the gray bars are standard-error bands. The figure shows that when house prices grow rapidly (at more than 10% per year), there is no significant difference in foreclosure rates between FRMs and ARMs, with or without controls for borrower and loan characteristics. However, as house price growth decelerates and falls below 10%, differences do emerge. Moving from right to left in both panels, average default rates on ARMs rise much more rapidly as prices fall than do the default rates on FRMs. Once house price growth becomes strongly negative, the standard error bands no longer overlap, suggesting a statistically significant difference in foreclosure propensities between the two types of loans. Note that controls for borrower and loan characteristics make some difference to the average gap between the two lines in each panel, suggesting that these characteristics do help predict the average level of foreclosures. However, the differential sensitivity of ARMs to falling prices is present with or without the controls.

There are number of reasons why subprime ARMs are more sensitive to falling prices. One is that ARM borrowers might have expected to refinance within the initial 2- or 3-year period of their mortgages. When house prices fell, these borrowers may have correctly surmised that their chances to refinance their loans had fallen. If these borrowers believed that they could not have afforded their fully indexed interest rates, then they may have simply defaulted well in advance of their reset dates. (Fixed-rate mortgages, by contrast, offer more flexibility in refinancing due to the lack of a specific reset date.) If this theory is correct, it implies that a specific feature of ARM contracts made these mortgages more sensitive to falling prices. But the differential sensitivities in Fig. 6 could also result from differences in borrowers likely to choose ARMs over FRMs. ARM borrowers may have had higher expectations for future price appreciation than FRM borrowers. Alternatively, ARM borrowers may have also been less “financially literate,” with the implication that these borrowers were more likely to run into liquidity problems during periods of declining house prices than FRM borrowers.

3.4. A related puzzle on the pricing subprime of ARMs and FRMs

A related issue concerns how subprime ARMs and FRMs were priced in the market. We would expect the initial interest rate for a hybrid ARM to be much lower than the interest rate on an FRM, because the ARM borrower is taking on
interest-rate risk. In the data, however, initial rates on ARMs and FRMs are strikingly close. Table 7 presents interest-rate differentials on FRMs versus ARMs from regressions run on 1998–2007 data from the Boston Fed’s LP dataset. Row 1 shows that the typical interest rate on a fixed-rate loan appears lower than the typical ARM rate when we perform a simple comparison of raw averages. This difference may not be the true cost of using a fixed-rate product, however, given the systematic differences between borrowers that choose ARMs and those that choose FRMs. As we have seen, fixed-rate borrowers tend to have better FICO scores and lower LTVs than ARM borrowers, and they are also more likely to fully document their mortgage applications. These good characteristics partially explain why FRM borrowers enjoyed relatively low interest rates. Row (2) controls for differences in borrower credit histories by adding a flexible control for borrower FICO scores in the regression. The interest-rate differential turns positive and equals about 14 basis points. While this estimate is statistically significant, it is small in magnitude. In row (3), we add some additional controls, but the difference remains quantitatively small. Finally, row (4) uses data from 2005–2007 only, but the regression again implies a small difference in interest rates of slightly more than 16 basis points.

This small differential is difficult to explain. One possible interpretation is that ARM borrowers do not bother to demand a risk premium because they expect to refinance before their resets hit. Alternatively, ARM borrowers could be more likely to fold their closing costs into their mortgages, paying these costs with higher interest rates. If so, then the resulting increase in the ARM interest rate could mask a true rate differential between FRMs and ARMs that actual borrowers face in the market. Finally, financial literacy may also play a role. If ARM borrowers are unable to quantify the degree of interest-rate risk they take on with an adjustable-rate product, then these borrowers may not demand to be compensated for this risk with lower initial interest rates. Unfortunately, our data do not allow us to test these hypotheses directly, nor do they allow tests of theories to explain the differential default sensitivities shown earlier in Fig. 6. We therefore leave these questions for future research.

4. The role of subprime underwriting standards

Differences in underwriting standards and in corresponding risk characteristics will obviously affect the performance of different types of mortgages. In popular accounts, the most-often mentioned risk characteristic of a subprime loan is the credit history of the borrower. While subprime lending originated as a way to serve borrowers with tarnished credit histories, the mature subprime mortgage market cannot be characterized along the single dimension of borrower credit quality. Subprime loans were riskier than prime loans for other reasons as well. In this section, we discuss how underwriting standards for subprime loans changed as the housing boom matured. We then explain how changing risk characteristics made subprime loans highly sensitive to declines in housing prices.

