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The Impact of House Prices on Consumer Credit: Evidence From an Internet Bank

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Abstract

This paper shows that house price fluctuations can have a significant impact on credit markets well beyond the mortgage segment. Using new data from Prosper.com, a peer to peer lending site that matches borrowers and lenders to provide unsecured consumer loans, we find evidence that home owners in states with declining house prices face higher interest rates and greater rationing of credit, while also becoming delinquent faster. Investigating the mechanism, we find separate supply and demand effects, and especially large effects for those subprime borrowers whose balance sheets are likely to be most exposed to asset price declines. This evidence suggests that asset price fluctuations can play an important part in determining credit conditions and are thus a potentially significant mechanism for propagating macroeconomic shocks.

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Introduction

How do the cost and availability of credit vary with asset price movements? Do lenders tend to raise rates or ration credit when declining asset prices weaken the balance sheets of potential borrowers? Does the cost of credit rise even further, as agents demand more credit to help smooth negative asset price shocks? These questions are at the cornerstone of macroeconomics and finance, and a now substantial theoretical literature has explored this credit channel, identifying the various mechanisms through which declining asset prices and worsening household balance sheets can interact with financial market frictions to alter credit conditions and depress real economic activity (Aoki et. al (2004), Bernanke and Gertler (1989), Iacoviello (2005)). [2] The current mortgage default crisis has also underscored the potential importance of asset price fluctuations—particularly in the housing market—on the real economy.[3]

There is however significantly less empirical evidence on the impact of asset price fluctuations on household credit conditions.[4] Therefore, to help gauge the economic importance of asset price fluctuations in shaping credit conditions, this paper studies the impact of house price fluctuations on the cost and availability of unsecured credit using a detailed dataset from Prosper.com, an internet based person to person micro credit website that lent about $200 million from 2006 through the collapse of the housing market in the second quarter of 2008.

The structure and information content of the Prosper.com dataset provides a useful laboratory for understanding the relationship between house prices and credit decisions at each step of the intermediation process. The dataset includes information both on loan applications, the cost of credit for those applications that were "funded" or approved, as well as the performance of these loans over time. We are thus able to construct relatively direct tests of the impact of borrower house price fluctuations on the extensive margin, studying how these fluctuations might shape the credit supply decision. We can also examine the impact of house price fluctuations on the cost of credit for those applications funded in equilibrium, as well as on the probability of loan default.

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[2] See also the surveys in Bernanke and Gertler (1995) and Bernanke et. al (1999). Bernanke (2007) and Muellbauer and Murphy (2008) are surveys that focus on the credit channel and house prices explicitly.

[3] Some recent papers on the causes and consequences of the housing market crisis include, Demyanyk and Van Hemert (2009), Doms et. al (2007), and Gabriel and Rosenthal (2007), Keys et. al (2010), Leamer (2007), and Mian and Sufi (2009).

[4] There have been a number of empirical studies examining the credit channel among firms—see the survey in Hubbard (1998).

The structure of the dataset also helps in interpreting these tests of the borrower balance sheet channel. Homeownership can for example correlate with other facets of a borrower's profile that could also affect the cost and availability of credit (Gross and Souleles (2002)). This in turn can make it difficult to identify the impact of house price fluctuations and the condition of a borrower's balance sheet on credit outcomes. However, because Prosper.com makes available all the verifiable borrower information that lenders use when making their credit supply decision, we can more easily discriminate between the impact of housing market conditions on the credit terms that homeowners face versus that of other borrower characteristics that might also correlate with homeownership.

In addition, the arm's length nature of the intermediation platform helps to minimize the role that "soft", difficult to observe information might play in confounding inference about credit decisions (Liberti and Mian (2008)). Instead, the data reflect the collective credit decisions of half a million agents operating over a similar platform rather than a handful of lending officers, and is also an opportunity to understand better how individuals collectively use asset prices and other economic information to price risk in a decentralized environment. Also, because Prosper.com's own balance sheet is not directly impacted by the housing market, this allows us to isolate the effect of housing market developments operating through the perceived creditworthiness of borrowers, separately from the impact of these developments on bank leverage and liquidity (Chen (2001), Khwaja and Mian (2009)).

Our results are easily summarized. Using information on the 222,000 loan applications or listings observed from 2006 through 2008, we find evidence that house price fluctuations appear to have a large effect on the supply of credit. Among homeowners, a one standard deviation decrease in house prices is associated with a percentage point decline in the probability of receiving credit—the unconditional probability of receiving credit is 8 percent. And consistent with the evidence indicating that the balance sheet of subprime borrowers may have been most sensitive to house price declines, these estimates of rationing are nearly double among the sample of subprime applicants (Bajari et. al (2008), Demyanyk and Van Hemert (2009)). Using the spread between the LIBOR and the 90 day Treasury Bill, there is also evidence that distress in the traditional banking system may have amplified the impact of house price fluctuations on credit rationing.

Among the 18,262 listings that became loan contracts, there is also evidence that fluctuations in house prices at the state level appear to significantly affect the cost of consumer credit on the Prosper.com marketplace. For two observationally identical borrowers, the equilibrium interest rate on a Prosper loan is more than 2 percent (38 basis points, for the median interest rate) higher for a homeowner in a state experiencing a one standard deviation decline in house prices. Mirroring the previous results, these effects are also substantially larger among the subsample of subprime borrowers. Of course, lenders may ration credit in the face of worsening balance sheets rather than charge higher interest rates, and the estimated impact of house price movements on the equilibrium interest rate is also considerably larger when controlling for this non random selection in the credit supply decision.

The Prosper dataset also allows us to explore the underlying mechanisms that might explain these results. Consistent with results in other unsecured credit markets, declining house prices are associated with greater defaults, suggesting that the higher interest rates charged might help to compensate lenders for greater risk (Gross and Soueles (2002), Chatterjee et. al (2007)). But using the maximum interest rate that an applicant was willing to pay at the time of the listing as an indicator of loan demand, there is evidence that homeowners, again especially the subprime borrowers, appear increasingly willing to demand non collateralized credit at higher prices on Prosper.com as home prices deteriorate in their state. This suggests that increasing demand for credit may also account in part for the rise in the equilibrium interest rate.

Taken together, these results are supportive of the credit channel, and suggest that house price fluctuations may affect credit markets well beyond the mortgage segment.[5] The magnitude of these results also lend plausibility to some of the larger estimates on the marginal propensity to consume out of housing wealth (Carroll et. al (2006)).[6] Moreover, that the impact of declining house prices on credit conditions appears largest for subprime borrowers is also consistent with

[5] Specifically, our results provide evidence for a significant balance sheet channel for the household sector with respect to housing wealth. Bernanke and Gertler (1995) argue that the balance sheet channel occurs via the impact of monetary policy on asset values and hence, via borrowers' balance sheets, on the cost of borrowing compared to the shadow price of internally generated funds (the external finance premium). The basic idea is that increasing asset values help to attenuate principal-agent problems between borrower and lender, by giving the former more 'skin in the game.' Our evidence suggests that declining home prices lead to greater demand for unsecured credit and higher default risk among affected homeowners, placing upwards pressure on lending rates and increasing incentives for lenders to ration credit. Of course our results relate only to the second stage of the credit channel (whereby asset prices affect credit conditions), not to the first stage (where monetary policy affects asset prices).

[6] Campbell and Cocco (2007), Gan (2007), and Case, Quigley and Shiller (2005) also provide estimates on the impact of house prices on consumption.

broader research suggesting that liquidity constrained households often rely on home equity to help smooth consumption (Hurst and Stafford (2004), Mian and Sufi (2011)).[7]

The remainder of the paper is organized as follows: Section I describes the data and empirical framework; Section II presents the main results, while Section III concludes.

I. Theories and Data

A. Theories

Because a stronger financial position (greater net worth) enables a borrower to reduce his potential conflict of interest with lenders --see the survey in Hart (2001)—the balance sheet of homeowners may be an important channel through which house price movements could affect the cost and availability of credit (Iacoviello (2005)). A homeowner with greater net worth may for example be able to self finance a larger share of his investment project and is less likely to default in order to preserve his reputation and credit access, and avoid higher future borrowing costs (Corbae et. al (2008)). [8] Higher net worth homeowners may also have lower default probabilities because they might more easily be able to service their debt across a range of income shocks.

Given the connection between house prices and net worth, standard arguments predict that declining house prices with the potential for higher default probabilities may lead homeowners to face greater credit rationing, or obtain credit at a higher price ((Diamond (1991), Holmstrom and Tirole (1997), Stiglitz and Weiss (1981)). For instance, after a drop in house prices and a possible rise in negative equity, a homeowner may decide not to repay her mortgage (Demyanyk and Van Hemert (2009). Such homeowners may also expect to repudiate their non collaterized debts as well, evincing a greater willingness to pay higher interest rates on Prosper. Anticipating this form of adverse selection, lenders in turn may perceive homeowners who are willing to pay high interest rates as worse repayment risks. And since the lender's expected return depends on the probability of repayment, the equilibrium interest rate may ration those

[7] See also Adams et. al (2009), Campbell and Mankiw (1989), Carroll and Dunn (1997), and Zeldes (1989) for evidence on financing constraints at the household level.

