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Mortgage Debt Overhang: Reduced Investment by Homeowners at Risk of Default

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ABSTRACT

Homeowners at risk of default face a debt overhang that reduces their incentive to invest in their property: in expectation, some value created by investments in the property will go to the lender. This agency conflict affects housing investments. Homeowners at risk of default cut back substantially on home improvements and mortgage principal payments, even when they appear financially unconstrained. Meanwhile, they do not reduce spending on assets that they may retain in default, including home appliances, furniture, and vehicles. These findings highlight an important financial friction that has stifled housing investment since the Great Recession.

A LONGSTANDING AND IMPORTANT IDEA in finance theory is that leverage can distort investment decisions. Myers (1977) introduces the notion of corporate debt overhang, arguing that borrowing introduces an agency conflict that curtails productive investments. In public finance, Keynes (1920), Krugman (1988), and Sachs (1990) point out that heavy public debt loads reduce incentives for public sector investments in infrastructure and private sector investments in physical and human capital. This paper applies the same thinking to household financial decisions and provides evidence that homeowners reduce their housing investments when faced with mortgage debt overhang.

The reasoning behind debt overhang is straightforward. For an incremental investment in a debt-free asset, the owner captures the investment's payoffs

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in all states of the world. In contrast, for a levered asset with some risk of default, the investment's payoffs accrue to the foreclosing lender when the owner defaults. Faced with the same investment outlay today and the prospect of sharing the future payoffs with the lender, the owner of a levered asset may underinvest, forgoing economically efficient investments.

Following the precipitous decline in home values in the United States between 2006 and 2011, mortgage debt overhang has become an important issue. During this period, home values fell by 26% nationwide and by more than 50% in some states, leaving many homeowners with negative home equity, that is, mortgage liabilities that exceed the value of their home.[1] At the end of 2011, 15% of homeowners had negative home equity and another 7.5% of homeowners had minimal home equity (less than 10% of home value). Borrowers in this position default at much higher rates in the future and thus are subject to debt overhang.

This analysis uses data from the Bureau of Labor Statistics' Consumer Expenditure Survey (CE) to investigate whether highly leveraged homeowners respond to debt overhang by investing less in their home. The data contain property-specific information for a national sample of homeowners, including mortgage balances and principal payments, home improvement and maintenance expenditures, and property values as estimated by the homeowners. Using these inputs to measure property-level expenditures and to construct each property's mortgage loan-to-value ratio, I test whether spending varies with leverage and default risk.

I find that homeowners with negative home equity spend $200, or 30%, less per quarter on home improvements and maintenance relative to homeowners with positive equity. Homeowners with negative equity also pay down less of their mortgage principal: controlling for differences in mortgage balances, they cut unscheduled principal payments by $180, or 40%. These reductions in investment and debt repayment are not explained by differences in income, total expenditures and financial wealth, nor are they explained by a rich set of controls for household demographics, property characteristics, and mortgage traits. Even for a matched sample of positive- and negative-equity homeowners—among whom key characteristics such as age, income, wealth, nonmortgage indebtedness, and length of ownership are very similar—the presence of negative equity predicts similar declines in housing investment.

In an additional test that ties the empirical model more directly to debt overhang theory, I confirm that homeowners respond to default risk. The CE lacks information on borrowers' delinquency and perceived default risk, so I use an additional data source to calibrate a mortgage default model and estimate each CE respondent's probability of default as a function of their mortgage loan-to-value ratio. While the default risk estimate and the negative-equity indicator are defined using the same underlying variation in loan-to-value

[1] These changes in home values are calculated using the Case-Shiller Indexes between December 2006 and December 2011. State-level declines of 45% to 60% occurred in Arizona, California, Florida, and Nevada.

ratios, the default risk model refines the identifying variation in indebtedness in two ways. First, it ascribes some default risk to households with limited positive equity, and second, it attributes substantially greater risk of default to a homeowner that is deeply "underwater" compared to a homeowner that is barely underwater. Consistent with debt overhang theory, improvements and debt repayment both show a strong negative correlation with estimated default risk.

The patterns in housing investment described above are consistent with debt overhang theory but do not rule out other possible interpretations. For example, heavily indebted homeowners may prefer to invest in their properties but lack the liquidity or borrowing capacity to finance those expenditures (Hurst and Stafford (2004), Mian and Sufi (2011), Cooper (2013), Mian, Rao, and Sufi (2013)). In the balance of the paper I make careful use of the CE data to test a range of predictions that distinguish debt overhang from alternative hypotheses such as financial constraints.

I begin by showing that homeowners with high incomes and substantial financial assets—who are unlikely to be financially constrained—reduce their housing investments when they are in a negative-equity position. These facts are consistent with debt overhang but are difficult to reconcile with an interpretation based on financial constraints. Foreclosure law also affects wealthy homeowners as debt overhang theory predicts. Many states allow mortgage lenders to claim borrowers' financial assets when the collateral falls short of the loan balance, and homeowners in such "recourse" states are less likely to default (Ghent and Kudlyak (2011)). In the CE data, I find that wealthy households in recourse states reduce their housing investments only modestly when they have negative equity. By contrast, when lenders lack recourse and "strategic" default is more likely, wealthy homeowners reduce their housing investments substantially when they are underwater.

The next test strengthens the case for debt overhang by showing that negative-equity homeowners reduce spending *specifically* on those durable investments that are sacrificed to the lender in default. After controlling for the same set of covariates as in the main analysis, spending on home durables (major appliances and furniture) is similar between positive- and negative-equity homeowners. Likewise, underwater homeowners spend similar amounts on entertainment-related durables (for example, televisions and recreation equipment), jewelry, and vehicles after accounting for other household characteristics such as income, total expenditures, financial wealth, and indebtedness. When taken together with the main results, this evidence strongly supports debt overhang relative to other explanations, since it demonstrates within-household variation in spending that matches the predictions of debt overhang theory. Alternative hypotheses that postulate a household-level difference among heavily indebted homeowners—like a binding financial constraint, the expectation of low future income, or a preference, not captured by observables, to invest little in home-related and other durables—cannot easily explain the full set of facts.

The final pair of tests control for omitted household characteristics through household fixed effects. I incorporate fixed effects in two ways. First, I

examine changes in spending over time for households that experience a change in equity position in the year between their first CE interview and their final CE interview. Second, I use the CE's property-level data and compare spending across properties among households that own multiple properties. The identifying variation in this model comes from homeowners for whom one property is underwater and the other has positive equity. While both fixed-effects specifications are estimated on small samples and accordingly have less statistical power than the main analysis, the estimation results generally confirm the main findings. The evidence on improvements and maintenance spending provides particularly strong confirmation that households respond to default risk—households invest less over time as default risk rises and also cut back their investments in underwater properties relative to properties with positive equity. The evidence on principal payments is mixed—homeowners do not cut back principal payments as default risk rises over time, but multiproperty owners do pay down less debt on their underwater properties.

This study highlights an important financial friction that has suppressed residential investment and destroyed value among foreclosed properties during the recent recession and ongoing economic recovery. The evidence developed in this paper does not reject the argument that declines in housing equity during the Great Recession tightened borrowing constraints and reduced consumption (Mian, Rao, and Sufi (2013)). Rather, the evidence shows that debt overhang caused *further* reductions in an important component of household investment. At roughly $140 billion per year, home improvement and maintenance spending is nearly half as large as household saving and new housing construction, respectively.[2] I estimate that, between 2008 and 2011, debt overhang reduced spending on home improvements by 3% to 5% per year nationwide, and by 10% or more in states like Arizona, California, Florida, and Nevada that experienced the largest home price declines. The consequences of debt overhang are most severe for foreclosed properties. As foreclosure approaches, homeowners lack the incentive to undertake even basic, economically efficient repairs, such as fixing a roof or plumbing leak. Indeed, debt overhang contributes to the neglect and deterioration of properties that end up in foreclosure, which sell for 20% to 30% less than comparable homes outside of foreclosure (Campbell, Giglio, and Pathak (2011), Harding, Rosenblatt, and Yao (2012)). This point suggests an additional economic motivation for mortgage modification programs that reduce borrowers' risk of default: such programs can restore borrowers' incentive to care for their homes and thereby mitigate costly underinvestment in housing.

The rest of the article proceeds as follows. Section I reviews theory and evidence about debt overhang. Sections II and III describe the data, regression

[2] Between 1993 and 2007, improvement and maintenance spending averaged $142 billion per year (Census Bureau c50 Report), which amounts to nearly half of the $308 billion per year invested in the construction of new homes (Census Bureau c30 Report). Over the same period, household savings averaged $306 billion per year (Bureau of Economic Analysis's Personal Income and Outlays). For each data series, I convert nominal values into 2009 dollars using the Bureau of Labor Statistics' national CPI-U price index.

sample, and research design. Sections IV to VIII review the regression results. Section IX concludes.

I. Debt Overhang: Theory and Evidence

The central insight of Myers (1977) is that debt contracts, which may improve ex ante efficiency for a variety of reasons, introduce ex post inefficiency by creating an agency conflict that worsens as default becomes more likely. Though the owner controls the asset and bears the full cost of additional investments, she reaps only a portion of the investment payoffs, with the lender capturing the payoffs in the event of default. Accordingly, the owner forgoes some investments that would otherwise be efficient and postpones principal payments that subsidize the lender's position.[3]

As noted in Myers (1977), the social cost of debt overhang depends on the nature of the forgone investment. The efficiency loss is largest for investment opportunities that disappear or decline in value if not exercised. For example, forgone maintenance of some types—failing to fix a foundation problem or a plumbing leak—can be quite socially costly when the subsequent owner faces greater damage and a more costly repair in the future. Forgone additions and remodeling are examples of investment opportunities that do not vanish, but the delay introduced by debt overhang reduces welfare for the current homeowner while she remains in the home. For these types of projects, the efficiency loss is smaller, but increases with the duration of debt overhang.

An extensive theoretical literature incorporates debt overhang into models of corporate, public, and macrofinance.[4] Within household finance specifically, Shiller and Weiss (1998) emphasize the possibility of underinvestment when owners use mortgage contracts in which they share home value appreciation or equity with the lender, Mulligan (2008) proposes a model of labor supply in which mortgage debt overhang plays a crucial role, and Haughwout, Peach, and Tracy (2010) conjecture that negative-equity homeowners will underinvest in their homes as well as their neighborhoods.

Despite this emphasis on debt overhang in theoretical work, there are few empirical studies on the topic. Olney (1999) identifies aggregate loan delinquency patterns during the Great Depression that are consistent with debt overhang, but due to data limitations cannot assess the extent of

[3] I assume that informational frictions—difficulty specifying optimal improvements and maintenance, and difficulty identifying homeowners who are underinvesting—prevent borrowers and lenders from overcoming debt overhang through ex ante contracting and contract renegotiation.