4.1. Explaining rising FICO scores among subprime borrowers

Fig. 7 investigates risk characteristics for all types of subprime borrowers (grouping ARMs and FRMs together), illustrating how the characteristics of different types of subprime borrowers changed over time. To set the stage, we can simply note that the average FICO score of subprime borrowers was rising. This fact is reflected in Panel A of Fig. 7; the higher line in this panel is the fraction of subprime borrowers that had a FICO score of 620 or higher. This fraction rises from slightly less than 40% in 1999 to around 70% by 2004. Increases in the fraction of high-FICO borrowers in subprime pools have also been found in other nationwide datasets (Gerardi et al., forthcoming; Brooks and Simon, 2007). These increases suggest that the quality of the subprime pool was actually getting better over time.

We saw in Fig. 3, however, that other risk characteristics of subprime loans deteriorated over the sample period, so that a plot of average credit scores presents an incomplete picture of the riskiness of subprime loans. The lower line in Panel A of Fig. 7 plots the fraction of subprime loans for which the borrower had a credit score of 620 or higher, the DTI ratio on the loan was 40% or less, the LTV ratio was 90% or less, and full documentation of the application was provided. This fraction begins at about 13% in 1999 and falls to around 5% by 2006. In contrast to the graph of bor-

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26 The data for the table come from subprime first-lien mortgages used for home purchases only.

27 A difference of 14 basis points is only 14 one-hundredths of a percentage point, so this implies an adjustable-rate mortgage with an 8% interest rate could be replaced with a fixed-rate mortgage with an 8.14% interest rate.
rrower credit scores, this more complete measure of sub-
prime loan quality is getting worse over time.

The opposite movements of the two lines can be recon-
ciled by asking why the share of high-FICO borrowers is
rising over time. One reason typically offered for the pres-
ence of high-FICO borrowers in the subprime market is
that they were inappropriately steered there by unscrupu-
lous mortgage brokers in search of higher commissions.
While this is a possibility, high-FICO borrowers will also
show up in the subprime pool if they desire mortgages that
are riskier than those offered by prime lenders.

Panel B of Fig. 7 illustrates this point by showing the
evolution of average LTVs for different cohorts of sub-
prime borrowers. The horizontal axis groups borrowers
into seven categories based on their credit scores. Each
line in the figure represents a 2-year cohort of subprime
loans. For the earliest cohort (1999–2000), the average
LTV is around 80% for borrowers in the lowest category,
suggesting an average downpayment of 20%. The LTV is
only slightly higher for borrowers in this cohort with
the highest credit scores. As the years pass, however,
the difference in LTVs across different FICO classes be-
gins to grow. By 2005–2006, average LTVs for the low-
est-score borrowers had risen to around 85%, but
average LTVs for the highest-score borrowers had surged
to near 95%.

A similar analysis for documentation status is shown in
Panel C. In the earliest years of the sample, the fraction of
fully documented loans made to the lowest-FICO borrow-
ers was between 70 and 80%. The corresponding fraction
for high-FICO borrowers was about the same. But in
2001, the fraction for high-FICO borrowers began to fall.
By 2005–2006, the fraction of fully documented loans for
high-FICO borrowers had declined all the way to 40%, even
though the corresponding fraction for the low-FICO bor-
rrowers had changed only a little since the start of the sam-
ple period. Qualitatively, this pattern resembles that of the
previous graph of LTVs; the riskiness of the entire sub-
prime pool grew because of the behavior of the high-FICO
borrowers.

Finally, Panel D displays the third indicator of loan risk,
the DTI ratio. Early in the sample, DTIs for the lowest-FICO
borrowers in the subprime pool were somewhat higher
than those for the highest-FICO borrowers. The subsequent
behavior of this characteristic is different than that of the
previous two characteristics, in that DTIs deteriorated for
borrowers of all FICO classes, not just the high-FICO bor-
rrowers. By the end of the housing boom, average DTIs for
all borrowers exceeded 42%.

Taken together, the three risk characteristics—LTVs,
documentation status, and DTIs—tell a consistent story.
All of these indicators moved in the direction of greater
risk as the housing boom progressed and house prices moved higher. For LTVs and documentation status, most of this movement was caused by borrowers with high credit scores who were entering the subprime pool in larger numbers. In all likelihood, it would have been impossible for these borrowers to find prime lenders willing to make loans as risky as the subprime loans they eventually obtained. Prime lenders would have required larger downpayments, they would have insisted on lower DTI ratios, and they would have demanded better documentation of income and assets.