[8] Loans on Prosper are not collateralized, but credit impairments on Prosper are reported to the three main credit bureaus.

homeowners in states with declining home prices. In some cases, those homeowners who are rejected at lower interest rates may obtain credit at higher interest rates. We thus develop a number of different empirical tests motivated by the twin predictions that declining house prices may impact the cost and availability of credit on Prosper.

Unfortunately, the data requirements for identifying credit rationing and the effects of the balance sheet channel on the terms of credit contracts can be onerous. Ideally, the empirical analysis needs to observe both the contracts funded in equilibrium, as well as those rejected (Becchetti et. al 2011).[9] In addition, lenders often use several measures to help price the risk of default under imperfect information, some of which can be "soft", difficult to observe and potentially correlated with other observable borrower characteristics, making causal inference in traditional banking datasets difficult (Liberti and Mian (2008)).

The Prosper market place provides information on both loan applications—listings; credit terms for those listings that were funded in equilibrium—loans; as well as subsequent loan performance. We are thus able to examine the impact of house price fluctuations and balance sheet considerations on key aspects of the financial intermediation process. Specifically, we first assess the impact of house price fluctuations on credit supply and rationing; then for those listings that did become loans in equilibrium, we measure the impact of house price fluctuations on the cost of credit. Finally, with the data on the evolution of loan performance, we examine the relationship between house price fluctuations and loan default.

That said, interpreting these tests of the balance sheet channel can be difficult if other elements of the information set used in credit decisions are also correlated with homeownership status. Sinai and Souleles (2005) observe for example that the decision to own a home may depend on aggregate factors like the variance of local rents, as well as on borrower specific characteristics that shape how long a borrower expects to stay in the area. And in traditional banking relationships, some of these borrower characteristics that are correlated with homeownership status, like age or neighborhood tenure, might also be used directly in the credit decision. Omitting those borrower characteristics from the estimation could be a source of bias.

[9] Although the focus is only on the sample of loans funded in equilibrium, another important test of these ideas involves measuring the stickiness of loan interest rates with respect to the benchmark rate (Berger and Udell (1992)).

In developing tests of the balance sheet channel on the cost and availability of credit, the empirical strategy exploits the set-up of the Prosper marketplace to address some of these concerns. The Prosper platform makes available all the verifiable borrower observables available to lenders at the time of their credit decision. Including this information in the estimation can in turn reduce considerably the possibility of omitted variable bias. The "arms length" structure of Prosper's intermediation platform, which reduces the importance of "soft" or "informal" information in the lending decision also helps with inference. [10]

For instance, in the credit decision, a traditional relationship lender might use information on how long an individual has lived in the neighborhood, or the extent of her community involvement. But neighborhood tenure or attachment might also be both highly correlated with homeownership and difficult to observe, and could be a source of bias in studies using traditional data. However, because many of these borrower characteristics are also not observed by potential lenders on the Prosper platform, the potential for biased estimates is less.

Nevertheless, since homeownership is non random, we consider a number of different robustness checks to asses the robustness of the main results. Variables such as the debt to income ratio, as well as borrower credit grade are key observables on Prosper that are also correlated with homeownership status (Figure 3), and throughout, we include these variables linearly as well as interacted with house price growth. We also control for a variety of state level observables, including income and unemployment, in order to disentangle the effects of house price developments from broader macroeconomic trends within the state that might also shape the equilibrium credit decision (Wheaton and Nechayev (2008)). The analysis also controls for state (time invariant) characteristics, and aggregate time trends that affect borrowers similarly.

Beyond simply perturbing the baseline specification along plausible dimensions to assess the balance sheet channel, the analysis also exploits the possibility that the magnitude of the balance sheet channel might vary with borrower credit quality. Specifically, as bank lending standards declined during the housing boom, highly leveraged mortgages became increasingly available to subprime borrowers (Mian and Sufi (2009)). But with limited home equity to begin with, the balance sheets of these subprime borrowers were often most susceptible to any

[10] However, there is some evidence that non verifiable observables, such as race and the perception of beauty, could also affect credit outcomes in this marketplace (Ravina (2008)).

unplanned increase in household leverage, resulting in higher mortgage defaults among subprime borrowers because of falling home prices (Bajari et. al (2008), Demyanyk and Van Hemert (2009)).

We would expect then that for subprime homeowners on Prosper, declining house prices would more easily generate negative equity, increasing default incentives as their balance sheet conditions worsen, and leading to ex-ante more rationing and higher equilibrium interest rates (Chatterjee et. al, 2007). In addition, given that the cost of unsecured credit is generally higher than the after tax cost of home equity lines of credit, homeownership among subprime applicants on Prosper may already signal limited net home equity, and restricted credit access from conventional credit sources, increasing the likelihood of default and suggesting an even stronger relationship between equilibrium credit outcomes and house price changes among these liquidity constrained borrowers (Adams et. al (2009), Deng et. al (2000)).

This logic allows us to exploit the heterogeneity in borrower credit quality within the sample of Prosper borrowers to assess whether the impact of house price changes on the cost and availability of credit for homeowners on Prosper is particularly large for the subprime borrowers, those for whom the balance sheet channel is likely to be most salient. The next section describes the data in more detail.

B. Data

Prosper.com is a peer to peer (P2P) credit market on the internet. Potential borrowers post loan requests or listings—the amount they wish to borrow, and the maximum interest rate they are willing to pay—along with standard economic information such as credit scores and debt to income ratios. Lenders, other members of the public, then compete to fund loan requests based upon the borrower's information. All loans that are extended have a 36 month repayment period. Prosper has also spawned a number of independent web sites that use Prosper data to help members make more informed credit decisions, and more than 90 percent of listings are not funded.

Our sample period begins in the second quarter of 2006—at the peak of the housing boom—and ends in the second quarter of 2008 amid the financial crisis and the collapse of Bear Stearns. It consists of over 222,000 loan listings, of which about 18,000 became loans, with

borrowers located in 46 states plus the District of Columbia.[11] As of October 2009, the site had approximately 860,000 registered members, and originated more than $180 million in total loans. Prosper.com suspended lending beginning in Q4 2008, as part of the Securities and Exchange Commission application approval process for companies wishing to offer securitized loan products. The site has since resumed operations.

The required economic information to borrow on Prosper.com is standardized across all borrowers—Table I lists all the borrower information available to lenders during the sample period. Prosper.com also verifies this information before making it available to potential lenders using standard bank procedures such as credit reports and income verification. Borrowers can also post non verifiable information, including reasons for the loan, as well as photographs. And as with micro credit, potential borrowers can also join groups.

The bidding process through which lenders compete to supply credit is akin to a Dutch auction. Beginning at the borrower's maximum interest rate, lenders decide how much of the loan request to supply and at what price or interest rate—minimum bids are $50. A loan request is funded if the sum of outstanding bids at least equals the amount requested, and the equilibrium interest rate is less than the borrower's maximum interest rate. The equilibrium interest rate is 0.05 percentage points less than the last highest losing bid.[12]

Consistent with the emergence of ancillary sites intended to help with credit decisions, there is evidence of risk based pricing in this credit market. Prosper assigns credit grades to borrowers based on their FICO scores. Figure 1 plots the median interest rate across the different borrower credit grades, based on FICO credit scores, in the sample period. Intuitively, the median interest rate increases as the credit quality of the borrower declines. On average,

[11] Two states (Texas and South Dakota) are excluded from the sample because legal restrictions prevented or severely restricted Prosper.com's ability to operate in these states. In addition, Nevada and Rhode Island are excluded because the pool of borrowers from these states is too small to allow for the estimation of the clustered variance-covariance matrix.

[12] Consider the case of a listing for $3,000 at 10%. Lender 1 bids $1,000 at 9%. The listing is not funded, and remains open at 10%—the 9% bid is private information. Lender 2 bids $1,000 at 8%. The listing is still not funded, and is open at 10%. Lender 3 bids $1,000 at 7 %. The listing is now funded, and the interest rate drops to 9.95%. Suppose Lender 4 bids $1000 at 6%. Since Lender 1 is now the highest losing bid, the interest rate drops to 8.95%. Assuming no more bids, the listing is now funded—a loan for $3,000 at 8.95%. Please see http://www.prosper.com/help/tutorials/bidding-1.aspx for more information. Potential borrowers can choose, at the time of listing, whether to keep their listing "active" (accepting bids) beyond the point at which it is funded, in the hope of securing a lower interest rate. This choice is also public information, and presumably acts as a signal of patience.

borrowers with an AA rating borrow at around 775 basis points less than those ranked C—the most common grade in the sample (Figure 2).

The correlations among key borrower observables are also intuitive. Figure 3 shows that borrowers with higher credit ratings are also generally more likely to be homeowners. Meanwhile the debt to income ratio behaves non-monotonically across credit grades. Both the very best and worst quality borrowers have smaller ratios, as the former are likely to be richer with access to credit, while the latter may have limited access to credit.