[4] Titman, Tompaidis, and Tsyplakov (2004) apply debt overhang in modeling default risk for commercial real estate loans. Myers (1977), Mello and Parsons (1992), Parrino and Weisbach (1999), Hennessy (2004), Moyen (2007), and Admati et al. (2012) emphasize the debt overhang channel for corporate investment and financing decisions. Krugman (1988) and Sachs (1990) study debt overhang in the context of public finance. Finally, Lamont (1995), Occhino and Pescatori (2015), Phillipon (2010), and Phillipon and Schnabl (2013) incorporate debt overhang as a friction in macroeconomic models.

underinvestment.[5] Harding, Miceli, and Sirmans (2000a) study the effect of homeowner leverage on maintenance and improvement spending, but examine a time period (1985 to 1993) with substantially less debt overhang than today so cannot draw strong conclusions about the extent of underinvestment during a severe housing downturn such as the current one.[6] The contribution of my paper is to provide further evidence that households are forward looking in their investment choices and that leverage affects these choices above and beyond the effects of borrowing or liquidity constraints.

II. Data, Sample Construction, and Summary Statistics

A. Data

The primary data for this study come from the CE, specifically, the Interview Survey, which follows a rotating random sample of households for a yearlong period and provides quarterly observations on each household's expenditures. At any given time the survey includes roughly 30,000 households, with 7,500 participants concluding their participation during each quarter and a new cohort of 7,500 replacing them. As I elaborate below, the CE data are well suited for this study because they provide detailed information on housing investments, mortgage balances, and home valuations.

The CE devotes an entire unit of each interview to tracking spending on home improvement and maintenance projects. Homeowners classify their prior quarter's improvement projects into categories such as "electrical work," "insulation," "plumbing," and "window replacement." For each project, they report the cost of materials and the cost of outside labor. Home appliance costs are tracked separately, even if they arise in the context of a broader improvement project. The data therefore allow for tests that distinguish between investments in the property's physical structure and investments in home-related durables such as appliances and furniture. Homeowners also report expenditures by property, which allows for spending comparisons across properties in multiproperty households. Finally, the CE measures nonhousing expenditures and thereby provides perspective on whether homeowners cut back housing investments relative to other durable and nondurable spending. In this way the CE offers an advantage over other housing-specific surveys such as the American Housing Survey.

In contrast to other mortgage data sources that include only first liens, the CE provides a comprehensive view of households' mortgage indebtedness. For each property, the CE measures the outstanding loan balances on first liens, home equity loans (lump sum), and home equity lines of credit. For first liens and lump sum home equity loans, borrowers report the key terms of the loan

[5] Households continued to pay installment loans secured by durable goods in which they typically had equity, but ceased payments on nonrecourse mortgages that likely exceeded their home's value.

[6] They find evidence of decreased investment for homeowners with loan-to-value between 90% and 105%, but lack statistical power to draw conclusions about homeowners who are more deeply underwater.

contract: the origination date, original principal balance, loan type (fixed/floating and interest only), interest rate, and loan duration. The CE does not ask for the current mortgage balance, but instead estimates the balance by applying the appropriate amortization schedule to the original balance, given the loan characteristics.[7] For lines of credit, borrowers report the current loan balance directly. Summing the actual or estimated mortgage balances across all loans, I estimate the total mortgage debt outstanding on each property as of the beginning of the quarter.

The CE also measures borrowers' discretionary, or unscheduled, mortgage payments. In each interview borrowers report the dollar amount of principal payments in excess of the required payment on first mortgages and lump sum home equity loans. Borrowers also report loan payments on home equity lines of credit. The CE then imputes the principal and interest components of payments toward lines of credit, assuming an interest rate of prime plus 1.5 percentage points. Adding together the unscheduled principal payments on first and second liens and the estimated principal payment on the home equity line of credit, I calculate each household's total unscheduled principal payment.

The final aspect of the data necessary for this study is the homeowner's valuation of his property. The CE questionnaire elicits property values by asking: "About how much do you think this property would sell for on today's market?" Self-reported home values measure market values with error.[8] They nevertheless provide the most relevant valuation for studying debt overhang, since we would expect homeowners to compare the mortgage amount to their *perceived* home value rather than the true value, to the extent that those valuations differ. In Section III.C below, I also confirm that the cross-sectional variation in self-reported loan-to-value ratios correlates strongly with estimates that use administrative data on loan balances and infer property values using local home price indices.

B. Sample Construction

The regression sample includes all homeowners interviewed between the first quarter of 2006 and the first quarter of 2011. In total there are roughly 115,000 property-quarter observations, but missing data among key independent variables limit the sample: state identifiers are suppressed for roughly 16,600 observations in states with small populations, property values and mortgage balances are missing for 13,500 and 6,100 observations, and the age of the home and the current owner's length of ownership are missing for 4,700

[7] The current mortgage balance is thus measured with error if the homeowner has deviated from the mortgage payment schedule prior to entering the survey. However, more significant errors due to mortgage refinancing events are not an issue. The CE asks specifically about refinancing, and records up-to-date information as of the refinancing date.

[8] See Goodman and Ittner (1992) and Agarwal (2007) for analysis comparing homeowners' valuations to outside appraisal and transaction values.

and 900 observations, respectively.[9] The remaining sample has some observations with very low home values and implausibly high loan-to-value ratios. A natural explanation is that these cases are reporting or coding errors. For example, the reported value may be missing a zero (a $50,000 home recorded as a $5,000 home) or may be reported in thousands of dollars (a $50,000 home recorded as a $50 home). With no systematic way of identifying and correcting these cases, I focus the analysis on homes with value above $30,000 and a loan-to-value ratio of two or less.[10] This selection rule excludes roughly 4,500 observations, leaving the final sample at just under 70,000 quarterly observations on 23,500 properties.

C. Negative Equity within the CE Sample

The prevalence of negative equity in the CE data increased dramatically over the sample period, rising from 2.6% of properties in 2006 to 7.5% in 2011. The latter number is similar to other estimates that use the homeowner's valuation, but lower than estimates that rely on nonsubjective measures of home values.[11] For example, analysis by mortgage servicing data provider First American CoreLogic suggests that 14% of properties had negative home equity in the first quarter of 2011 (CoreLogic (2011)). Much of the difference between the CE and CoreLogic estimates can be explained by the fact that homeowners, particularly those with higher loan-to-value ratios, overestimate their home value by 5% to 10% (Goodman and Ittner (1992), Agarwal (2007)). Within the CE in the first quarter of 2011, the proportion of properties with negative equity increases to 13.5% if home values are adjusted downward by 10%.

Though negative equity is underestimated in the CE, it displays the pattern that one would expect in the cross-section. Figure 1 shows a scatter plot with a state-by-state comparison of the CE and CoreLogic estimates of the prevalence of negative equity. Florida, Michigan, Nevada, Arizona, and California have among the highest rates of negative equity, consistent with the First American report. The correlation of negative equity in the CE and in First American data is also quite high at 0.86. The fact that the variation across states matches other sources bodes well for the quality of measured variation in mortgage loan-to-value.

[9] Some respondents either fail or refuse to report an estimated home value. For these instances, I follow an imputation scheme designed to use only directly related information. If the homeowner never reports a home value in any interview, I leave the property value as missing for each quarter. If the homeowner provides a valid response in some but not all quarters, I replace the missing value with the value from the prior period, if available.

[10] Even within a sample of homeowners in the worst-performing housing markets who also had combined loan-to-value of 100% at origination, Bhutta, Dokko, and Shan (2010) find very few instances of loan-to-value in excess of two.

[11] The CE is not alone in underestimating the prevalence of negative equity—within the 2009 American Housing Survey, 6% of homeowners report negative equity, similar to the CE.

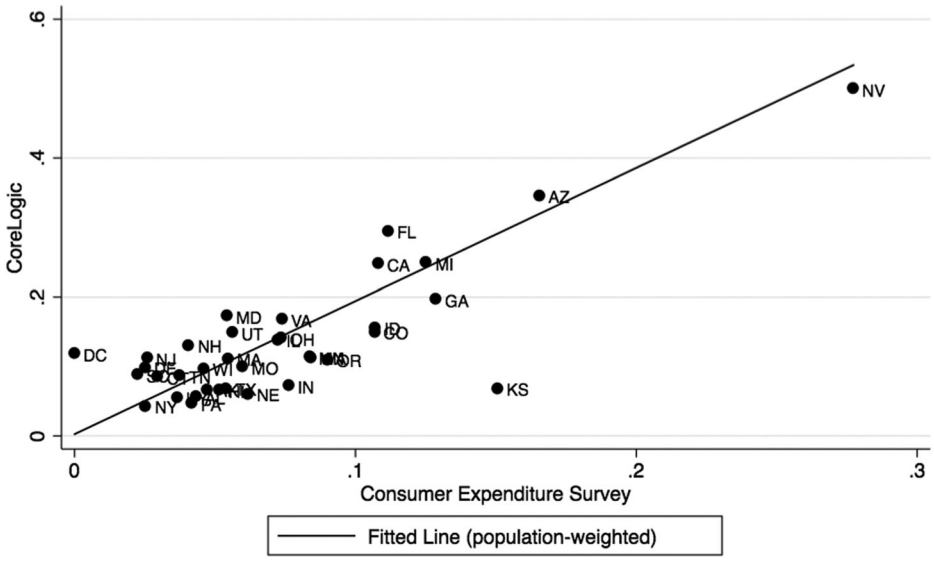

Figure 1. Average proportion of homeowners with negative home equity by state (Q3, 2009 through Q1, 2011). This figure compares the proportion of negative-equity homeowners in each state in the Consumer Expenditure Survey to the proportion of negative-equity homeowners estimated by CoreLogic (CoreLogic (2011)). The population-weighted correlation between the two series is 0.86.

D. Summary Statistics

Average improvement and maintenance spending within the regression sample is $686 per quarter, or $2,744 per year, which amounts to 0.9% of home value per year. As a proportion of total expenditures, improvement spending is just under 3%. Unscheduled debt payments average $452 per quarter, or $1,808 per year, among households with an outstanding mortgage. Annually, these payments amount to 1.2% of the outstanding mortgage balance and 1.8% of total expenditures.

Table I shows sample statistics, by equity status, for home improvement and maintenance spending as well as unscheduled principal payments. Negative-equity owners spend substantially less on home improvement and maintenance—an average of $389 per quarter, compared to $702 per quarter among positive-equity owners. Likewise, owners with negative equity pay down less principal—an average of $232 per quarter in unscheduled principal payments, compared to $470 per quarter among borrowers with positive equity. These differences in average spending are evident along both the extensive and intensive margins of spending. Negative-equity owners are less likely to make an improvement (20% vs. 24%) and pay unscheduled principal (18% vs. 23%). Conditional on making an improvement or principal payment, they also spend less. This difference is evident across the spending distribution from the 5th to the 95th percentiles.