4.2. Implications

There are at least three important implications of these findings. First, from a policy perspective, they speak to the issue of whether some of the high-FICO borrowers were inappropriately steered into the subprime market. It is possible that little such coercion occurred. Mortgage brokers may have simply found subprime lenders that were willing to make the risky loans that high-FICO borrowers themselves had determined were appropriate, given the market prices of the homes that they wanted to buy. As prime borrowers would have frowned on these loans, the subprime market was the only option available. The evidence is not supportive of the view that borrowers were steered into the subprime market for loans they could have received more cheaply elsewhere. But it does not speak to the possibility that borrowers were steered into buying homes or borrowing amounts of money that required them to take subprime loans. In any case, the problem of “potentially prime” borrowers stuck in subprime loans is mitigated by the risk-based pricing models used by most subprime lenders. Using our LP data, we calculated the percentage of subprime loans for owner-occupied homes that had an LTV of 90% or below, that were fully documented, that had borrower FICO scores of 620 or higher, and had a DTI of 45% or less. About 9.6% of the subprime mortgages in the LP data met all of these criteria, so about 10% of the borrowers with outstanding subprime loans could have qualified for prime loans. We then asked whether these borrowers were paying the onerous terms typically associated with subprime loans. Of these borrowers, approximately 65% had fixed interest rates. Furthermore, the average initial interest rate for these loans was 6.7%, the median was 6.6%, and the 90th percentile rate was 7.9%. By contrast, only 29% of all subprime loans in the dataset were fixed-rate instruments, and the average interest rate calculated over all subprime loans was 7.7% (90th percentile was 9.4%). This calculation shows that the borrowers that can be identified as “potentially prime” already had much more favorable mortgage terms than the typical subprime borrower.

A second implication of our findings concerns claims by some commentators that the subprime crisis is proof that “some people should not own houses.” Implicit in this view is the notion that the subprime market is wholly characterized by irresponsible low-FICO borrowers who lack the financial or emotional wherewithal to remain current on mortgages. It is true that the subprime market originally specialized in serving borrowers with tarnished credit histories. Yet we have seen that risky subprime loans were also made to borrowers with high FICO scores. Thus, blaming borrowers with low credit scores for the subprime mess is a vast oversimplification of the problem. Understanding why prime borrowers stretched themselves into risky loans available only in the subprime market would seem to be a more productive line of research.

A final implication concerns the debate over the whether the subprime crisis resulted from poor underwriting standards, which placed people in unaffordable mortgages, or from falling house prices, which brought about widespread negative equity and thus prevented profitable sales or refinances when borrowers suffered adverse life events. To us, this is an artificial debate. We learn from Figs. 3 and 7 that subprime LTV ratios rose during the housing boom. Because loans with high LTV ratios have small equity cushions, they are more likely to suffer from negative equity when house prices fall. Other panels of Figs. 3 and 7 showed that the prevalence of high DTI ratios and low-doc or no-doc loans rose in the subprime market over time. These are precisely the types of loans that are likely to cause borrower distress when adverse life events occur.28 Thus, these loans will default more often when house prices fall. All in all, the right way to think about the subprime housing crisis is that both falling prices and relaxed underwriting standards were important. Looser underwriting standards created a class of loans that were highly sensitive to falling prices. When housing prices did fall, subprime loans therefore defaulted in greater numbers than prime loans. But, if prices had not fallen, we would not have seen nearly the number of subprime foreclosures that we did.29

5. The role of subprime refinancing

In this section, we take a closer look at subprime refinancings. Table 1 showed that the subprime fraction of defaulted loans was larger than the subprime fraction of purchase mortgages of foreclosed homes. This discrepancy indicates that many prime purchasers refinanced into subprime loans before defaulting. A main motivation for refinancing is to liquify home equity in a cash-out refinancing. Though our data do not allow us to measure cash-outs directly, we can use the purchase date of homes to get a rough indication of how much equity was available to be cashed out. According to our state-wide repeat-sales index, average Massachusetts house prices increased by more than 60% from 1999 to early 2008. If we find that homes purchased in 1999 or before were eventually lost to foreclosure, it is likely that the owners refinanced at one or more points along the way in order to extract equity. Our data allow us to count the number of mortgages in each ownership experience to test this hypothesis.