To measure house price fluctuations, we use the Office of Federal Housing Enterprise Oversight (OFHEO) house price index. Because Prosper does not consistently provide information on the borrower's city or MSA location, we employ the OFHEO data at the state level.[13] For the nine quarters in our sample, beginning in the second quarter of 2006, Figure 4 plots the average change in house prices, as well as the minimum and maximum change, aggregated over the District of Columbia and the 46 states in the sample. The average change in house prices has steadily declined, with deflation beginning in the third quarter of 2007; Utah experienced the largest increases in house prices, while California had the biggest declines. Table II presents the descriptive statistics for the variables in the dataset.

II. Main Results

A. Funding Decision

Models of equilibrium credit rationing suggest that deteriorating household balance sheets could prevent this credit market from clearing altogether, and we first examine the relationship between house prices and the funding decision. Using the fact that we observe both those listings that were funded in equilibrium, as well as those that failed to receive funding, we construct a simple linear probability model with the dependent variable equaling 1 if a listing was funded, and 0 if credit was denied. We also measure homeownership with an indicator variable that equals 1 for applicants who are homeowners. To investigate the impact of house price fluctuations in shaping credit access, we interact the change in house prices, lagged one quarter, with the homeowner indicator variable.

[13] The Case Shiller Index, which often has larger price movements, omits 13 states and is incomplete for another 29 states, and is thus less suitable (Leventis (2007)).

Of course, because homeownership might be correlated with other borrower characteristics that could also independently influence the credit supply decision, the baseline specification controls for the main observables of a borrower's profile that are visible to potential lenders: the borrower's debt to income ratio; credit grade; an indicator variable for whether the borrower belongs to a group; as well as the amount the borrower demanded, and the maximum interest rate that the borrower is willing to pay. Credit grade is highly correlated with homeownership itself, and the baseline regressions also interacts house price changes with dummies for the borrower's credit grade.

Lenders may also use a borrower's willingness to wait for funds—patience—as a supplemental indicator of credit risk, and we also include a dummy variable for whether the borrower elected to settle the listing as soon as it was funded, or chose to wait for a lower interest rate. Finally, all specifications include dummies for borrower state and the time period in which the loan is made (year and quarter); standard errors are clustered at the (borrower state, time period) level.

From column 1 of Table 3, among homeowners, house price fluctuations appear to have a large effect on the extensive margin, as homeowners in states with declining house prices appear less likely to obtain credit relative to other applicants. The magnitude of this effect also appears to be economically large. Among homeowners, a one standard deviation decrease in house prices is associated with a 1 percentage point decline in the probability of receiving credit. To put these estimates in context, the unconditional probability of obtaining credit is about 8.1 percent.

The other variables also enter with intuitive signs. More heavily indebted applicants are less likely to obtain credit; while consistent with the micro credit literature, applicants who are members of groups have a 4.1 percentage point higher probability of obtaining credit compared to those without group membership (see the survey in Hermes and Lensink (2007)). We also find that those applicants who evince less patience by opting to settle the listing as soon as it is funded are significantly less likely to be funded. Interestingly, while requesting higher amounts tend to decrease the probability of funding, a willingness to pay a higher interest rate seems to increase the likelihood of getting a loan.

Homeownership is closely correlated with other borrower characteristics, and the baseline specification already includes a number of these observables, as well as interactions between borrower credit grade and house prices. But as a further robustness check, column 2

interacts house price growth with the applicant's debt to income ratio. The results are little changed. Available upon request are results that also interact the maximum interest rate the applicant is willing to pay with house price changes—the results are unchanged.

Aggregate state level factors could still confound interpretation. To this end, column 3 of Table 3 linearly includes both the change in state per capita income and the state unemployment rate. These variables are also interacted with the home ownership indicator variable. The results are broadly unchanged, suggesting that weakening house prices and a deterioration of home owner balance sheets may account for these supply effects independent of broader macroeconomic factors.

That said, states varied considerably in their overall regulation of the housing market, and some of these state level differences might affect homeowners differently relative to other applicants (Pence (2006)). We focus on these issues in a later subsection, but it would be useful to establish at the onset that the homeownership result is not an artifact of general state level heterogeneity. To this end, column 4 interacts state dummies with the homeowner variable. The results are if anything larger and more robust than in the baseline specification. Column 5 assesses the robustness of the baseline results to general time trends, interacting the quarter/year dummies with the homeownership variable. The estimated impact of state level house prices on credit rationing among homeowners is smaller than in the baseline, but remains significant.

Subprime Borrowers

The connection between house prices and the credit supply decision appear robust to a number of plausible robustness checks, but focusing on the heterogeneity in borrower credit quality might offer further evidence of the balance sheet hypothesis. In particular, if indeed these results reflect the impact of balance sheet positions on credit availability, then the estimates should be largest among subprime homeowners. During the housing boom these borrowers tended to be more leveraged than other types of borrowers. Declining house prices in the subsequent bust would then more easily generate negative equity among subprime borrowers, and thus, greater default risk ((Mian and Sufi (2009), Bajari et. al (2008), Demyanyk and Van Hemert (2009)). This mechanism would in turn predict that the impact of house price

fluctuations on the equilibrium availability of credit on Prosper would be especially strong for subprime homeowners.

The results from estimating the baseline specification—column 1 of Table 3—separately for the seven different credit grades are in Table 4. Among the highest quality borrowers—those rated "AA" and "A"— as well as among the lowest quality borrowers—"HR" and "E"—there is no significant evidence that house price fluctuations matter for homeowners' access to credit. In the case of the former, the balance sheets of these high quality borrowers are likely to be sufficiently strong so that changes in housing equity will not substantially affect their creditworthiness. Meanwhile, despite the expansion of credit in the 2000s, HR and other very low quality borrowers still had limited access to mortgage financing, and very few became homeowners (Figure 3).

But for borrowers with average and below average credit scores ("B", "C", and "D")—those usually classified as subprime in the mortgage market, and whose equity position would likely make their balance sheet most susceptible to price declines—developments in the housing market appear to have a large impact on credit access. Among "B" homeowners: a one standard deviation decrease in house price growth is associated with a 2.9 percentage point decrease in the probability of getting credit. Among "C" homeowners, a similar decrease in state wide house prices is associated with a 3.6 percentage point decrease in the probability of the loan becoming funded.[14]

Aggregate Supply Factors

The sample period includes both the boom and bust in nationwide house prices and the onset of the financial crisis, and this variation in aggregate supply conditions offer another dimension to study the connection between balance sheet effects and credit availability. In an attempt to rebalance away from riskier assets during the crisis, investors could for example reallocate more capital to Prosper, leading to an increase in the supply of funds on Proper (Hau and Rey (2006)). To be sure, the decline in wealth from the collapse in equity prices could have the opposite effect, forcing investors to reduce their exposure to Prosper. These supply side factors could also affect homeowners differently relative to other types of applicants, as investors

[14] The unconditional probability of funding for "B" and "C" borrowers are 23 and 17 percent respectively.

could rebalance assets towards Prosper, but discriminate more forcefully against homeowners in states with falling house prices.

One measure of these aggregate supply conditions is the spread between the London Inter Bank Rate (LIBOR) and the three month US Treasury bill. This spread is a common proxy for funding pressures and uncertainty in the traditional banking sector. We also use the VIX index, a standard measure of the volatility of the S&P 500, to measure uncertainty in equity markets. Both series spiked dramatically with the onset of the financial crisis.[15]

Column 1 of Table 5 augments the baseline specification, including the LIBOR spread observed at the time of the listing. The spread is included linearly, as well as interacted with the homeownership indicator variable. The results suggest that disruptions in the traditional banking sector may have had a positive impact on credit supply on the Prosper market place.[16] However, this positive impact appears to have been significantly more muted among applicants who were homeowners. In particular, a one standard deviation increase in the LIBOR spread is associated with a 0.1 percentage point increase in probability that a loan is funded. However, among homeowners, the impact of a similar increase in the spread is actually negative: a 0.1 decline in the likelihood of funding.

Column 2 indicates that house price movements may have shaped the impact of distress in the traditional banking sector on the extensive margin in Prosper. This specification adds a triple interaction term, interacting house prices with the homeownership indicator variable and the LIBOR spread. The point estimates suggest that at the bottom decile of the house price change distribution, a one standard deviation increase in the LIBOR spread is associated with a 0.6 percentage point drop in the likelihood that a homeowner receives funding. But for an otherwise similar homeowner experiencing house price movements at the top decile of the distribution, a one standard deviation increase in the LIBOR spread suggests a 0.1 percentage point rise in the probability of funding.

Column 3 restricts the sample to subprime borrowers: credit grades “B”, “C” and “D”, yielding magnitudes that are more than double those observed in the full sample. A one standard deviation increase in the LIBOR spread is associated with a 1.7 percentage point drop in the

[15] At the beginning of the sample in 2006, the LIBOR spread was around 50 basis points. By the end of the sample in the second quarter of 2008, the spread had risen to about 300 basis points. Similarly, by the end of the sample period, the VIX index almost doubled from its pre crisis low in 2006.