Table I

Summary Statistics, Home Improvement Spending and Unscheduled Principal Payments (CE, 2006 to 2011)

This table presents summary statistics for home improvement and maintenance spending and unscheduled mortgage principal payments in the main regression sample—homeowners who participated in the Consumer Expenditure Survey (CE) between the first quarter of 2006 and the first quarter of 2011—stratified by an indicator for negative home equity (*Negative Equity*).

Panel A: Quarterly Spending on Home Improvement and Maintenance

	Negative Equity = 0	*Negative Equity* = 1
Mean ($)	702	389
Fraction with spending > 0 (%)	24	20
Number of observations	65,150	3,432
	Conditional on Spending > 0	
Mean ($)	2,895	1,901
5th percentile	40	30
25th percentile	198	131
50th percentile	600	410
75th percentile	2,330	1,500
95th percentile	11,602	6,700

Panel B: Quarterly Payments of Unscheduled Principal (Mortgagors Only)

	Negative Equity = 0	*Negative Equity* = 1
Mean ($)	470	232
Fraction with payment > 0 (%)	23	18
Number of observations	41,818	3,432
	Conditional on Payment > 0	
Mean ($)	2,030	1,270
5th percentile	26	20
25th percentile	160	105
50th percentile	431	340
75th percentile	1,114	850
95th percentile	5,428	3,287

Both spending distributions have substantial mass at zero. More than 75% of homeowners spend nothing on home improvement and maintenance in a given quarter, and 80% of mortgagors make no unscheduled principal payments in a given quarter. Conditional on positive spending, both distributions also display right skew.[12] While the main analysis relies on simple linear models estimated with least squares, I also examine a variety of functional forms and estimation techniques to demonstrate that the main findings are not an artifact of least squares estimation within a nonnormal distribution. Least squares estimates can also be heavily influenced by outlying observations, particularly in smaller samples. To prevent outlying observations from distorting inferences from the

[12] Housing investments are naturally right-skewed, but it is also possible that extreme values in the spending distribution include measurement errors, as is the case with property values.

regression analysis, I winsorize the home improvement and repayment measures at the 97.5th percentile in specifications estimated on small subsets of the main sample.

Table II presents summary statistics for the regression covariates, again separating observations by home equity status. Naturally, households with negative equity have larger mortgage balances. Their mortgage debts are higher in each category, with the largest difference in the first mortgage balance: they owe $250,568 through first mortgages, compared to $130,115 for mortgagors with positive equity. Negative-equity households also own lower-value homes, at $220,628 on average compared to $310,039. The average home equity balance is −$47,440 among negative-equity owners. Homes in which the owner has negative equity are newer—built within the last six years on average—but in size and other physical characteristics there is little difference between the two groups.

Negative-equity homeowners do not differ much from their positive-equity counterparts in income and education, but they are younger and less wealthy, they spend less on nonhousing goods and services, and they are more likely to be minorities. Both groups have annual income of roughly $90,000, but those with negative home equity spend less on nonhousing goods and services: $10,016 per quarter compared to $10,822 per quarter. Throughout the regression analysis, I control for nonhousing expenditures to provide estimates of the *relative* decline in improvement spending compared to other spending. Negative-equity owners have less financial wealth on average ($25,557 vs. $91,413) and owe more on vehicle loans ($8,259 vs. $5,304) and unsecured loans ($9,189 vs. $4,425). The average level of education does not differ much with equity status, but negative-equity owners display less variance in educational attainment—fewer ended their education at high school and fewer received a graduate degree. Positive- and negative-equity owners are at different points in the life cycle. Negative-equity owners are 11 years younger (43 years old vs. 54 years old) and have owned their home for nine years less (6 years vs. 15 years) than those with positive equity. Minority groups—African American, Hispanic, and Asian—also comprise a larger share of negative-equity households.

Looking ahead to the empirical analysis, a number of these differences must be accounted for, particularly those that are expected to influence home improvement spending. Based on life cycle and wealth information, negative-equity homeowners appear more likely to be liquidity constrained (Hurst and Stafford (2004), Cooper (2013)). New homeowners and younger households are also known to spend more on improvements (Mendelsohn (1977), Montgomery (1992), Davidoff (2006), Gyourko and Tracy (2006)). Finally, older and larger homes are likely to require more maintenance (Mendelsohn (1977), Montgomery (1992)). Because of the rich property-level detail in the CE, I am able to: (1) measure and control for these differences; (2) use matching or sample restrictions to narrow comparisons to observably similar positive- and negative-equity owners; and (3) conduct placebo tests to confirm that durable spending, conditional on observables, is not correlated with mortgage debt overhang.

Table II
Summary Statistics, Stratified by Negative Equity (CE, 2006 to 2011)

This table presents summary statistics for the main regression sample—homeowners who participated in the Consumer Expenditure Survey (CE) between the first quarter of 2006 and the first quarter of 2011—stratified by an indicator for negative home equity (*Negative Equity*).

	Negative Equity = 0		*Negative Equity* = 1	
	Mean	*SD*	Mean	*SD*
Panel A: Housing Characteristics				
Property value ($)	310,039	302,797	220,628	150,203
Age of home (years)	37.9	29.9	31.5	28.8
Years owned	14.7	13.6	5.9	7.2
Rooms	6.9	2.2	6.7	2.0
Bedrooms	3.2	0.9	3.2	0.9
Bathrooms	1.9	0.8	1.9	0.8
Central air	0.70	0.46	0.75	0.43
Swimming pool	0.12	0.32	0.14	0.35
Porch	0.84	0.36	0.83	0.37
Off-street parking	0.82	0.38	0.81	0.39
Mortgagor	0.64	0.48	1.00	0.00
Home equity ($)	187,474	245,727	−47,440	59,107
Number of observations	65,150		3,432	
Panel B: Mortgage Characteristics				
Total mortgage balance ($)	140,449	124,593	268,068	184,085
First mortgage balance ($)	130,115	118,930	250,568	175,861
Home equity loan balance ($)	2,813	14,109	6,505	27,838
Home equity line of credit balance ($)	7,521	32,168	10,995	44,740
Age of mortgage (months)	72.0	71.8	44.1	39.1
Mortgage interest rate (%)	5.87	2.12	6.46	1.45
Fixed rate mortgage	0.85	0.36	0.87	0.33
Variable rate mortgage	0.08	0.27	0.13	0.34
Mortgage insurance (indicator)	0.08	0.27	0.14	0.35
Number of observations	41,818		3,432	
Panel C: Household Characteristics				
Income / Wealth				
Annual income ($)	89,715	75,444	89,963	63,705
Nonhousing expenditures ($, quarterly)	10,822	10,662	10,016	8,170
Financial assets ($)	91,413	384,098	25,557	169,295
Unsecured debt ($)	4,425	14,826	9,189	18,968
Vehicle debt ($)	5,304	10,903	8,259	15,334
Education				
No high school diploma	0.08	0.27	0.08	0.27
High school diploma only	0.22	0.41	0.18	0.39
Some college	0.29	0.46	0.34	0.47

(*Continued*)

Table II—*Continued*

Panel C: Household Characteristics				
College degree	0.25	0.43	0.28	0.45
Graduate degree	0.16	0.37	0.12	0.33
Race/Ethnicity				
White	0.80	0.40	0.69	0.46
Black	0.07	0.25	0.11	0.31
Hispanic	0.08	0.26	0.12	0.33
Asian	0.04	0.21	0.06	0.24
Other	0.02	0.12	0.02	0.15
Other				
Age (years)	53.7	15.1	43.1	11.8
Family size	2.7	1.4	3.1	1.5
Number of observations	65,150		3,432	

III. Research Design

Debt overhang theory predicts that housing investments will decrease as the probability of mortgage default increases. The CE questionnaire, however, does not elicit information about respondents' perceived risk of default, nor does it ask whether respondents are current on their mortgage payments. As a proxy for elevated default risk, therefore, the main empirical analysis uses an indicator variable for negative equity.

There is a strong rationale for an empirical model of this type that estimates a nonlinear effect of mortgage leverage on default risk and housing investments. First, being in a negative equity position is a necessary condition of mortgage default in most models; among borrowers unable to pay debt service, selling or refinancing the home dominates defaulting when there is positive equity. Moreover, among borrowers with the resources to pay, having negative equity beyond a certain level becomes a sufficient condition for default.[13] For both of these reasons, homeowners' probability of default accelerates around the point where combined mortgage balances exceed the home value. A number of empirical studies confirm that mortgage default rates are substantially higher among negative-equity homeowners (Deng, Quigley, and Van Order (2000), Deng and Gabriel (2006), Foote, Gerardi, and Willen (2008)). I provide further supporting evidence in Section IV.B below.

A. Regression Model

The key tests throughout the paper rely on linear regressions of expenditures on an indicator for negative equity. The main regression model is given by

$$y_{ipst} = \alpha + \beta Negative\ Equity_{pt} + \gamma \mathbf{X}_i + \delta \mathbf{Z}_p + \eta_{st} + \varepsilon_{ipst}. \quad (1)$$

[13] As noted in Kau, Keenan, and Kim (1994), simply being above 100% loan-to-value is not sufficient for default: there is option value in delaying default while there is still reasonable chance of regaining positive equity.

The dependent variable is either spending on home improvement and maintenance or payments of unscheduled mortgage principal for household i on property p in state s during quarter t. The coefficient β measures the difference in mean spending on improvements or principal payments between positive- and negative-equity homeowners. All specifications include state-year fixed effects, denoted by η. The vectors $\mathbf{X}$ and $\mathbf{Z}$ include household- and property-level controls, respectively. Household-level covariates in $\mathbf{X}$ are: income, quarterly expenditures on nonhousing goods and services, financial asset balance, vehicle debt balance, unsecured debt balance, number of household members, a quadratic in the head of household's age, and a set of dummy variables indicating the head of household's education and race.[14] Property-level covariates in $\mathbf{Z}$ include both housing and mortgage characteristics. The housing characteristics are: an indicator for first year of ownership; quadratics in the age of the home and number of years owned; number of rooms, bedrooms, and bathrooms; and indicators for central air conditioning, off-street parking, porch, and swimming pool. The mortgage characteristics are: mortgage interest rate; a quadratic in the age of the mortgage; and indicators for whether the property secures a mortgage, the type of mortgage (fixed or floating interest), whether the property secures a home equity line of credit, and whether the borrower pays mortgage insurance.