28 Higher DTI ratios increase the probability that a borrower suffering a decline in income or an increase in expenses will find his mortgage payment onerous. A lack of complete documentation acts as a “multiplier” on the effect of DTI, since the true DTI is likely to be higher than the DTI listed on the loan.

29 See Gerardi et al. (2007) for some calculations along these lines.
In fact, the data do show that many of the prime purchases that were eventually lost to foreclosure were purchased in 1999 or earlier, so they were likely to have amassed substantial equity. Fig. 8 presents the absolute numbers of 2006–2007 Massachusetts foreclosures grouped by type of house, subprime-purchase status, and year of purchase. The top panel plots the data for prime purchases. Of the 4389 single-family foreclosures designated as prime purchases, almost half (2087) were purchased in 1999 or before. Across all types of homes, there were 6961 prime purchases foreclosed upon in 2006 and 2007. Of these, 2965 (42.6%) were purchased before 1999.

Fig. 8 also confirms our other findings. We saw in Fig. 4 that foreclosures are high among homes purchased at the height of the housing boom, presumably because these homes never had a chance to amass positive equity before prices started falling. As we would expect, Fig. 8 confirms that homes purchased in 2003–2005 are strongly represented in 2006–2007 foreclosures. Additionally, Fig. 8 illustrates the high rates of foreclosure among multi-family homes, particularly for multi-families purchased with subprime mortgages near the height of the recent boom (2003–2005). The absolute number of subprime multi-family foreclosures from the 2003–2005 cohort (898) is close to the number of subprime single-family foreclosures in that cohort (1024), even though the multi-family purchases were far less common than purchases of single-family homes in this period.

We next look for evidence of refinancing activity among homes that had appreciated in price. Table 8 shows that foreclosed homes experienced higher refinancing activity than homes that were purchased at the same time, but that have not yet been foreclosed upon or sold. The first row of the table measures the total number of mortgages for homes purchased in 1999. Homes that were purchased in that year and foreclosed upon in 2007 averaged 5.1 mortgages during their entire ownership experiences. For homes purchased in 1999 that have not yet been foreclosed upon or sold, the average number of lifetime mortgages is only 3.8. A similar discrepancy is present for homes purchased in 2000 through 2003.

What role did subprime refinances play in these foreclosure patterns? Table 9 repeats this exercise but focuses only on the total number of subprime mortgages for various ownership experiences. The top row shows

![Fig. 8. 2006–2007 Massachusetts foreclosures by type of residence, purchase year, and subprime-purchase status.](image-url)
that homes that were purchased in 1999 and foreclosed upon in 2007 had an average of 1.6 subprime mortgages during their ownership experiences. The comparable number for homes purchased in 1999 that have not yet been foreclosed upon or sold is only 0.2. The inability to measure cash-out refinancing makes this analysis only suggestive. Yet the data are consistent with the view that subprime mortgages were extensively used to exact equity from homes that had appreciated in price, and that this extraction had an important impact on foreclosure patterns.

6. Conclusion and directions for future research

This paper has presented a number of facts about the subprime crisis which are at odds with oft-made claims. A simple model that claims a wave of subprime resets set off the crisis is hard to square with the facts, and it is hard to make a prima facie case that large numbers of subprime borrowers were inappropriately steered into their mortgages. Additionally, though subprime mortgages have proven especially fragile during the current housing downturn, prime mortgages have also been affected. Indeed, most of the homes lost to foreclosure in Massachusetts were purchased with prime mortgages, though many of their owners refinanced into subprime mortgages before defaulting.

These facts are consistent with the view that the widespread decline in housing prices is the proximate cause of the current housing crisis. They are also consistent with a claim that higher housing prices caused many high-FICO borrowers to turn to the subprime market in order to purchase increasingly expensive homes. Yet while high prices may have encouraged subprime lending, a crucial outstanding question is the degree of causality in the other direction, specifically, whether subprime lending put upward pressure on housing prices. This question lies beyond the scope of this paper. But there is some suggestive evidence that, at least in Massachusetts, higher housing prices were not caused by higher subprime lending. Fig. 9 shows that house prices started increasing in the Bay State well before subprime lending took off. Specifically, house prices were rising by more than 10% per year by the year 2000, when the subprime fraction of new purchases in the state was still quite small. In any case, figuring out the ultimate effect of subprime lending on house prices, and vice versa, is a difficult problem that will require innovative empirical approaches to answer.

Fig. 9. House price appreciation and subprime-purchase lending in Massachusetts, 1988–2007.

References