[16] These results are similar if we also use the quarterly average of the LIBOR spread or the VIX.

likelihood that a subprime homeowner in a state at the bottom decile of house price growth receives funding. At the top decile, the impact is also negative: a similar increase in the spread is associated with a 0.4 percentage point drop in the probability of funding. It would seem then that greater distress in the traditional banking sector may have amplified the importance of balance sheet effects in the lending decision on Prosper, especially for subprime borrowers.

Instead of the LIBOR spread, column 4 of Table 5 uses the VIX. Unlike the LIBOR spread, the VIX itself has no direct impact on the loan probability, rather, the effect appears to depend on whether the borrower is a homeowner: a one standard deviation increase in the VIX is associated with a 0.4 percentage point drop in the loan probability among homeowners. Column 5 uses a double interaction term to study the effects of home price fluctuations. The estimates are less precise, but there is some evidence that home price fluctuations might amplify the impact of the VIX on the loan probability for homeowners, as the interaction terms are jointly significant at the one percent level. And consistent with the previous results, restricting the sample to subprime borrowers yields even larger point estimates (column 6).[17]

B. Equilibrium Interest Rate

The evidence thus far suggests that house price fluctuations may have shaped credit availability. In this subsection, we now focus on whether house price movements might have also affected the cost of credit among the subset of loans funded in equilibrium. There are 18, 262 loans in this subsample of listings, and the baseline specification in column 1 of Table 6 suggests that borrower balance sheet considerations may have also significantly affected the cost of credit. The additional risk premium associated with home ownership is around 3 percent (50 basis points at the median interest rate) for a homeowner in a state that experienced no change in house prices the previous quarter. But this premium increases to around 5.2 percent (88 basis points) for otherwise similar borrowers in states that experienced a one standard deviation decrease in house prices. This result differs somewhat from the existing literature, which finds

[17] Movements in the LIBOR spread or the VIX could also affect loan demand, as traditional sources of credit might diminish during the financial crisis. However, these results, available upon requests, are unchanged when proxying for credit demand using the actual number of loan listings competing for funding on Prosper.

that quantity rather than price tends to matter more in borrower—lender relationships (Peterson and Rajan (1994), Khwaja and Mian (2009).

To determine whether these results might be driven by the balance sheet of lenders, column 2 includes house price changes in the lenders' state linearly, as well as interacted with whether the borrower is a homeowner. [18] Since there are multiple lenders for each loan, lenders' state-level house price changes in column 2 are a weighted average of price changes in each lender's state, with the weight determined by the lender's contribution to the loan. There is no evidence that fluctuations in lenders' house prices affect the equilibrium interest rate, while the effect of borrowers' state-level house price changes is unaffected. Results are also little changed when the change in house prices is interacted with debt to income (column 3) or when state unemployment and income are included (column 4).

The ease of defaulting on general debt obligations differs considerably across states, and this variation could further help identify the link between homeownership and the interest rate. While bankruptcy is generally handled in federal courts, states have wide latitude in determining the value of exemptions that individuals may claim in bankruptcy proceedings (Gropp et al., 1997; Berkowitz and Hynes, 1999). Some states, such as Florida, allow individuals to exempt their homes from bankruptcy, while others limit considerably the exemptions that borrowers might claim. Borrowers in states with more generous homestead exemptions may therefore be more willing to declare bankruptcy in response to declining home values. In Florida, for example, a bankrupt borrower would be able to eliminate non collateralized debt, while keeping his home. Hence, if these results reflect balance sheet considerations and the fear of default, then we should expect interest rates to be higher for homeowners in states with more generous exemption laws.

Column 7 of Table 6 investigates this hypothesis, creating an indicator variable equal to 1 if a borrower lives in a state that provides particularly generous homestead exemptions, which we define as an exemption in excess of $100,000 (including unlimited exemptions), and 0 otherwise.[19] This variable is interacted with the home ownership dummy, and there are separate

[18] See for example Kashyap and Stein (2000) for evidence on the importance of bank balance sheets on lending.
[19] State bankruptcy exemptions are obtained from Sommer et al. (2006; 2007). We chose the $100,000 cutoff as a value that would be sufficiently large to encompass a meaningful number of mortgage holders but not so large that the number of states with exemptions above this number would be too small. 14 states out of our sample of 47

interaction terms with house prices, as well as house prices interacted with homeownership. Consistent with the idea that generous household exemption laws might make personal bankruptcy less onerous and more likely, the homeownership premium is significantly higher for borrowers that live in states with generous exemption laws. Finally, columns 8 and 9 control for more general forms of heterogeneity, with state fixed effects interacted with the homeownership variable (column 8); and time dummies interacted with the homeownership variable (column 9).

Subprime Borrowers

To explore how borrower heterogeneity may interact with the balance sheet channel in shaping these results, Table 7 estimates the baseline specification across the seven different borrower credit grades. As with the extensive margin, for the most and least credit worthy—AA and HR (High Risk) borrowers—information about developments in the housing market appear to be superfluous to the pricing of risk. But for the borrowers with average and below average credit scores, developments in the housing market have a large impact on the interest rate. The impact is largest among "D" borrowers: a one standard deviation decrease in house price growth is associated with a 3.2 percent increase in the equilibrium interest rate for homeowners in this credit grade (64 basis points for the median interest rate at this credit grade). The estimated impact among B borrowers is only slightly smaller. Thus, consistent with the balance sheet mechanism, these results suggest that the risk premium associated with homeownership is especially large among subprime borrowers.

Selection

While borrower balance sheet effects appear to affect both the cost and availability of credit, estimates of the former could be biased. Because of adverse selection or moral hazard concerns, lenders may prefer to ration credit in the face of worsening balance sheet considerations rather than charge higher interest rates. This rationing could in turn bias downwards the sample of observed interest rates.

Therefore, to understand the potential impact of balance sheet considerations on the interest rate for the population of loan applicants, rather than just the subsample that were

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(including the District of Columbia) have exemptions at this number or above, accounting for 23 percent of the loans in our sample.

funded, Table 8 presents results that attempt to control for the selection process that determines whether a listing becomes a loan in equilibrium. In column 1, the Heckman selection model uses the number of days that a borrower chose to keep a listing open in the first stage selection or "funding" equation. Listings open for a longer duration are likely to also receive more bids, and we would expect that the number of days that a borrower chose to keep her listing open would mechanically increase the probability that the listing becomes funded.

Consistent with these arguments, duration is positively associated with the probability of funding (column 1 of Table 8, Panel B). After controlling for the probability of selection based on this duration variable, the estimated impact of house prices movements on the interest rate reported in column 1 Panel A of Table 8 is about 33 percent larger than the OLS results in column 1 of Table 6.

The reliability of these estimates depends in part on the credibility of the assumption that "duration" can be excluded from the interest rate equation. Therefore, to gauge the robustness of this approach, we use the group membership variable rather than duration in the selection equation. This approach builds on the previous results which indicate that group membership significantly affects the probability of funding, while having no significant conditional impact on the cost of credit. Controlling for selection based on group membership—column 2—yields estimates similar to those in column 1 derived from duration.

Instead of relying on borrower characteristics to identify the selection equation, we turn to the evidence on the importance of aggregate supply factors in shaping the propensity to fund a listing on Prosper. To this end, column 3 uses the LIBOR spread as the excluded variable in the selection equation, while column 4 uses the VIX in the selection equation. These variables enter with different signs in the selection equation, suggesting that banking sector distress might have led to a reallocation of capital towards Prosper, while S&P volatility may have had the opposite effect. However, the estimates of house price changes are similar to those obtained earlier based on borrower characteristics.

The average number of bidders that all listings attract within a calendar month also provides a time varying measure of liquidity in Prosper that can determine whether a listing becomes funded. The selection equation in column 5 Panel B indicates that funding probabilities increase when more bidders are active, while Panel A suggests that controlling for selection via this mechanism yields similar estimates to those obtained earlier. Thus, although each of these

variables may imperfectly control for selection, controlling for selection based on either borrower characteristics or aggregate factors strengthen the evidence that balance sheet considerations might be of significant economic importance in determining interest rates.

Loan Demand

The maximum rate that an applicant is willing to pay—the equilibrium rate is bid down from this starting point—is one indicator of the underlying demand for credit. Information on this maximum interest rate thus provides a useful opportunity to study how house price fluctuations might affect the demand for credit, and the equilibrium interest rate. For example, declining house prices and a weakening of borrower balance sheets could increase the demand for credit, either because of adverse selection motives or to help smooth the balance sheet shock, which, other things being equal, could lead these borrowers to evince a greater willingness to borrow at higher interest rates.