Some specifications include linear controls for the property value and mortgage balance. The control for property value ensures that differences in maintenance and improvements due to housing quantity are not attributed to negative equity, which naturally correlates with property value. Likewise, the mortgage balance is mechanically related to negative equity and may also correlate with unscheduled principal payments (holding fixed loan-to-value). For example, borrowers with small balances outstanding may pay less in unscheduled principal. The linear control for total mortgage balance helps to ensure that debt repayment differences are not attributed to the negative-equity variable when they are simply due to differences in the outstanding loan balance.

The model is estimated with Ordinary Least Squares (OLS). Observations are clustered by state in calculating standard errors, for two reasons: first, to account for cross-sectional correlation of residuals caused by geographic clustering of negative equity and improvement spending, and second, to account for serial correlation in residuals due to autocorrelation in negative equity and spending at the household level.

B. Estimating Default Risk Conditional on Mortgage Leverage

To provide a more explicit estimate of CE respondents' probability of mortgage default, I use additional data from the Census's Survey of Program

[14] The racial categories are: White, Black, Hispanic, Asian, and other. The education categories are: less than high school diploma, high school diploma, some college, college degree, and graduate degree. Where financial asset information is missing, financial assets are replaced with zero; the model also includes a dummy indicating missing asset information.

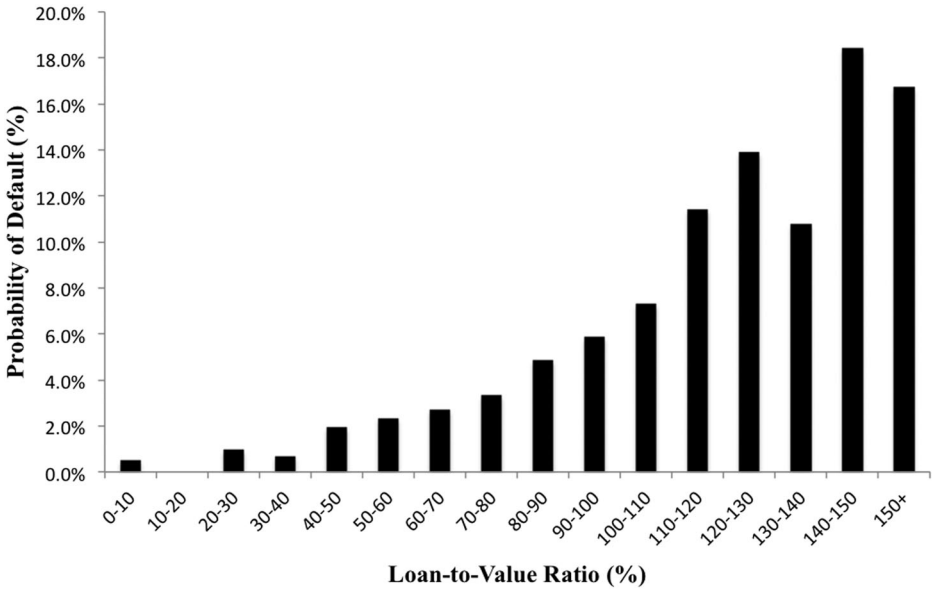

Figure 2. Estimated default probability by loan-to-value ratio. This figure reports the incidence of mortgage default (at least one missed mortgage payment over the prior 12 months) for homeowners in 10-point loan-to-value bins within the 2010 Survey of Income and Program Participation.

Participation (SIPP). The SIPP assesses mortgage default and also includes the mortgage and home value information necessary to compute the homeowner's self-reported mortgage loan-to-value.[15] Among borrowers in the 2010 panel of the SIPP, I estimate the average default probability for each 10-point loan-to-value bin ranging from 0% to 150%. These estimates are displayed in Figure 2. Default risk increases around 80% loan-to-value and accelerates upward in the negative-equity region.[16] Pairing this model with the self-reported loan-to-value information in the CE, I estimate each CE borrower's probability of default. In specifications that are otherwise identical to model (1), I test whether homeowners respond to default risk by replacing the negative-equity indicator with this default probability estimate, which I denote *Default Risk*.

IV. How Do Housing Investments Vary with Home Equity?

A. Main Analysis

As a prelude to the regression analysis, I begin by describing the relationship between leverage, improvement and maintenance spending, and debt repayment in the raw data. The top half of Figure 3 plots the average level of

[15] The SIPP includes the question: "Was there any time in the past 12 months when you did not pay the full amount of the rent or mortgage?"

[16] This pattern in default risk matches empirical studies of default (Foote, Gerardi, and Willen (2008)) and calibrated quantitative models (Campbell and Cocco (2015)).

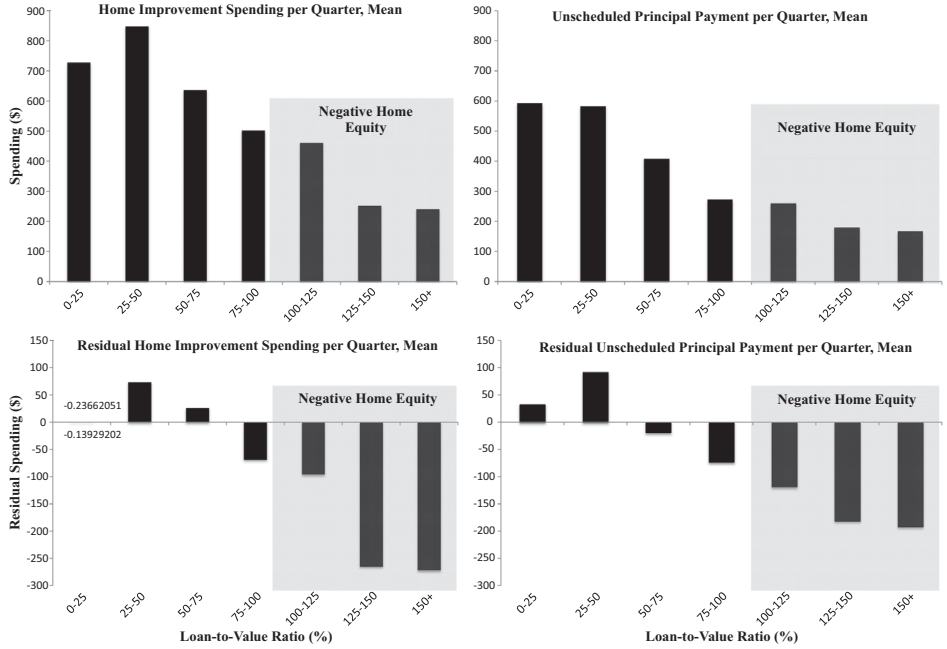

Figure 3. Home improvement and maintenance spending and unscheduled principal payments, by loan-to-value ratio (CE, 2006 to 2011). The top panel reports raw means of quarterly spending across 25-point loan-to-value bins for homeowners in the Consumer Expenditure Survey (CE). The bottom panel reports means of residual spending for the same sample, with residuals calculated from regression model (1) using all independent variables except the indicator for negative home equity (*Negative Equity*).

improvement spending and unscheduled principal payments by loan-to-value ratio. Both improvement spending and unscheduled debt payments decline as loan-to-value rises, and the lowest spending is evident among homeowners with negative equity. These patterns become even more evident after conditioning on the observable characteristics (except for *Negative Equity*) specified in regression model (1). The bottom half of Figure 3 plots average residual spending by loan-to-value ratio. Both residual improvements and principal payments remain positive or close to zero for homeowners with loan-to-value below 75% before turning negative and decreasing substantially in the negative-equity region.

Table III displays regression estimates from the analysis of home improvement and maintenance spending. The results show that homeowners with negative equity spend less on improvements and maintenance than their counterparts with positive equity. This pattern holds across a variety of model specifications with different control variables and functional form assumptions. In the first three specifications, the dependent variable is the dollar amount of home improvement and maintenance spending. In a sparse regression model with only state-year fixed effects to absorb common regional variation

Table III

Negative Home Equity and Spending on Home Improvement and Maintenance

This table presents estimates from regressions of quarterly home improvement and maintenance spending on *Negative Equity*—an indicator of whether the homeowner has negative home equity—and control variables. The measure of spending varies across specifications as indicated in the table heading. Mean spending is reported for households with positive home equity. Each model includes state-year fixed effects; additional control variables are included as specified in the table. The control variables include household, property, and mortgage characteristics as well as linear controls for the property value and mortgage balance. The household characteristics are: income, quarterly expenditures on nonhousing goods, financial asset balance, vehicle debt balance, unsecured debt balance, number of household members, quadratic in head of household's age, and indicator variables for the head of household's education and race (five categories each). The housing characteristics are: indicator for first year of ownership, quadratics in age of home and number of years owned, number of rooms, bedrooms, and bathrooms, and indicators for central air conditioning, off-street parking, porch, and swimming pool. The mortgage characteristics are: mortgage interest rate, quadratic in age of mortgage, and indicators for whether the property secures a mortgage, the type of mortgage (fixed or floating interest rate), whether the property secures a home equity line of credit, and whether the borrower pays mortgage insurance. Standard errors are calculated with observations clustered by state and are reported in parentheses. ** and *** indicate statistical significance at 5% and 1% levels, respectively.

	Home Improvement and Maintenance Spending						
Dependent Variable:	Spending ($)			Fraction of Total Spending (%)	Log Spending	Any Spending	Spending ($)
Mean:	702			3.01	1.57	0.24	702
Model:	Ordinary Least Squares (OLS)			OLS	OLS	OLS	Tobit
Negative Equity	−282***	−205**	−195**	−0.76***	−0.27***	−0.04***	−227***
	(65)	(78)	(73)	(0.13)	(0.05)	(0.01)	(51)
R^2	0.01	0.02	0.03	0.02	0.04	0.03	0.01
$N = 68{,}582$							
Control variables							
State-year fixed effects	Y	Y	Y	Y	Y	Y	Y
Household, property, and mortgage characteristics	N	Y	Y	Y	Y	Y	Y
Property value and mortgage balance	N	N	Y	Y	Y	Y	Y

in spending and housing leverage, I estimate that negative-equity homeowners spend $282 less on improvements. In the second model, which includes additional controls for household, housing, and mortgage characteristics, I find that negative-equity homeowners spend $205 less on their home. Finally, after adding linear controls for mortgage balance and property value, I estimate $195 lower spending by negative-equity homeowners. This estimate implies 28% less

improvement and maintenance spending relative to positive-equity homeowners, who spend on average $702 per quarter.