Table 9 presents results from a series of regressions with the maximum interest rate posted by the borrower as the dependent variable. Using the sample of the 18,262 listings that became loan contracts, column 1 of Table 9 indicates that, for otherwise identical borrowers, homeowners demanded credit at significantly higher interest rates in states where house prices declined, consistent with an increase in demand. Instead of focusing only on the successful listings, these results are replicated even when including the more than 90 percent of listings that were denied credit in equilibrium (column 2)—again we can include unfunded listings since we are focusing only on the demand side. Column 3 restricts the sample to subprime applicants. Consistent with previous results, demand effects appear most pronounced for subprime borrowers (credit grades “B”, “C” and “E”), who appear significantly more willing to pay a higher price for non collateralized credit as housing market conditions worsen.

To what extent does this demand side explanation account for the link between house prices and equilibrium credit conditions? In column 4 of Table 9, we replicate the baseline results in Table 6 (column 1), with the *equilibrium* interest rate as the dependent variable but including as an *independent* variable the applicant’s maximum interest rate. This specification allows us to assess whether there remains an independent effect of housing market developments on the cost of credit, once we control for any effect operating through the applicant’s maximum interest rate.

House price developments continue to affect the equilibrium interest rate, even after controlling for the maximum interest rate as a proxy for demand shifts, but the magnitude of the effect drops by two thirds, suggesting that worsening balance sheet conditions and growing credit demand among borrowers might account for the bulk of the relationship between house prices and credit conditions. Of course, these estimates could be an upper bound on the importance of the demand side channel, as the willingness of potential borrowers to pay a higher interest rate might reflect their expectation of worsening loan supply conditions.

C. Loan Performance

The evidence on greater credit rationing and higher equilibrium interest rates observed among homeowners in states with declining house prices is consistent with the prediction that the equilibrium price charged on a loan might help to compensate lenders for the higher objective default frequency (Chatterjee et. al (2007)). This subsection now considers this hypothesis, investigating whether in fact the realized default rate among homeowners on Prosper is sensitive to the variation in house prices. Prosper.com categorizes loans as either current, one, two or three months late. [20] Loans past three months are considered delinquent and referred to a collection agency.[21] We first estimate a survival model, in which the time to default, or more generally the time to a deterioration in credit status, is related to housing market developments. As a robustness check, we augment this analysis with a simple linear probability model, with default as the binary dependent variable.

Time to Delinquency: Accelerated Failure-Time Model

This subsection uses an accelerated failure-time (AFT) model to study how loan status evolves over the sample period. In the AFT model, the natural logarithm of the survival time or

[20] The data on defaults comes from a separate 'object' in the prosper dataset. Unlike the loan and listings objects that are used in the main body of the paper, the loan performance object has multiple observations per loan application, recording each change in loan status (e.g. current to late or defaulted). Descriptive statistics for this portion of the dataset are available from the authors on request.

[21] To give an idea of the incidence of loan delinquency, 28 percent of loans in our sample originated in the second quarter of 2006 were at least 3 months late by July 2008, when the data was downloaded. Among HR borrowers this percentage was 52 percent.

time to failure, defined in this case as the time between loan origination and default, $ln(t_j)$, is expressed as a linear function of the covariates:

$$\ln t_j = x_j \beta + z_j \quad (3)$$

where $\boldsymbol{x}_j$ is a vector of covariates, $\boldsymbol{\beta}$ is a vector of regression coefficients, and z_j is the error with density *f()*. Hence, the effect of independent variables in the AFT model is to change the time scale by a factor of $\exp(-x\beta)$. The distribution *f()* determines the regression model, and depends on the underlying (random) process that determines the rate at which loans go bad (independent of the observable, deterministic factors such as credit grade or housing market developments). In principle there are several options available. We use the most general specification for *f()*, the generalized gamma distribution, to model the duration of loan status.[22]

For robustness, we consider three types of regressions based on different definitions of what constitutes 'failure,' or a change in loan status. The first definition considers any deterioration in the loan's broad status (from either current to late, current to default or late to default) as a failure event, with *t* denoting the time between each event (so that multiple observations are possible per loan). For our purposes, loans are considered to be in default if they are more than 3 months late. Loans whose repayments are 3 months late or less are defined as late; otherwise loans are considered current. The first specification is designed to account for the fact that either the initial deterioration in loan status (from current to late), or the subsequent default, might be driven by external factors (such as developments in the housing market). The second and third definitions are simpler: here, either defaulting or becoming late for the first time respectively defines failure. Therefore *t* measures the time in quarters from loan origination to default or becoming late (multiple failure events are ruled out). The variables included in $\boldsymbol{x_j}$ are the same as in the baseline regressions.

Table 10 presents results from an AFT model of defaults on Prosper loans. The coefficients represent the percentage change in the time to delinquency for a one unit change in

[22] Several simpler specifications frequently used in survival analysis models, including the Weibull, exponential and lognormal distributions, are special cases of the generalized gamma (see Cleves, Gould and Guitierrez, 2002). We opted for the more general model as tests of the appropriate parameter restrictions rejected the restricted models. Nevertheless, the results are fully robust to different specifications.

the covariates. Columns 1-4 in the upper panel use the broad "default or late" failure event specification. Column 1 indicates that falling home prices significantly accelerate delinquency. In this case, a one standard deviation decrease in house price growth decreases the time to failure by about 15 percent among homeowners.[23]

These results are also robust when we use house price growth controlling for state and time fixed effects (column 2) and for state level income and employment outcomes (column 3).[24] Column 4 additionally includes the equilibrium interest rate: although higher interest rates are associated with quicker default, including the equilibrium interest rate has little impact on the estimated coefficient of focus. This suggests that, despite the interest rate effects documented in the previous section, the loan interest rate fails to fully reflect the higher default risk associated with lower house price growth. Column 5 estimates the baseline specification on the subsample of subprime borrowers, yielding larger effects than the full sample. Columns 6 and 7 replicate the baseline specification using the simpler failure definitions (moving from current to late or from late to default, respectively). The results are broadly the same.

Probability of Delinquency

To check the robustness of using the AFT model, and to more directly examine the determinants of delinquencies, including the impact of loan age, we use a simple linear probability model in Table 11. The dependent variable in this case is a binary variable that equals one if a loan is current (or less than three months late), and 0 if it is at least three months past due. Using the same baseline controls as in the AFT model, the estimates in column 1 of Table 11 suggests that the probability of delinquency increases by about 2 percent for a homeowner in a state experiencing a one standard deviation decline in house price growth. Column 2 controls directly for the age of the loan in months using a fifth order polynomial (Gross and Souleles (2002)). The age variables are jointly significant at the one percent level, and there is some evidence of "seasoning". The marginal probability of remaining current declines by about 0.68

[23] The estimated impacts of the other observables remain intuitive. For example, larger loans are more likely to become delinquent sooner, while the time to delinquency is significantly delayed as the borrower credit quality increases.

[24] The maximum likelihood estimation of the AFT model fails to converge when state and quarter dummies are included. Hence, we detrend house price growth using a two-step procedure, in which we first regress house price growth on time period and state dummies and enter the residuals in the AFT regression.

percentage points when a loan ages from 11 to 12 months. But the probability of remaining current declines by only 0.16 percentage points for a loan aging from 23 to 24 months, suggesting that the marginal probability of default declines with age.

IV. Conclusion

This paper has turned to detailed data on loans, delinquencies and loan applications from Prosper.com, an internet peer to peer credit marketplace, to understand better how fluctuations in house prices affect the borrowing conditions that households face. The evidence suggests that the cost of credit is higher, and the availability of credit lower, for homeowners in states with declining house prices. That is, we find evidence for both price and quantity effects (credit rationing). Supporting the view that these effects are driven by balance sheet effects of declining home equity values, we find that the impact on credit conditions appears most severe for subprime borrowers, whose balance sheets already tended to be most vulnerable. Subprime homeowners are also more likely to default, and to evince a greater willingness to accept credit at higher prices as house prices decline. This evidence of risk based pricing is consistent with recent models of unsecured consumer lending (Chatterjee et. al (2007)). More generally, this apparent link between house price fluctuations and the cost and availability of credit supports the view that declining asset prices and worsening household balance sheets can interact with financial market frictions to alter credit conditions (Aoki et. al (2004), Bernanke and Gertler (1989), Iacoviello (2005)).

The Prosper marketplace offers a rich data environment for assessing how the evolution of household balance sheets impacts on credit conditions, and we are able to control for the same observables as lenders, which greatly helps with identification. However, this approach is not without limitations. Chief amongst these is the fact that lenders on Prosper are a relatively small and self-selected subset of all U.S. households, who may be particularly savvy in their financial knowledge. Thus, the evidence on risk based pricing and the apparent importance of balance sheet effects linking house prices to credit market outcomes may not be readily extrapolated to the general population. Additional research that can draw upon unique features of different datasets can deepen our knowledge of these issues, and enhance the external validity of these results.

Figure 1

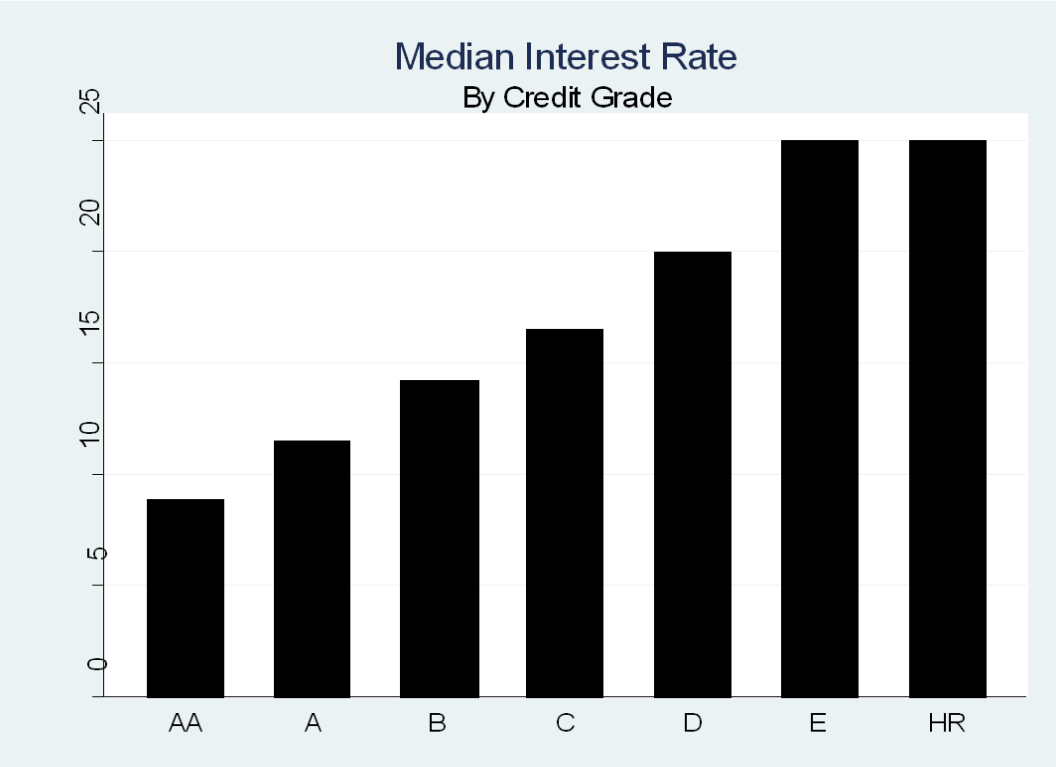
Median Interest Rate
By Credit Grade
0
5
10
15
20
25
AA
A
B
C
D
E
HR

Figure 2

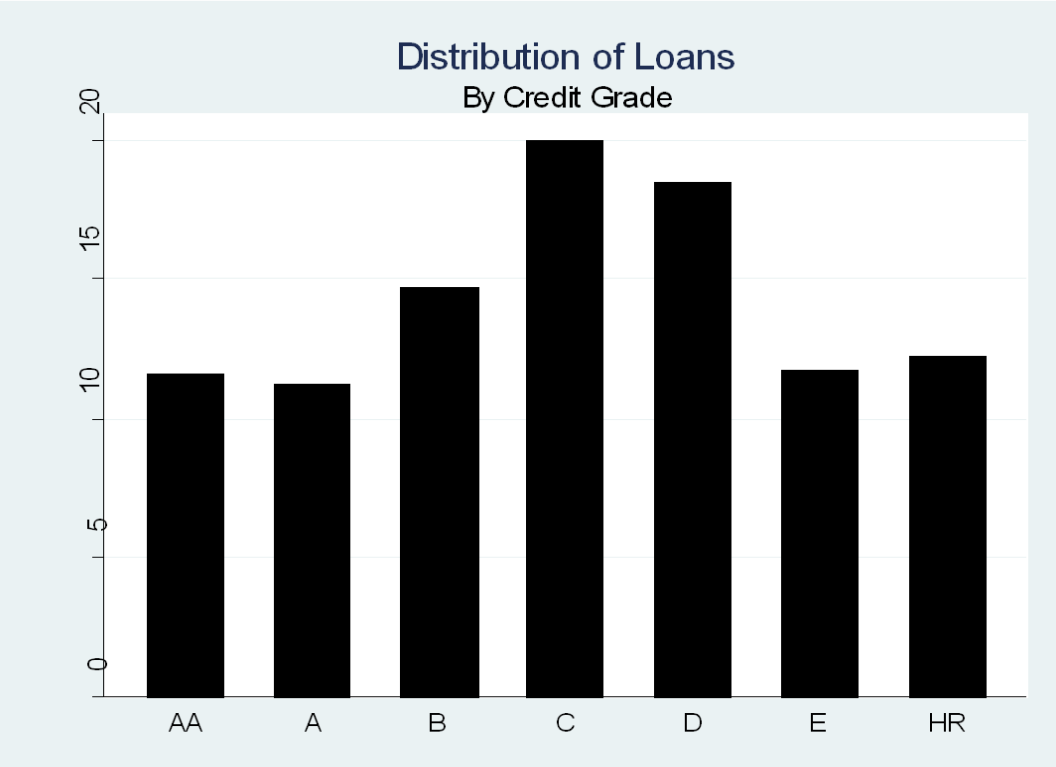

Figure 3.

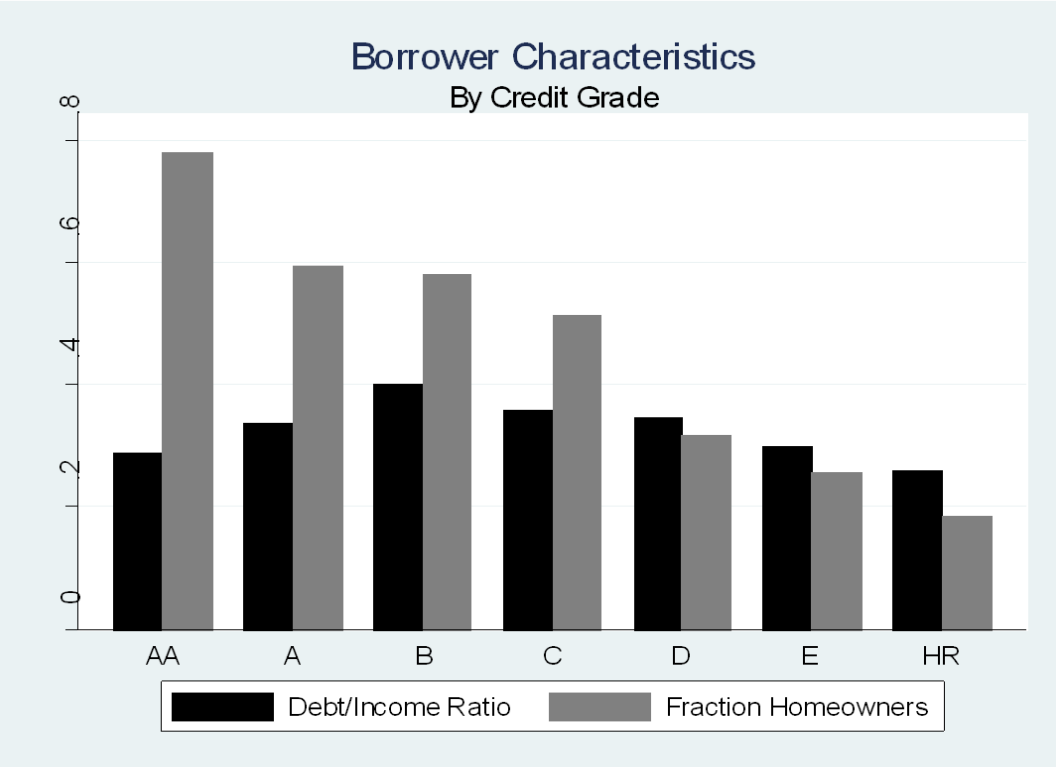
Borrower Characteristics
By Credit Grade
0
.2
.4
.6
.8
AA
A
B
C
D
E
HR
Debt/Income Ratio
Fraction Homeowners