These findings are quite robust to alternative assumptions about functional form. As a proportion of total household spending, improvement and maintenance spending is 76 basis points (or 25%) lower among negative-equity homeowners. In a specification with log expenditures as the dependent variable, the coefficient on the negative-equity indicator is –0.27, which implies 24% ($= e^{-0.27} - 1$) lower improvement spending among homeowners with negative equity.[17] Similar findings hold for a model that ignores the dollar amount of spending and instead examines whether the homeowner makes a positive expenditure. The OLS, or linear probability, estimates for this specification show that homeowners with negative equity are four percentage points (or 17%) less likely to spend money on improvements and maintenance. This result confirms that measurement error and outlying values for improvements are not obscuring the main result. Finally, a Tobit specification (Tobin (1958)) that accounts for left censoring of spending at zero confirms the sign and magnitude of the OLS estimates. The Tobit marginal effect shows that negative-equity owners spend $227 less than positive-equity owners.

Table IV displays analogous results for unscheduled mortgage payments. In a model with state-year fixed effects as controls, debt payments are on average $220 lower among negative-equity homeowners. After adding controls for household, home, and mortgage characteristics, the difference is somewhat smaller, at $143, but still strongly significant. Finally, with the full set of controls I estimate $179 lower quarterly debt payments among homeowners with negative equity. This difference is 38% of the average payment by positive-equity borrowers ($470 per quarter).

The rest of Table IV explores the robustness of the relationship between negative equity and debt repayment. As a proportion of nonhousing expenditures, principal payments are lower among negative-equity homeowners. The coefficient of –0.31 on *Negative Equity* indicates roughly 17% lower payments relative to the average normalized payment of 1.77% among mortgagors. In the model examining log debt payments, the coefficient on the negative-equity indicator is –0.15, which implies 14% ($= e^{-0.15} - 1$) lower debt payments among negative-equity homeowners. A linear probability model reveals that owners with negative equity are two percentage points, or 9%, less likely to make an unscheduled debt payment than owners with positive equity. Finally, the Tobit model suggests $43, or 9%, lower repayment by borrowers with negative equity. While the estimated effects vary somewhat in magnitude, the qualitative finding holds across specifications: a negative-equity position predicts lower debt payments.

One may worry that prepayment penalties, which are not observable in the CE, reduce principal payments among high loan-to-value borrowers. However, the most common prepayment penalties on first and second mortgages

[17] As a dependent variable, I use the transformation ln(1 + expenditure) to include observations with zero spending in the estimation.

Table IV
Negative Home Equity and Unscheduled Mortgage Principal Payments

This table presents estimates from regressions of quarterly unscheduled mortgage principal payments on *Negative Equity*—an indicator of whether the homeowner has negative home equity—and control variables. The measure of payments varies across specifications as indicated in the table heading. Mean payments are reported for households with positive home equity. Each model includes state-year fixed effects; additional control variables are included as specified in the table. Those variables include household, property, and mortgage characteristics (listed in notes to Table III) as well as linear controls for the property value and mortgage balance. Standard errors are calculated with observations clustered by state and are reported in parentheses. ** and *** indicate statistical significance at the 5% and 1% levels, respectively.

	Unscheduled Principal Payment						
Dependent Variable:	Payment ($)			Fraction of Total Spending (%)	Log Payment	Any Payment	Payment ($)
Mean:	470			1.84	1.37	0.23	470
Model:	Ordinary Least Squares (OLS)			OLS	OLS	OLS	Tobit
Negative Equity	−220***	−143***	−179***	−0.31**	−0.15***	−0.02**	−43***
	(41)	(40)	(48)	(0.12)	(0.05)	(0.01)	(12)
R^2	0.01	0.05	0.05	0.11	0.38	0.34	0.06
$N = 68{,}582$							
Control variables							
State-year fixed effects	Y	Y	Y	Y	Y	Y	Y
Household, property, and mortgage characteristics	N	Y	Y	Y	Y	Y	Y
Property value and mortgage balance	N	N	Y	Y	Y	Y	Y

apply only to payments that exceed 20% of principal outstanding (Freddie Mac (2006)). Censoring payments at this limit does not change the main findings, since less than 2% of observed payments exceed 20% of the outstanding balance. Furthermore, both components of unscheduled principal payments—unscheduled payments on first and second mortgages and payments on lines of credit—decline for properties with negative equity.[18] The latter finding cannot be explained by constraints on prepayment since prepayment penalties on lines of credit are rare.

[18] As reported in Table IA.IV in the Internet Appendix, unscheduled payments on first and second mortgages decline by $103 ($p$-value < 0.01) and payments on lines of credit decline by $75 ($p$-value < 0.10). The Internet Appendix is available in the online version of the article on *The Journal of Finance* website.

B. Further Robustness Tests

In additional tests reported in Tables IA.I and IA.II in the Internet Appendix, I further examine the robustness of the main findings. I first confirm that the main findings are robust to using lagged home price and mortgage information in calculating home equity. I implement this test using two-stage least squares, instrumenting for $Negative\ Equity_{pt}$ with $Negative\ Equity_{pt\text{-}1}$. Both home improvements and principal payments show a negative and significant relationship with the negative-equity indicator in the two-stage model. The estimated decline in improvements of \$226 per quarter (p-value < 0.10) is similar in magnitude to the main findings, while the decline in principal payments of \$334 (p-value < 0.01) is larger than the main findings.

The next analysis collapses the quarterly data into a single observation per household-property. To do so, I measure households' equity position in the first interview and compute their average spending in subsequent interviews. The results for the collapsed data are very similar to the main findings: households with negative equity spend an average of \$233 less per quarter on improvements (p-value < 0.05) and \$206 less per quarter on debt payments (p-value $= 0.11$).

A third specification demonstrates that the main findings are robust to measuring debt overhang with the *depth* rather than the *presence* of negative home equity. The estimates, which show strong statistical significance, indicate that home improvements and principal payments are \$371 lower and \$295 lower, respectively, for each \$100,000 of negative home equity.

The fourth model includes metropolitan statistical area (MSA)-by-year fixed effects in place of state-year fixed effects. The CE only provides the homeowner's MSA for cities with a population greater than 100,000, so this sample is slightly less than half the size of the main sample. This model restricts the identifying variation in negative equity by controlling flexibly for city-level trends, including trends in home prices and construction costs. Changing the identifying variation in this way has little impact on the negative-equity coefficients, which remain similar in magnitude and statistical significance to the main findings.

A final pair of tests addresses concerns about outlying observations by repeating the main analysis with improvement and maintenance spending and debt payments winsorized at the 97.5^{th} percentile. The *Negative Equity* coefficients are strongly significant and imply substantially lower home improvements (–28%) and mortgage debt payments (–32%) when measured as a proportion of average winsorized spending.

Collectively, the findings above confirm the first two predictions about debt overhang: negative-equity households invest less in their homes, in terms of both incremental improvements and debt payments. In the subsequent analysis, I address omitted variables and distinguish debt overhang from other possible interpretations of these findings. Before moving on to those tests, however, I first make note of two interpretations that do not fit the initial findings. A regional economic shock that drives down real estate values and household

spending (including improvement spending) would not explain these estimates, which are identified using household-level variation in negative equity within a region, controlling for differences in income and nonhousing expenditures. It is also natural to wonder whether negative-equity homeowners—many of whom have suffered large declines in their home value—invest less because they have limited investment opportunities.[19] Even debt-free owners would forgo improvements when they perceive low returns from investing. But this line of thinking does not account for the reduction in principal payments, which do not change the underlying asset and therefore should not fall simply due to low forecast returns from incremental investments.[20]

C. Analysis Using Default Risk

The next analysis explores the relationship between default risk and housing investments. This analysis ties the empirical model more directly to debt overhang theory and imposes more structure on the identifying variation in indebtedness by replacing the negative-equity indicator with the borrower's estimated probability of default. To highlight two important differences from the negative-equity specification: (1) the default model ascribes some default risk to households with limited, but positive, equity; and (2) the default model attributes substantially greater risk of default to a homeowner that is deeply underwater compared to a homeowner that is barely underwater.

Table V displays the regression estimates. As background for interpreting the regression estimates, the average difference in default probability between negative- and positive-equity owners is 10 percentage points. The coefficient on default probability is negative and strongly significant for both improvement spending and principal repayment. The first model's *Default Risk* coefficient of –2,865 implies that a 0.10, or 10 percentage point, increase in default risk corresponds to a roughly $287 reduction in improvement spending. The estimates for principal payments are nearly identical, indicating a $286 reduction for a 10-percentage-point increase in default risk (third column of Table V). The estimates in the second and forth columns show that the default probability measure drives out the negative-equity indicator and displays much more explanatory power when both variables are included in the model. Although *Negative Equity* and *Default Risk* display a strong correlation of 0.76, the additional variation in the default probability provides a better fit in explaining the patterns in housing investments.

[19] The models of Jorgenson (1963) and Tobin (1969) offer a rational explanation for lower spending: investment returns are low when market values are below replacement cost. Choi, Hong, and Scheinkman (2014) propose a behavioral explanation for the same phenomenon: homeowners reduce improvements because they underestimate returns when home prices have fallen. In an empirical study, Gyourko and Saiz (2004) confirm that homeowners spend less on improvements when home values are low relative to replacement cost.

[20] If the debt overhang channel is shut down (zero risk of default), then the marginal return on principal payments is the interest rate on the loan.

Table V
Mortgage Default Risk and Housing Investments

This table presents estimates from regressions of home improvement and maintenance spending or unscheduled principal payments on the homeowner's estimated probability of mortgage default (*Default Risk*), an indicator for negative home equity (*Negative Equity*), and control variables. Each model includes state-year fixed effects, property value, mortgage balance, and the full set of household, property, and mortgage characteristics used in the main analysis (see Table III). Standard errors are calculated with observations clustered by state and are reported in parentheses. ** and *** indicate statistical significance at the 5% and 1% levels, respectively.

Dependent Variable:	Home Improvement and Maintenance Spending		Unscheduled Principal Payment	
Mean if Positive Equity:	702		470	
Default Risk	−2,865**	−3,279		
			−2,862***	−3,557***
	(1,139)	(2,066)	(547)	(860)
Negative Equity		54		91
		(155)		(72)
R^2	0.03	0.03	0.05	0.05
$N = 68{,}582$				

D. Housing Investments and Negative Equity in a Matched Sample

As noted in the discussion of summary statistics, positive- and negative-equity homeowners differ along a number of dimensions. While the main analysis controls for many observable differences, inferences from those models may be unreliable because of lack of common support in key variables within the positive- and negative-equity homeowner subsamples or because of errors in the assumed functional form of the control variables.

The analysis in Table VI addresses this issue by examining a matched sample of positive- and negative-equity homeowners. I match homeowners on their predicted probability of having negative equity, as calculated from a probit model with the following explanatory variables: state-year fixed effects, homeowner age, years of ownership, mortgage age, income, financial asset balance, vehicle debt balance, and unsecured debt balance.

The matching procedure is largely effective in balancing the sample. As shown in Panel A of Table VI, the average values of the key covariates are quite similar in the positive- and negative-equity subsets of the matched sample, with only modest differences in financial assets and unsecured debt balance that are significant at the 5% level.

Panel B shows the estimated spending differences between the matched positive- and negative-equity homeowners. As in the main analysis, improvement spending and discretionary principal payments are significantly lower among homeowners with negative equity. The difference in improvement spending is –$226, which is a 36% decline relative to the average of $622 spent by positive-equity households in the matched sample. This difference is significant at the 5% level and is slightly larger than the 28% decline estimated in the

Table VI
Negative Home Equity and Housing Investments within a Matched Sample

This table presents an analysis of a matched sample of positive- and negative-equity homeowners. Each negative-equity homeowner is matched without replacement to the nearest positive-equity homeowner based on their propensity to have negative equity. Propensities are calculated from a probit model with the following explanatory variables: income, homeowner age, years of ownership, mortgage age, financial asset balance, vehicle debt balance, unsecured debt balance, and state-year fixed effects. Panel A reports the mean characteristics of the matched sample, stratified by equity status. Panel B reports the difference in mean home improvement and maintenance spending and unscheduled principal payments between the positive- and negative-equity homeowners in the matched sample. * and ** indicate statistical significance at the 10% and 5% levels, respectively.

Panel A: Balance of Matched Sample (Means)

	Negative Equity = 0	*Negative Equity* = 1	Difference = 0 (*p*-value)
Income	88,173	87,477	0.67
Age of homeowner (years)	43.5	43.4	0.82
Years owned	6.2	6.0	0.20
Age of mortgage (months)	44.1	44.5	0.70
Financial assets	32,287	24,262	0.04
Vehicle debt	8,186	8,024	0.70
Unsecured debt	8,084	9,150	0.05
Number of observations	3,055	3,055	

Panel B: Treatment Effects

Dependent Variable: Mean if Positive Equity:	Home Improvement and Maintenance Spending 622	Unscheduled Principal Payment 367
Negative Equity	−226** (101)	−125* (70)

main analysis. The difference in principal payments is –$125, implying a 34% decline relative to the average $367 payment among the positive-equity control group. This estimate is significant at the 10% level and is slightly smaller than the 38% decline estimated in the main analysis.

The matching analysis confirms the inferences drawn in the main analysis. While the positive- and negative-equity homeowners may still differ in unobservable characteristics, narrowing the comparison to observably similar treatment and control groups does not meaningfully change the results.[21]

[21] An alternative to matching is to restrict the sample to observably similar positive- and negative-equity homeowners. Regression results reported in Table IA.III in the Internet Appendix confirm that housing investments are lower among negative-equity homeowners even after restricting the sample by age (less than 40 years old), length of ownership (less than five years), and time since refinancing (less than three years).

Table VII
Negative Home Equity, Default Risk, and Housing Investments among Financially Unconstrained Households

This table presents an analysis of housing investments and mortgage debt overhang within subsets of the main sample. The two subsamples—households with annual income of $165,000 or more and households with financial assets of $100,000 or more—are chosen to isolate households that are likely to be financially unconstrained. The key independent variable is either an indicator for negative home equity (*Negative Equity*) or an estimate of the homeowner's probability of mortgage default (*Default Risk*). Each model includes state-year fixed effects, property value, mortgage balance, and the full set of household, property, and mortgage characteristics used in the main analysis (see Table III). The dependent variables are winsorized at the 97.5th percentile. Standard errors are calculated with observations clustered by state and are reported in parentheses. * and ** indicate statistical significance at the 10% and 5% levels, respectively.

	Home Improvement and Maintenance Spending			
Sample:	Income ≥ 165,000		Fin'l Assets ≥ 100,000	
Mean if Positive Equity:	1,697		1,328	
Negative Equity	−409**		−561**	
	(176)		(208)	
Default Risk		−2,368		−5,424**
		(2,051)		(2,233)
R^2	0.06	0.06	0.07	0.07
N	8,536		7,974	
	Unscheduled Principal Payment			
Sample:	Income ≥ 165,000		Fin'l Assets ≥ 100,000	
Mean if Positive Equity:	1,162		1,073	
Negative Equity	−235		−409	
	(190)		(325)	
Default Risk		−4,985**		−5,380*
		(2,113)		(2,868)
R^2	0.12	0.13	0.12	0.12
N	8,536		7,974	

V. Does Negative Equity Proxy for Limited Liquidity and Borrowing Capacity?

The analysis presented in Table VII explores whether the spending decline by heavily indebted homeowners is driven by financial constraints. For these tests, I estimate the impact of negative equity and default risk among households with high incomes and substantial financial assets who appear financially unconstrained. Debt overhang should affect the improvement spending of homeowners in these two subsamples if they are at risk of default. Current financial constraints, on the other hand, are an unlikely explanation for any differences in spending that they display, as these homeowners have the savings or borrowing capacity to fund improvements. In this analysis, the dependent

variables are winsorized at the 97.5th percentile to ensure that inferences are not influenced by a small number of outlying observations.

Homeowners who appear financially unconstrained invest less in their properties when they have negative equity. Within roughly the top decile of income (above $165,000 per year), households with negative equity spend $409 less on improvements. Compared to the average improvement spending for high-income, positive-equity households ($1,697 per quarter), this estimate implies a reduction of 24%, which is only modestly lower than the estimate from the main sample. Likewise, homeowners with at least $100,000 of financial assets reduce their improvement spending by $561, or 42%, when they have negative home equity. The same qualitative pattern is evident in models using the probability of default rather than the negative-equity indicator, with a negative but insignificant coefficient for the high-income sample and a negative and significant coefficient for the high-asset sample.

Financially unconstrained households also repay less mortgage principal when they are in a negative-equity position. The results in the bottom panel of Table VII show that high-income and high-asset households pay $235 less and $409 less, respectively, in unscheduled principal when their mortgage balance exceeds their home value. These point estimates indicate substantial spending reductions of 20% and 38%, respectively, but are imprecise and therefore are statistically insignificant (p-values of roughly 0.20). Statistical power is somewhat greater in the model using the estimated default probability as the measure of debt overhang: within both the high-income and high-asset subsamples, principal repayment has a negative and statistically significant correlation with default risk.

These findings show that the main results are not readily explained by financial constraints. Since wealthy households can continue making mortgage payments in the case of job loss, the large spending declines observed in this subsample are noteworthy. Being in a negative-equity position should not expose them to substantially higher default risk unless they are considering strategic default to avoid paying the excess mortgage balance above the value of the home.[22] In that case, whether mortgage lenders have recourse to financial assets should affect the borrower's risk of default. The analysis in Section VII explores the role of lender recourse.

It is worth mentioning that potentially constrained homeowners also reduce improvement spending when they are in a negative-equity position (see Table IA.V in the Internet Appendix). I estimate substantial reductions for those with zero financial assets (–32%) and somewhat smaller reductions (–20%) for those with income below $100,000. For unscheduled mortgage principal, the subsample with zero financial assets reduces payments substantially (–46%) when they have negative equity, but the low-income subsample shows a smaller, statistically insignificant reduction of –5%.

[22] Bhutta, Dokko, and Shan (2010) and Guiso, Sapienza, and Zingales (2011) estimate that 20% to 30% of recent defaults are strategic.

Table VIII
Negative Home Equity, Mortgage Default Risk, and Spending on Durable Goods

This table presents an analysis of durable goods spending and mortgage debt overhang. The key independent variable is either an indicator for negative home equity (*Negative Equity*) or an estimate of the household's probability of mortgage default (*Default Risk*). The dependent variable is quarterly spending on one of four categories of durable goods: home durables, entertainment-related durables, jewelry, and automobiles. Each model includes state-year fixed effects, property value, mortgage balance, and the full set of household, property, and mortgage characteristics used in the main analysis (see Table III). Standard errors are calculated with observations clustered by state and are reported in parentheses.

Dependent Variable:	Home Durables Spending: Major Appliances and Furniture		Entertainment-Related Durables Spending: Televisions, Stereos, and Sports and Recreation Equipment	
Mean if Positive Equity:	231		614	
Negative Equity	18		−8	
	(29)		(37)	
Default Risk		77		−85
		(358)		(439)
R^2	0.05	0.05	0.04	0.04
$N = 68{,}582$				
Dependent Variable:	Jewelry Spending		Vehicle Spending	
Mean if Positive Equity:	62		1,004	
Negative Equity	4		−79	
	(18)		(80)	
Default Risk		84		−588
		(213)		(1,050)
R^2	0.04	0.04	0.02	0.02
$N = 68{,}582$				

VI. Using within-Household Variation to Test for Debt Overhang

A. How Does Durable Spending Vary with Home Equity and Default Risk?

The analysis presented in Table VIII investigates whether heavily indebted households also reduce spending on other durable goods. The debt overhang hypothesis predicts no difference in spending on durable assets that stay with the homeowner in the event of default. I consider four categories of durables: (1) home-related durables, including furniture and major appliances; (2) entertainment-related durables, including televisions, stereos, and sports and recreation equipment; (3) jewelry; and (4) automobiles. Furniture and appliances are closest in nature to home improvements by virtue of their connection to the home. Automobiles are large-ticket items that are closest in size to home improvements. However, many households depend on vehicles for transportation to work, so vehicle spending may not be particularly elastic with respect to financial circumstances. The last two categories,

entertainment-related durables and jewelry, consist of nonessential goods that households can forgo when facing financial constraints.

For each durable category, I estimate two regression models, one with the negative-equity indicator as the independent variable and the other with the estimated default probability. The control variables are identical to those included in the analysis of improvements, except that the total expenditures variable excludes spending in the category that is being examined. For example, when examining vehicle spending I control for total nonvehicle expenditures. The dependent variable in each regression is the quarterly expenditure on goods in that category.

The regression estimates, which are displayed in Table VIII, reveal no relationship between durable spending and the two proxies for debt overhang. Across all four spending categories, the coefficients on *Negative Equity* and *Default Risk* are statistically insignificant. The coefficients on the negative-equity indicator are small and insignificant for home durables, entertainment-related durables, and jewelry. For home durables and jewelry, the coefficients actually have the opposite sign as the main findings. Though vehicle spending displays a modestly negative point estimate for *Negative Equity*, the coefficient is insignificant and implies an 8% decline in spending, which is substantially smaller than the estimated effect of negative equity on housing investments.

These results show that the spending decline attributed to negative equity is specific to the category for which we expect mortgage overhang: it is specific to the home and even within the home it is specific to investments in the permanent structure. The muted response of durable spending to home equity is also not due to general inelasticity in these spending categories: jewelry and entertainment-related durables are nonessential goods that one would expect to be quite income and wealth elastic.