Figure 4

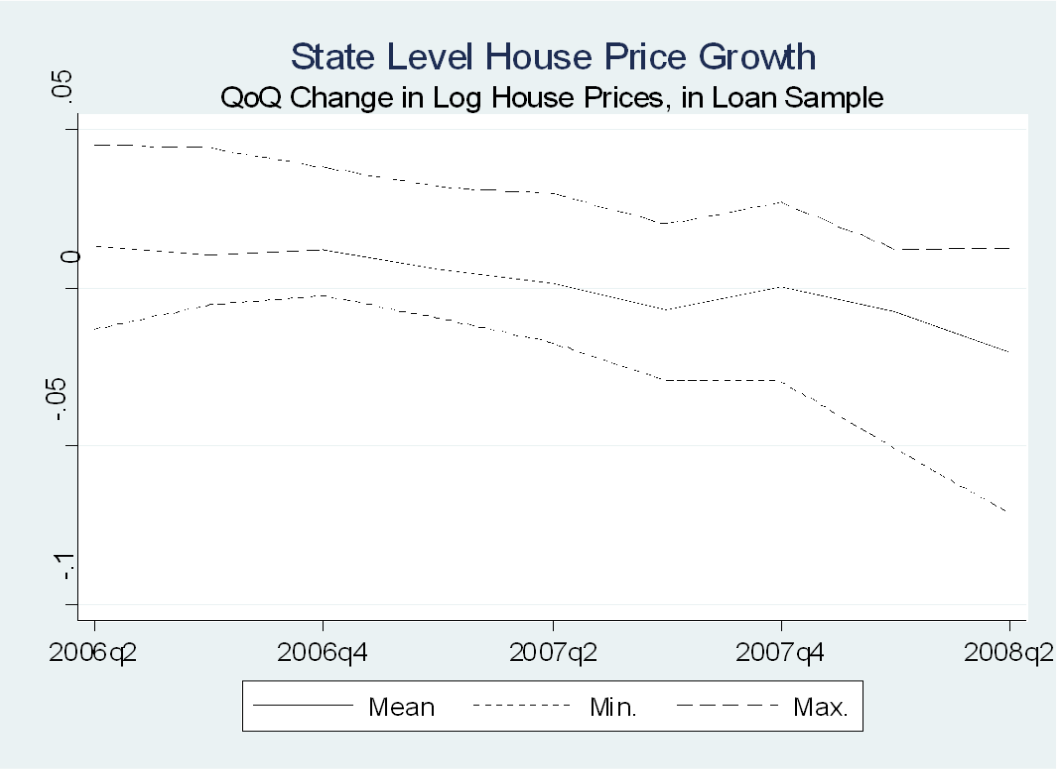
State Level House Price Growth
QoQ Change in Log House Prices, in Loan Sample
.05
0
-.05
-.1
2006q2
2006q4
2007q2
2007q4
2008q2
Mean
Min.
Max.

Table I. Prosper Borrower Information

Variable	Observations
Equilibrium interest rate	Interest rate borrower pays on loan
Borrower's Max. Interest rate	Maximum interest rate borrower is willing to pay on loan
Home Owner	Borrower's home ownership status
Amount Borrowed ($000's)	Amount borrower requests and receives in Prosper loan
Debt/Income Ratio	Ratio of total unsecured borrowing to income, including Prosper loan
Group Member	Member of a borrower group on Prosper.com
Open for Duration	Borrower chooses to have listing open for full duration, after fully funded
Borrower stat	Borrower's state of residence
Credit Grade (HR - AA)	Credit grade, based on FICO score

This is information available on all borrowers. Some additional information is posted for some borrowersbut not verified.

Table II. Descriptive Statistics

Variable	Observations	Mean	SD	Min.	Max.
Log Eqm. Interest Rate	18,262	-1.79	0.42	-9.21	-1.02
Log Borrower's Max. Interest Rate	18,262	-1.64	0.39	-9.21	-1.02
Change in Log House Prices (t-1)	18,262	0.00	0.02	-0.04	0.05
Change in Log State Personal Income (t-1)	15,092	0.01	0.01	-0.05	0.05
State Unemployment rate (t-1)	15,092	4.67	0.91	2.27	7.43
Home Owner	18,262	0.46	0.50	0.00	1.00
Amount Borrowed ($000's)	18,262	6.37	5.66	1.00	25.00
Debt/Income Ratio	18,262	0.33	0.95	0.00	10.01
Group Member	18,262	0.43	0.49	0.00	1.00
Open for Duration	18,262	0.72	0.45	0.00	1.00
Credit Grade E	18,262	0.12	0.32	0.00	1.00
Credit Grade D	18,262	0.18	0.39	0.00	1.00
Credit Grade C	18,262	0.20	0.40	0.00	1.00
Credit Grade B	18,262	0.15	0.35	0.00	1.00
Credit Grade A	18,262	0.11	0.32	0.00	1.00
Credit Grade AA	18,262	0.12	0.32	0.00	1.00
State Homestead Exemption >$100,000	18,262	0.23	0.42	0.00	1.00

Sample for principal regression results (Funded loans, Q2 2006 - Q2 2008, 46 States+DC)

Table 3. House Prices and the Probability That a Listing is Funded.

Dependent Variable: A Listing is Funded (1), and (0) if Listing is Not Funded.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Baseline	Debt to Income Ratio	Income and Unemployment	State Dummies	Time Dummies
Change in house prices, previous quarter	0.132	0.105	-0.078	0.031	0.218
	(0.197)	(0.189)	(0.238)	(0.188)	(0.195)
Homeowner*change in house prices, previous quarter	0.453***	0.453***	0.385***	0.887***	0.286***
	(0.101)	(0.101)	(0.132)	(0.157)	(0.109)
Homeowner	0.003**	0.003**	-0.003	0.052	0.004
	(0.001)	(0.001)	(0.011)	(0.053)	(0.009)
Amount requested, ($000)	-0.008***	-0.008***	-0.007***	-0.008***	-0.008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Maximum interest rate	0.426***	0.426***	0.527***	0.431***	0.424***
	(0.032)	(0.032)	(0.043)	(0.032)	(0.032)
Debt to income ratio	-0.007***	-0.007***	-0.007***	-0.007***	-0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Group Member	0.041***	0.041***	0.038***	0.041***	0.041***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Open for Duration	-0.016***	-0.016***	-0.012***	-0.015***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Debt to Income Ratio* change in house prices, previous quarter		0.077			
		(0.047)			
Unemployment rate, previous quarter			-0.011*		
			(0.006)		
Unemployment Rate, previous quarter* Homeowner			0.002		
			(0.002)		
Change in Personal Income, previous quarter			-0.060		
			(0.119)		
Change in Personal Income, previous quarter* Homeowner			-0.008		
			(0.259)		
Observations	223,421	223,421	194,949	223,421	223,421
R-squared	0.153	0.153	0.158	0.154	0.153

These regressions examine the impact of house price changes on the probability of receiving a loan. The OLS standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include dummy variables for the applicant's state of residence; the year and quarter of the application; and dummy variables for the applicant's credit grade linearly, as well as interacted with house price growth, lagged one quarter, in the borrower's state. In column 2 house price growth is interacted with the applicant's debt to income ratio; in column 3 income and unemployment are interacted with homeownership. Column 4 interacts the homeownership indicator with the state dummy variables, while column 5 interacts the homeownership indicator variable with the year and quarter of the application.

Table 4. House Prices and the Probability That a Listing is Funded, by Credit Grade.
Dependent Variable: A Listing is Funded (1), and (0) if Listing is Not Funded.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HR	E	D	C	B	A	AA
Homeowner*change in house prices, previous quarter	0.0550	-0.0720	0.595**	1.220***	1.361***	0.642	0.459
	(0.0767)	(0.179)	(0.297)	(0.386)	(0.386)	(0.701)	(0.729)
Homeowner	0.00228**	-0.00207	-0.00957**	-0.00675	0.0110	0.0395***	0.0611***
	(0.00102)	(0.00210)	(0.00415)	(0.00535)	(0.00815)	(0.00963)	(0.0142)
Observations	103,513	41,166	31,746	21,809	11,552	7,324	6,311
R-squared	0.040	0.088	0.106	0.130	0.163	0.168	0.161

These regressions examine the impact of house price changes on the probability of receiving a loan, by borrower credit grade subsamples. The OLS standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include the loan amount requested; maximum interest rate; debt to income ratio; group member; open for duration; change in house prices, previous quarter; dummy variables for the applicant's state of residence; and the year and quarter of the application.

Table 5. Aggregate Supply Factors and the Probability That a Listing is Funded

Dependent Variable: Listing is Funded (1), and (0) if Listing is Not Funded.

	(1)	(2)	(3)	(4)	(5)	(6)
	LIBOR Spread			VIX		
VARIABLES	Full Sample	Full Sample	Subprime	Full Sample	Full Sample	Subprime
LIBOR Spread	0.006*	0.006*	0.019**			
	(0.004)	(0.004)	(0.009)			
Homeowner* LIBOR Spread	-0.011*	-0.011**	-0.037***			
	(0.006)	(0.006)	(0.012)			
Homeowner* LIBOR Spread *change in house prices, previous quarter		0.894***	1.362**			
		(0.306)	(0.633)			
VIX				-0.000		
				(0.000)		
Homeowner* VIX				-0.001**		
				(0.000)		
Homeowner* VIX* change in house prices, previous quarter					0.017	0.035
					(0.020)	(0.044)
Homeowner* Change in house prices, previous quarter	0.409***	0.215*	0.472	0.339***	0.015	0.030
	(0.100)	(0.123)	(0.333)	(0.119)	(0.423)	(0.916)
Observations	223,421	223,421	65,107	223,421	223,421	65,107
R-squared	0.153	0.153	0.132	0.153	0.153	0.132

These regressions examine the impact of house price changes and aggregate supply factors on the probability of receiving a loan. The OLS standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include the amount requested; maximum interest rate; debt to income ratio; group member; open for duration; change in house prices, previous quarter; dummy variables for the applicant's state of residence; whether the applicant is a homeowner and the year and quarter of the application. The LIBOR spread is the difference between the LIBOR rate the three month US Treasury Bill. VIX is the volatility index of the S&P500.

Table 6. House Prices and the Cost of Credit

Dependent Variable: Interest Rate (Log)

	(1)	(2)	(3)	(4)	(7)	(5)	(6)
VARIABLES	Baseline	Lender House Prices	Debt to income	Income and Unemployment	Exempt	State	Date
Homeowner* change in house prices, previous quarter	-1.455***	-1.309***	-1.460***	-1.530***	-1.444***	-1.607***	-1.339***
	(0.333)	(0.367)	(0.330)	(0.420)	(0.409)	(0.486)	(0.344)
Homeowner	0.030***	0.028***	0.030***	0.120***	0.024***	0.074	0.060***
	(0.005)	(0.005)	(0.005)	(0.031)	(0.005)	(0.083)	(0.014)
Amount requested, ($000)	0.018***	0.018***	0.018***	0.016***	0.018***	0.018***	0.018***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
Debt to income ratio	0.012***	0.012***	0.011***	0.010***	0.012***	0.012***	0.012***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Group Member	0.006	0.005	0.007	0.006	0.006	0.006	0.006
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Open for Duration	-0.187***	-0.188***	-0.187***	-0.166***	-0.187***	-0.187***	-0.187***
	(0.008)	(0.008)	(0.008)	(0.006)	(0.008)	(0.008)	(0.008)
Homeowner* change in **Lender** house prices, previous quarter		-0.411					
		(0.529)					
Debt to Income Ratio* change in house prices, previous quarter			0.165				
			(0.227)				
Change in Personal Income, previous quarter				-0.374			
				(0.699)			
Change in Personal Income, previous quarter* Homeowner				-0.583			
				(0.777)			
Unemployment Rate				0.019			
				(0.015)			
Unemployment Rate*Homeowner				-0.019***			
				(0.006)			
Exemption*Homeowner					0.026**		
					(0.013)		
Observations	18,262	18,207	18,262	15,092	18,262	18,262	18,262
R-squared	0.663	0.670	0.664	0.719	0.664	0.667	0.664

These regressions examine the impact of house price changes on the interest rate for those applications funded in equilibrium. The OLS standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include lagged house price growth, dummy variables for the applicant's state of residence; the year and quarter of the application; and dummy variables for the applicant's credit grade linearly, as well as interacted with house price growth, lagged one quarter, in the borrower's state. Column 2 includes lagged house price growth in lender states; column 3 interacts debt to income with house price changes; income and unemployment are interacted with homeownership in column 4. Column 5 interacts homeownership with the high exemption indicator, this indicator is also interacted with house price changes, as well as house price changes and homeownership. Column 5 interacts the homeownership indicator with the state dummy variables, while column 6 interacts the homeownership indicator variable with the year and quarter of the application.

Table 7. House Prices and the Cost of Credit, by Credit Grade

Dependent Variable: Interest Rate (Log)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	HR	E	D	C	B	A	AA
Homeowner* change in house prices, previous quarter	-0.488	-1.493**	-2.098***	-1.049**	-2.068***	-1.260***	-0.061
	(0.956)	(0.727)	(0.675)	(0.525)	(0.561)	(0.399)	(1.330)
Homeowner	0.025*	0.025**	0.040***	0.046***	0.037***	0.001	-0.008
	(0.014)	(0.011)	(0.010)	(0.009)	(0.012)	(0.008)	(0.012)
Observations	2,239	2,143	3,368	3,648	2,691	2,049	2,124
R-squared	0.420	0.385	0.300	0.293	0.298	0.515	0.558

These regressions examine the impact of house price changes on the interest rate for those applications funded in equilibrium, by credit grade subsamples. The OLS standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include lagged house price growth, dummy variables for the applicant's state of residence; the year and quarter of the application; the amount requested; debt to income ratio; group member; and open for duration.

Table 8. House Prices and the Cost of Credit, Controlling for Selection

	(1)	(2)	(3)	(4)	(5)
	A. Dependent Variable: Interest Rate (Log)				
Homeowner* change in house prices, previous quarter	-1.953***	-1.870***	-1.959***	-1.954***	-1.934***
	(0.397)	(0.385)	(0.397)	(0.397)	(0.397)
Homeowner	0.0154**	0.0156***	0.0152**	0.0152**	0.0149**
	(0.00618)	(0.00594)	(0.00620)	(0.00620)	(0.00619)
	B. Selection Equation: Probability that Listing is Funded				
	Duration	Group	LIBOR	VIX	Bids
	0.0174***	0.294***	0.0929***	-0.00593***	0.0147***
	(0.00223)	(0.0233)	(0.0205)	(0.00163)	(0.00235)

These regressions control for selection when examining the impact of house price changes on the interest rate for those applications funded in equilibrium. Standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include lagged house price growth, dummy variables for the applicant's state of residence; the year and quarter of the application; the amount requested; debt to income ratio; group member; and open for duration. Panel A reports estimates controlling for the probability that the listing becomes a loan. The first stage estimates of the excluded variables are reported in Panel B.

Table 9. House Prices and Credit Demand

	(1)	(2)	(3)	(4)
	Dependent Variable: Applicant Maximum Interest Rate (Log)			Dependent Variable: Equilibrium Interest Rate
VARIABLES	Funded	All	All subprime applicants	Funded
home owner*change in house prices, previous quarter	-1.227***	-0.694***	-0.851**	-0.460***
	(0.351)	(0.236)	(0.365)	(0.144)
home owner	0.032***	0.012***	0.030***	0.004
	(0.005)	(0.003)	(0.005)	(0.003)
Applicant Maximum Interest Rate				0.810***
				(0.015)
Observations	18,262	223,328	65,088	18,262
R-squared	0.615	0.502	0.437	0.885

These regressions examine the impact of house price changes on the applicant maximum interest rate listed in the loan application (columns 1-3). The OLS standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include lagged house price growth, dummy variables for the applicant's state of residence; the year and quarter of the application; and dummy variables for the applicant's credit grade linearly, as well as interacted with house price growth, lagged one quarter, in the borrower's state; the amount requested; debt to income ratio; group member; and open for duration.

Table 10. House Prices and Loan Performance, Accelerated Failure-Time.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Baseline	Detrended	State Macro	Equilibrium Interest Rate	Subprime	Defaulted	Late
homeowner*change in house prices, previous quarter	8.996***	12.667**	9.186***	8.854***	9.909***	5.590*	10.181***
	(1.600)	(5.475)	(2.148)	(1.644)	(1.133)	(3.050)	(1.106)
homeowner	0.012	-0.005	-0.061	0.010	-0.035	0.049	-0.012
	(0.021)	(0.027)	(0.111)	(0.021)	(0.027)	(0.032)	(0.026)
Equilibrium Interest Rate				-0.579***			
				(0.105)			
Observations	50,452	50,452	38,479	50,445	25,603	50,452	48,558
Subjects	14495	14495	12173	14493	7526	14495	14560
Failures	3124	3124	2601	3124	1209	948	2170
Log Likelihood	-6399	-6413	-5030	-6380	-2752	-2652	-5318
Chi-2	1407	1500	1579	1376	674.5	372.7	1153
p-value	0	0	0	0	0	0	0
Log Sigma	0.769	0.780	0.648	0.760	0.740	1.068	0.866
Kappa	-0.148	-0.174	0.122	-0.0970	-0.110	-1.685	-0.147

Standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include lagged house price growth; dummy variables for the applicant's credit grade; the amount requested; the applicant's maximum interest rate; debt to income ratio; group member; and open for duration. Column 2 detrends house prices. Column (3) includes the unemployment rate and the growth in personal income linearly, as well as interacted with homeownership. Column 4 includes the equilibrium interest rate. Column 5 includes only borrowers with credit grades B, C and D. Column 6 uses "default" as definition of failure, while column (7) uses "Late". Failure in columns (1)-(5) is defined as change in status: "current to late", or "late to default".

Table 11. House Prices and Loan Performance, Linear Probability Model

Dependent Variable: Loan Current (1), Otherwise (0)

	(1)	(2)
VARIABLES	Baseline	Age
homeowner*change in house prices, previous quarter	1.254***	0.747***
	(0.159)	(0.094)
homeowner	-0.004*	-0.003*
	(0.002)	(0.002)
Age		0.003
		(0.006)
Age^2		-0.0004
		(0.001)
Age^3		-0.00003
		(0.00001)
Age^4		0.003
		(0.005)
Age^5		-0.00006
		(0.00007)
Observations	66,077	63,946
R-squared	0.062	0.042

The OLS standard errors (in parentheses) are robust to clustering at state/time period level: *** p<0.01, ** p<0.05, * p<0.1. All specifications include lagged house price growth; dummy variables for the applicant's credit grade, linearly and interacted with homeownership; the amount requested; the applicant's maximum interest rate; debt to income ratio; group member; and open for duration; state and year and quarter fixed effects. Column 2 includes the fifth order polynomial of loan age, in months, which are jointly significant at the one percent level. Age^4 and Age^5 are multiplied by 1000.

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