These facts are helpful in interpreting the main results. The main regression results do not isolate exogenous variation in negative equity, so it is natural to worry that the correlations do not reveal a causal effect of negative equity on home investments. For example, underinvesting might cause negative equity. Heavily indebted borrowers, who are at greatest risk of having negative home equity, might also be a different type of homeowner for whom most positive-equity homeowners are a poor comparison group. But it is hard to imagine that such unobserved heterogeneity across households would not show up in other durable spending, particularly in home improvements that are closely related, but not attached, to the home.

We should not conclude, however, that home equity plays no role in relaxing financial constraints or that financial constraints have no effect on home improvement and durable spending. Indeed, I find evidence that financial constraints reduce spending, but that debt overhang causes an *additional* decline in housing investments beyond what is explained by financial constraints. Throughout the main analysis, I control for nonhousing expenditures. If, instead, I consider nonhousing expenditures as a dependent variable in a model without control variables, I find that negative-equity homeowners spend less than positive-equity homeowners. The summary statistics in Table II show, for

example, that negative-equity homeowners spend $806, or 7.4%, less per quarter on nonhousing goods and services than positive-equity homeowners. In a regression that also controls for income and household demographics (reported in Table IA.VI in the Internet Appendix), I estimate $697, or 6.4%, less spending. Yet in a specification with the full set controls (also reported in Table IA.VI in the Internet Appendix), which includes measures of financial constraints such as debt and asset balances, I estimate a much smaller and statistically insignificant spending difference of $215 ($p$-value = 0.29) between positive- and negative-equity homeowners.

Controlling for households' asset and debt balances therefore absorbs variation in spending due to binding liquidity or borrowing constraints. The striking fact in the main analysis, of course, is that housing investments do not show this pattern—they decline substantially in the negative-equity region even after controlling for total expenditures and financial variables that proxy for liquidity or borrowing constraints.

Another point worth noting is that the main analysis examines spending differences between positive and negative-equity homeowners, but does not explore how home improvement and durable spending differ among those with positive equity, where equity might be important in financing spending. As evidence along this dimension, I estimate negative coefficients on the household's mortgage debt balance in models explaining durable spending. This finding shows that households spend less when they face larger mortgage debts, even though they do not further reduce durable spending when they face elevated risk of default per se.

The results in this paper are therefore in line with recent findings that geographic areas with higher housing leverage experienced greater declines in durable spending in response to falling home prices during the Great Recession (Mian, Rao, and Sufi (2013)). Indeed, financial constraints and debt overhang are not mutually exclusive explanations, and the data show that both frictions matter in shaping household consumption and investment.

B. Estimation with Household Fixed Effects

The analysis in the previous section uses within-household differences in spending to address the critique that omitted household characteristics, such as financial constraints, explain why negative-equity owners invest less in their homes. Another way to account for unobserved differences across households is to control for household fixed effects. The analysis presented in Table IX implements this approach. These models rely only on within-household variation in mortgage leverage and default risk. Doing so reduces estimation bias by controlling flexibly for household-level factors, but also narrows the identifying variation quite dramatically and therefore reduces precision in estimation. As in the analysis of high-income and high-asset subsamples, the dependent variables are winsorized at the 97.5$^{\text{th}}$ percentile to ensure that inferences are not influenced by a small number of outlying observations.

I use household fixed effects in two tests. The first test focuses on the subset of households that complete all four quarterly CE interviews and experience

Table IX

Incorporating Household Fixed Effects: Using Variation in Mortgage Default Risk over Time and across Properties

This table presents an analysis of housing investments and mortgage debt overhang using household fixed effects. The key independent variable is either an indicator for negative home equity (*Negative Equity*) or the household's estimated probability of mortgage default (*Default Risk*). The first two models in each panel use variation in equity status and default risk over time among households that experience a change in *Negative Equity* between their first and final CE interviews. The third and fourth models use variation in home equity and default risk across properties among households that own multiple properties. Each model includes the full set of household, property, and mortgage characteristics used in the main analysis (see Table III). The dependent variables are winsorized at the 97.5th percentile and means are reported for households with positive home equity. Standard errors are calculated with observations clustered by state and are reported in parentheses. * and ** indicate statistical significance at the 10% and 5% levels, respectively.

	Home Improvement and Maintenance Spending			
Sample:	Households Experiencing a Change in *Negative Equity* between First and Final Interviews		Households Owning Multiple Properties	
Mean:	526		818	
Negative Equity	–337**		–284	
	(131)		(224)	
Default Risk		–1,856*		–3,723**
		(953)		(1,826)
R^2	0.55	0.54	0.29	0.29
N	978		9,921	
	Unscheduled Principal Payment			
Sample:	Households Experiencing a Change in *Negative Equity* between First and Final Interviews		Households Owning Multiple Properties	
Mean:	290		808	
Negative Equity	226		–283	
	(155)		(220)	
Default Risk		2,823		–3,227*
		(2,500)		(1,600)
R^2	0.56	0.56	0.29	0.29
N	978		9,921	

a change in *Negative Equity* between their first interview and their final interview. The resulting sample includes 978 observations, or two observations per property on 489 properties. The identifying variation in *Negative Equity* and *Default Risk* in this sample comes from changes in households' home equity over time. The second test focuses on the subset of households that own multiple properties at the same time. Just over 8% of households in the main sample meet this criterion (1,780 of 21,582 households in the main sample). The

resulting sample includes 9,921 observations, or 2.7 observations per property for the 3,714 properties owned by multiproperty households. The identifying variation in *Negative Equity* and *Default Risk* in this sample comes from differences in home equity across properties for a given household.

The top panel of Table IX presents the fixed-effects regression estimates for improvement and maintenance spending. Consistent with the main findings, the point estimates on the negative-equity indicator and the default risk measure are negative in all four specifications and significant in three of four models. Households that experience a change in home equity over time spend $337 less on improvements and maintenance when they have negative equity. The second model's coefficient of –1,856 on *Default Risk* implies a somewhat smaller reduction—a $186 decline for a 10-percentage-point increase in default risk—but confirms the negative correlation between default risk and spending. The third model shows that multiproperty owners invest $284 less in their underwater property compared to their property with positive equity. This estimate, while similar in magnitude to the estimates from the main analysis, is estimated fairly imprecisely and does not rule out substantial spending differences in either direction. The fourth model, in contrast, provides more power and confirms that spending is lower on properties for which the estimated default risk is higher, even after controlling for household fixed effects—a 0.10 increase in default probability corresponds to a $372 reduction in home improvement spending (p-value < 0.05).

The bottom panel of Table IX presents the fixed-effects tests for unscheduled principal payments. In the first test, which uses variation in leverage over time, the point estimates on *Negative Equity* and *Default Risk* are statistically insignificant and have the wrong sign. These estimates fail to confirm the debt overhang prediction in this sample, but do not reliably rule out large differences in repayment in either direction. The estimates for multiproperty owners, on the other hand, support the debt overhang interpretation. Multiproperty owners invest $283 less ($p$-value $= 0.21$) on their underwater property compared to their property with positive equity and reduce repayments by $323 ($p$-value $<$ 0.10) for every 10-percentage point increase in default risk.

VII. Foreclosure Laws, Financial Wealth, and Negative Equity

The final extension of the main analysis tests whether the choices of negative-equity homeowners depend on state foreclosure laws. In states that allow mortgage lenders to claim borrowers' financial assets when the collateral value falls short of the loan balance, mortgage default among wealthy negative-equity homeowners should be less prevalent, since the loss of other assets offsets the gain from defaulting on the mortgage. Ghent and Kudlyak (2011) provide evidence that lender recourse matters: negative-equity homeowners default more frequently in nonrecourse states.[23]

[23] Ghent and Kudlyak's (2011) data do not measure financial assets, but in their analysis recourse does have a substantially larger effect on default for homes with high appraisal values.

Table X

Negative Home Equity, Financial Wealth, and Lender Recourse

This table presents an analysis of whether mortgage debt overhang varies with state foreclosure laws and households' financial wealth. *Negative Equity* is an indicator for whether the homeowner has negative home equity. *Recourse* is an indicator for whether state foreclosure law allows lenders to claim borrowers' financial assets in foreclosure. *Fin'l Assets* measures the household's financial asset balance in \$100,000s. In addition to the variables reported in the table, each model includes *Recourse*, *Fin'l Assets*, the *Recourse-Fin'l Assets* interaction, state-year fixed effects, property value, mortgage balance, and the full set of household, property, and mortgage characteristics used in the main analysis (see Table III). The dependent variables are winsorized at the 97.5th percentile. Standard errors are calculated with observations clustered by state and are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Dependent Variable:	Home Improvement and Maintenance Spending	Unscheduled Principal Payment
Mean if Positive Equity:	690	489
Negative Equity	−45	−182***
	(81)	(59)
Negative Equity × *Recourse*	−149*	64
	(79)	(70)
Negative Equity × *Fin'l Assets*	−134***	−75*
	(43)	(37)
Negative Equity × *Recourse* ×	209**	75**
Fin'l Assets	(101)	(31)
R^2	0.04	0.08
$N = 58{,}418$		

The analysis presented in Table X uses three-way interactions to test whether the spending differences attributable to *Negative Equity* vary with state foreclosure laws and homeowners' financial wealth. The variable *Recourse* indicates whether lenders have recourse to the borrower's other assets in foreclosure.[24] The variable *Fin'l Assets* measures the homeowner's financial asset balance in \$100,000s.

The regression model is identical to the main analysis, but now includes the triple interaction *Negative Equity-Recourse-Fin'l Assets* as well as all two-way interactions of these variables and the variables themselves. The following abbreviated version of the regression model highlights the coefficients of interest:

$$\begin{aligned} y_{ipst} = \; & \alpha + \beta Negative\ \ Equity_{pt} + \gamma Negative\ \ Equity_{pt} \times Recourse_{ps} \\ & + \delta Negative\ \ Equity_{pt} \times Fin'l\ \ Assets_i \\ & + \theta NegEquity_{pt} \times Recourse_{ps} \times Fin'l\ \ Assets_i + \ldots . \end{aligned} \tag{2}$$

[24] I follow the classification of lender recourse in Ghent and Kudlyak (2011) and Pence (2006). The seven nonrecourse states represented in the CE data are Alaska, Arizona, California, Minnesota, Oregon, Washington, and Wisconsin. Iowa, Montana, North Carolina, and North Dakota also restrict recourse but are excluded from the sample because the CE suppresses geographic identifiers for those states during the sample period. Within California, I code homeowners with nonpurchase mortgages as subject to recourse since deficiency judgments are prohibited only for purchase mortgages.

Debt overhang theory predicts that households with substantial financial assets will be less likely to default when their lender can claim those assets in foreclosure. Homeowners with savings may still strategically default in recourse states, but only if their negative-equity balance is large and exceeds their savings. As financial assets increase, therefore, strategic default should become rare in recourse states.[25] Accordingly, wealthy homeowners with negative home equity should cut back home improvement spending by substantially less when they are subject to recourse than when they are not. Translating to the empirical model, the coefficient θ on the triple interaction should be positive if recourse is effective in reducing default risk and the associated debt overhang for wealthy homeowners. For households without assets, debt overhang theory also predicts lower spending among those with negative equity ($\beta < 0$) and no difference due to recourse ($\gamma = 0$).

The first column of Table X displays the regression results for improvement spending. Before comparing the results to the predictions of debt overhang theory, I first discuss and interpret the coefficient estimates. The estimate for β indicates that negative-equity homeowners who lack financial assets spend on average \$45 less than positive-equity homeowners. The first interaction with *Recourse* reveals that negative-equity homeowners who lack assets reduce spending by an additional \$149 (p-value < 0.10) when they are subject to recourse. The *Negative Equity-Fin'l Asset* coefficient of –134 (p-value < 0.05) implies that, for each additional \$100,000 of financial assets, negative-equity homeowners cut their improvement spending by an additional \$134. This estimate confirms the earlier finding that high-asset homeowners reduce spending by a larger dollar amount than low-asset homeowners when they have negative home equity. This *Negative Equity-Fin'l Asset* coefficient describes the spending patterns of homeowners who are *not* subject to recourse. To understand the pattern of spending among high-asset households in recourse states, one must add to it the coefficient on the triple interaction. The triple interaction coefficient of 209 is positive, significant (p-value < 0.05), and exceeds the *Negative Equity-Fin'l Asset* coefficient in magnitude. This finding implies that, wealthier homeowners with negative home equity reduce spending by substantially less when they are subject to recourse.

To gauge the magnitude of these spending differences, it is helpful to evaluate the model predictions at particular values of financial assets. For assets of \$100,000, the model predicts that in nonrecourse states negative-equity owners will spend \$179 less than positive-equity owners ($\beta + \delta$; p-value < 0.01), while in recourse states negative-equity owners will spend \$119 less than positive-equity owners ($\beta + \gamma + \delta + \theta$; p-value $= 0.18$). Fixing financial assets at \$300,000, the spending differences grow: the model predicts that negative-equity owners will spend \$447 less than positive-equity owners in nonrecourse states ($\beta + 3 \times \delta$; p-value < 0.01) and \$31 more than positive-equity owners in

[25] In the CE sample, less than 5% of negative-equity homeowners with financial assets above \$100,000, for example, have a negative home equity balance in excess of their financial assets (see Table IA.VII in the Internet Appendix).

recourse states ($\beta + \gamma + 3 \times \delta + 3 \times \theta$; p-value = 0.91). The spending patterns of wealthy owners therefore confirm the predictions of the debt overhang model with respect to lender recourse.[26]

The second column of Table X displays the regression results for unscheduled principal payments. The main coefficient on *Negative Equity* is –182 (p-value < 0.01). The coefficient on *Negative Equity-Recourse* is fairly small and statistically insignificant. Together these two estimates imply that, among homeowners who lack financial assets, being in a negative-equity position predicts lower debt repayment regardless of the state's recourse laws. As in the analysis of improvement spending, I find a negative and significant coefficient on *Negative Equity-Fin'l Assets* and a positive and significant coefficient on the triple interaction. Wealthy households thus cut back their mortgage principal payments when they are in a negative-equity position, but do so to a much lesser extent when lenders can claim their assets in default. For households with $300,000 of financial assets, the model predicts that negative-equity owners in nonrecourse states will pay $407 less in principal than positive-equity owners ($\beta + 3 \times \delta$; p-value < 0.01), while in recourse states they will pay $118 less than positive-equity owners ($\beta + \gamma + 3 \times \delta + 3 \times \theta$; p-value = 0.07).

This analysis of foreclosure laws confirms some but not all predictions of debt overhang theory. The homeowners for whom lender recourse is most relevant—those with financial assets to lose in a deficiency judgment—do show the spending pattern that one would expect based on debt overhang theory. They reduce their improvement spending and debt repayment by substantially larger amounts when lenders cannot claim their financial assets in foreclosure ($\theta > 0$).[27] The results for low-asset households, on the other hand, are mixed. Debt repayment shows the predicted pattern—negative-equity homeowners reduce spending and recourse has no effect ($\beta < 0$, $\gamma = 0$)—whereas improvement spending declines substantially more for negative-equity homeowners in recourse states ($\beta = 0$, $\gamma < 0$).

VIII. Additional Tests

In further analysis reported in the Internet Appendix, I evaluate three additional explanations for the main findings. The first consideration is intertemporal substitution of improvements. High improvement spending in the past

[26] In Table IA.IV in the Internet Appendix, I provide further evidence of strategic default within recourse states. In those states, households with negative *total* equity (property value + financial assets – mortgage balance < 0) may choose to cut back improvement spending, whereas households with positive total equity should not strategically default or forgo improvements. The spending patterns in recourse states are consistent with these predictions—owners with negative total equity substantially reduce improvement spending, whereas owners with negative *home* equity but positive *total* equity show no significant decline in spending.

[27] Harding, Miceli, and Sirmans (2000b) find greater spending on home maintenance and improvements in states where recourse is permitted through deficiency judgments. However, they identify this effect simply in the cross-section of states rather than exploring differences in the effects of recourse due to homeowner equity and financial wealth as I do.

may explain low spending today, and serve as a confounding factor if *Negative Equity* in the current period is positively correlated with past spending. Such a correlation may result, for example, if homeowners funded past improvements by refinancing and increasing their mortgage balance (Brady, Canner, and Maki (2000)). To account for such a relationship, the main regressions include controls for mortgage age with linear and quadratic terms. Likewise, the matching analysis pairs observations based on mortgage age. Finally, I estimate the effect of negative home equity within a sample of homeowners chosen to restrict variation in age, years of ownership, and time since refinancing. Within this subsample, positive- and negative-equity owners do not vary along these three dimensions on average, but the indicator for negative home equity still predicts sizeable and statistically significant declines in both improvements and principal payments (see Table IA.III in the Internet Appendix).

The household's ownership horizon may also affect spending on improvements, particularly for projects that provide utility to the current owner but may not be valued by a future owner. Homeowners with short horizons have less incentive to make such improvements. Therefore, if negative equity happens to be more prevalent among short-horizon homeowners, it will predict lower spending even in the absence of a debt overhang effect. If anything, studies of home equity and household mobility show the opposite relationship—negative-equity owners move less frequently (Chan (2001), Ferreira, Gyourko, and Tracy (2010))—but there is still uncertainty about this finding (Schulhofer-Wohl (2012)). Following Sinai and Souleles (2005, 2009), I proxy for differences in geographic mobility with an indicator variable for each age-occupation-marital status cell.[28] Doing so barely changes the coefficient on the negative-equity indicator (see Table IA.III in the Internet Appendix), suggesting that variation in mobility does not confound the effect of home equity on housing investments.

The third possibility is that homeowners may substitute their own labor for outside labor when they have negative home equity. The value of improvements and maintenance reported in the CE includes the cost of materials and outside labor, but excludes the value of the homeowner's own labor, which can be meaningful—within the CE, almost half of improvement jobs involve at least some work performed by the homeowner. If negative-equity homeowners were still improving their properties but were substituting their own labor for outside labor, the coefficients on the negative-equity indicator would overstate the effect of debt overhang. Yet there is no evidence that such substitution is occurring. Indeed, a multinomial logit analysis shows similar proportional declines in the prevalence of projects with homeowner labor as with contractor labor. A linear probability model also shows that negative-equity homeowners who make improvements are no more or less likely to contribute their own labor than positive-equity owners (see Table IA.VIII in the Internet Appendix).

[28] Households are classified into one of eight age categories (each group spanning 10 years), five marital status categories, and 19 occupation categories.

IX. Conclusions

This paper studies the financial choices of deeply indebted homeowners, an important topic in the aftermath of the Great Recession. The proportion of homeowners with negative home equity reached 15% by the end of the recession in 2009 and showed little improvement until home prices began to recover in early 2013. Finance theory predicts that homeowners in these circumstances, who face elevated risk of default, will reduce their housing investments due to debt overhang.

Using property-level data on leverage and expenditures, I test this conjecture and find strong evidence in favor of debt overhang. Homeowners with negative equity substantially reduce their housing investments, cutting home improvement and maintenance spending and discretionary mortgage principal payments by roughly 30% each. Consistent with debt overhang theory, housing investments show a strong negative correlation not just with the negative-equity indicator but also with a continuous measure of borrowers' estimated default risk. These cutbacks do not reflect a general spending decline by deeply indebted homeowners, nor are they limited to homeowners who face borrowing or liquidity constraints, as wealthy homeowners in nonrecourse states reduce their principal payments and improvement spending substantially when they have negative equity. Finally, comparing across categories of durable spending, the cutbacks are specific to investments in the physical structure of the home, on which the mortgage lender has a claim in foreclosure. Debt overhang best explains this collection of facts.

These findings show that households are forward-looking in their investment decision making. When homeowners are days away from default and certain of this outcome, it is unsurprising that they choose not to invest in their homes. Yet even if home improvement spending were reduced to zero for homes heading into foreclosure, average quarterly spending would have fallen by only 3%, far below the 30% reduction that I estimate.[29] The magnitude of the investment decline therefore implies that a much larger group of homeowners is cutting back and doing so on a forward-looking basis as they anticipate the increased possibility, if not certainty, of default. An ancillary finding—that wealthier homeowners in nonrecourse states also respond to debt overhang—implies further that strategic default is an important consideration for some homeowners.

Because debt overhang was so widespread and persistent, it contributed to meaningful declines in residential investment between 2008 and 2013. I estimate that debt overhang reduced nationwide spending on home improvements by 3% to 5% per year,[30] which accounts for roughly one-third of the decline in

[29] Foreclosure starts peaked at a quarterly rate of 1.4% of loans (0.91% of homeowners) and the stock of foreclosures peaked at 4.6% of loans (3.0% of homeowners).

[30] To calculate the aggregate spending decline due to debt overhang, I multiply the proportion of homeowners with negative home equity—which ranged from 10% to 15% over this period—by the estimated 30% decline in improvement spending.

improvement spending in that period relative to 2007.[31] In states like Arizona, California, Florida, and Nevada with the highest proportion of negative-equity homeowners, the spending reductions due to debt overhang were even larger, at 10% or more per year.

The consequences of debt overhang are most severe among foreclosed properties. I find that homeowners cut back spending by increasingly large amounts as default risk rises, which suggests that they forgo not only home additions and remodeling but also basic repairs and maintenance. This distortion may create substantial deadweight loss, since the value destroyed by forgone maintenance often exceeds the cost of the repair. An interesting topic for future research would be to quantify the social cost of mortgage debt overhang.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix