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Food insecurity among older adults in the US: The role of mortgage borrowing

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2. Abstract

Housing wealth is the primary source of wealth for many older adults, particularly those with lower incomes, who are more at risk of severe forms of economic hardship such as food insecurity. For housing wealth to directly improve food insecurity, it first must be liquefied. Understanding the role of housing wealth requires careful consideration of home equity and mortgage borrowing. A primary contribution of our report is to model the financial mechanisms through which housing wealth and its components—home value, home equity, and mortgage debt—affect food insecurity in older age. We use panel data on households from the Health and Retirement Study and instrumental variable linear probability models with household fixed-effects to assess the effects of new mortgage borrowing on food insecurity (N=20,421 household-years). Trend analyses reveal that food insecurity increased from the 2008 recession until 2014 and that new mortgage borrowing peaked prior to the recession. The proportion of older homeowners facing credit constraints is highest for those age 65 to 69 in all years. Regression results show that mortgage borrowing has a substantial short-term negative effect on food insecurity. Each additional $10,000 borrowed is associated with reduction of food insecurity of 2.2 percentage points. The effect of new mortgage borrowing on food insecurity is distinct from changes in house prices or changes in home equity, neither of which are statistically significant factors. In a simulation of the effects of relaxing the debt-to-income borrowing constraint, we find that food insecurity is reduced by 2.1 percentage points for previous non-borrowers and by 1.6 percentage points for borrowers. Results support the importance of access to mortgage borrowing to reduce material hardship in older age. (272 words)

Keywords:
Food insecurity, older adults, housing wealth, mortgage borrowing

3. Executive Summary

Motivation

Older adults can face distinct consequences of food insecurity because of their life stage. Food insecurity is associated with poor physical and mental health, higher health care utilization, and higher mortality, thus constituting an urgent policy issue. Lack of income and wealth are key hindrances to achieving food security. For older adults, heterogeneity in household wealth has been shown to be more important than income in predicting food insecurity. Housing wealth is the primary source of wealth for many older adults, particularly those with lower incomes. In 2018, about 80% of U.S. older adults owned their homes, and home equity comprised as much as three-quarters of the median net wealth for older households in the lowest income quartile. Mortgage borrowing is the predominant mode through which older adults access this important source of wealth. Newly borrowed funds may be used for consumption expenditures or competing expenses, such as medical bills, thereby reducing food insecurity. However, high levels of existing mortgage debt limit future borrowing in the event of an unexpected need, for example, if older adults encounter a costly health shock. Understanding the relationship between housing wealth, mortgage debt, and food insecurity thus requires careful consideration of home equity as well as mortgage borrowing. This report presents new evidence on the effects of housing wealth on food insecurity for older adults. A primary contribution of this study is modeling the financial mechanisms through which housing wealth and its components—home value, home equity, and mortgage debt—affect food insecurity in older age. While prior studies find that owning a home is associated with reduced food insecurity, the mechanisms underlying this relationship are poorly understood.

Study objectives

The objectives of the current study are:

1. To document trends in age-adjusted food insecurity, mortgage debt, and borrowing constraints among older adults from 2000 to 2018.
2. To identify the mechanisms through which financial and housing wealth influence food insecurity and estimate heterogeneity by race and location of residence.
3. To simulate how policy innovations in access to housing wealth affect food insecurity.

Food insecurity is measured with two questions, whether the older homeowners always had enough money to buy the food they needed during the past two years (food insecurity) and whether they ever ate less than they felt they should because there wasn't enough money to buy food during the past 12 months (severe food insecurity).

We exploit the panel nature of the Health and Retirement Study (HRS) by using ten biennial survey waves from 2000 to 2018. We limit our sample to homeowners age 65 and older, but exclude households who split due to a dissolved marriage or partnership or who move, but only during the period in which borrowing is measured. A household is permanently removed from the sample when the final household member dies. In trend analysis we examine three age groups of older adults (65-69, 70-79, 80 and older). Our sample size includes 6,319 households and 20,421 household-years across all waves.

Trends in food insecurity, housing and financial wealth

- Food insecurity rates in our sample were similar among older adult homeowners across age groups from 2000 to 2008, ranging from 2.64 to 4.61%. Food insecurity increased since the 2008 recession, particularly for homeowners age 65 to 69 in our sample, of whom over 6.5% were food insecure in 2018.
- Rates of severe food insecurity in our sample also increased since 2008 for homeowners age 65 to 69, reaching 4.1% in 2018. The rates were between 1% and 2% for the two older age groups during the time period from 2008 to 2018.
- Home equity peaked prior to the 2008 recession and declined until 2012 as house values declined. House values have been recovering in recent years. The frequency of new mortgage borrowing reflected the trend in home equity, while the average amount of mortgage borrowing among borrowers remained relatively flat among older homeowners from 2000 to 2016.
- The proportion of homeowners facing credit constraints through binding loan-to-value ratios was highest for the youngest age group from 2000 to 2016 and increased for all age groups during the 2008 recession until 2012, when the constraints started to relax again.

Mechanisms through which financial and housing wealth influences food insecurity

- An average of 3.3% of older homeowners in our sample experience food insecurity and an average of 1.4% of older homeowners experience severe food insecurity.
- Regression results show that mortgage borrowing has a substantial short-term effect on food insecurity. Each additional $10,000 borrowed is associated with reduction of food insecurity of 2.19 percentage points two years later, in the subsequent wave of the Health and Retirement Study.
- The effect of new mortgage borrowing on food insecurity is distinct from changes in house prices or changes in home equity, neither of which are statistically significantly associated with food insecurity in the analysis.
- We do not find evidence of a significant relationship between mortgage borrowing and severe food insecurity in our analysis. However, the rate of severe food insecurity is low and the number of severely food insecure older homeowners who borrow is small in our sample, resulting in lower statistical power to detect an effect.

Heterogeneity by race and location of residence

- Among food insecure homeowners age 65 and older in our sample, 31.5% are Black and 24.2% live in non-metropolitan counties. In comparison, only 10.6% of food secure older homeowners in our sample are Black; 21.5% of food secure older homeowners live in non-metropolitan counties.
- We examine Black vs. White older homeowners and older homeowners living in metropolitan vs non-metropolitan counties through interaction terms in the regression analysis. Each dollar borrowed has a similar effect on the food security of Black vs White older homeowners as well as those in metropolitan and non-metropolitan counties.

Simulation of policy innovations in access to mortgage borrowing

- Based on our regression estimates, we simulate the effects of policy innovations that increase borrowed amounts, reduce borrowing constraints, and eliminate monthly mortgage payments on food insecurity rates.
- We assign a borrowing amount equal to 50% of 2010 home equity to all 2012 borrowers and to homeowners who are constrained by high mortgage payment-to-income (PTI) ratios and therefore did not borrow in 2012 (newly borrowed amount was $0). Simulations show that borrowing in 2012 for the full sample increases by $9,549 and reduces food insecurity in 2014 by an additional 2.10 percentage points from the predicted baseline to 1.47%. In the simulations, non-borrowers with PTI<20% are kept at a borrowed amount of $0.
- Black older homeowners and homeowners in non-metropolitan areas have substantially lower levels of home equity at baseline than White and metropolitan homeowners, reducing their predicted borrowing amount through the simulations and thus the effects of relaxing borrowing constraints on food insecurity.
- The borrowing simulation reduces the predicted rate of food insecurity by 0.64 percentage points for Black homeowners, compared to 1.26 percentage points for White homeowners
- The borrowing simulation reduces the predicted rate of food insecurity by 0.62 percentage points for non-metropolitan homeowners, compared to 1.38 percentage points for older homeowners living in metropolitan counties.

Conclusion

In conclusion, our analysis identifies new mortgage borrowing as a mechanism that contributes to the relationship of food insecurity and housing wealth. Regression results show that new mortgage borrowing is associated with lower food insecurity, and the simulations indicate that additional borrowing substantially reduces observed food insecurity, particularly when borrowing is extended to constrained households who previously were unlikely to be approved for new mortgage borrowing.

General house price changes or changes in home equity are not significant predictors of food insecurity in our sample. This result underscores the need to liquefy and consume home equity in order to affect food insecurity. When examining the role of race and location of residence, we do not find that an additional $1 of borrowing has different effects for Black and White older homeowners or those living in metropolitan and non-metropolitan areas. There is little evidence that the racial and geographic discrepancies are driven by behavioral differences in the use of the mortgage borrowing proceeds.

Taken as a whole, our results suggest that borrowing through a mortgage is a mechanism that links housing wealth to economic security and supports the importance of access to mortgage borrowing to reduce material hardship late in life.

4. Introduction

Older adults can face distinct consequences of food insecurity because of their life stage. In older age, food insecurity is associated with poor physical and mental health (for a review, see Gundersen and Ziliak 2015), increased health care utilization (Bhargava and Lee 2016), and higher mortality (Ferri et al. 2012), thus consituting an urgent policy issue (Coleman-Jensen et al. 2019). As of 2018, about 7.5% of households with older adults over age 65 are food insecure (Coleman-Jensen et al. 2019). While lower than its recent peak of 8.9% in 2014 (Coleman-Jensen et al. 2015), food insecurity remains higher than the about 6% prevalence observed prior to the 2008 recession (Ziliak and Gundersen 2019). Not having enough money to buy food, as food insecurity is defined in the current study, poses a major health care challenge for an aging population (Ziliak and Gundersen 2018, p. 2). The Health and Retirement Study, which is the data used in the present research contains two connected food insecurity questions. The two questions are similar to questions in the USDA six-item short form to measure food insecurity (ERS 2012), but they are worded slightly differently. The first question is a measure of food insecurity, posed to all survey participants. It asks whether a person or household had sufficient money in the past two years to purchase the food they needed. Negative responses are followed-up with the question about whether a respondent ate less for financial reasons.

Lack of income and wealth are key hindrances to achieving food security (Gualtieri and Donley 2016, Wolfe, Frongillo, and Valois 2003). For older adults, studies have found that household wealth is even more important than income in predicting whether or not a household is food insecure (Ziliak, Gundersen, and Haist 2008). However, not all wealth is equally accessible to wealth holders (Gundersen and Gruber 2001). While housing wealth is the primary source of

wealth for many older adults, especially for low-income and Black households, it is an illiquid asset. In 2018, about 80% of U.S. older adults owned their home and the median homeowner age 65 and older had about $143,500 in home equity (Joint Center for Housing Studies 2019). In the lowest income quartile of adults aged 65 and older, median home equity is $80,000—as much as three-quarters of the median net wealth for older households; across all older homeowners, median home equity is $143,500, representing about 45% of median net wealth (Joint Center for Housing Studies 2019). Though the level of home equity varies, the need for liquefying this wealth in order to access it is common across all households.

Borrowing through a mortgage is the predominant mode by which older adults liquefy housing wealth.[1] Available mortgage products include first and second mortgages on a home, home equity lines of credit (HELOCs), and reverse mortgages (the most common being the Federal Home Equity Conversion Mortgage (HECM)), which is only available to older adults. A first mortgage is the primary lien on a property; they are typically offered for 15, 20 or 30-year periods. Homeowners can borrow from home equity on a first mortgage by refinancing the loan for more than the prior mortgage balance, thereby extracting a lump sum of home equity in the form of cash. Second mortgages are typically smaller than first mortgages, and are closed end loans that may be originated to borrow a lump sum of home equity. Home equity lines of credit (HELOCs) are open ended lines of credit against the equity in a home that can be accessed when needed, an approach similar to credit cards. Reverse mortgages are available to adults age 62 and older, and unlike the other types of mortgages, do not require repayment as long as the borrower remains in the home. Reverse mortgages can be structured as a lump sum, a lifelong monthly payment, or a line of credit based on the available equity in the home (Moulton, Loibl, and Haurin 2017).

[1] HRS data show that most older adults do not liquidate housing wealth through home sale until the last years of life, typically upon entry into assisted living or nursing home care (Mayer 2017).

If an older homeowner borrows, newly borrowed funds may be used directly for food consumption or for competing expenses, thereby reducing food insecurity. For example, borrowing from a mortgage can be used to repay other types of debt, such as medical bills, loans, or credit cards that would otherwise reduce an older household's discretionary income. However, high levels of existing mortgage debt reduce the ability to be approved for additional borrowing in the future, for example, if older adults encounter a health shock (Gupta et al. 2018).[2] Understanding the relationship between housing wealth and food insecurity thus requires careful consideration of home equity as well as new mortgage borrowing.

This report presents new evidence on the relationship between housing wealth and food insecurity for older adults. While prior studies find that owning a home is associated with lower food insecurity (Men 2017, Swann 2017, Huang, Guo, and Kim 2010, Bartfeld and Collins 2017), the mechanisms underlying this relationship are poorly understood. Using panel data from the 2006 to 2018 U.S. Health and Retirement Study (HRS), we use an instrumental variable approach and linear probability models with household fixed effects to identify financial mechanisms by which homeownership affects food insecurity. Specifically, we separately estimate the effect of home equity changes and new mortgage borrowing on food insecurity, allowing both to be endogenous, while controlling for time-invariant confounders and a rich list of time-varying financial and social indicators available in the HRS. We also explore heterogeneity in the effects of mortgage borrowing by estimating stratified sample regressions limited to Black and White older homeowners and those living in rural and urban locations. Finally, we simulate how policy

[2] The percentage of older adults who carry an existing mortgage into retirement has increased from 20% in 1992 to more than 40% in 2016 (Moulton, Loibl, and Haurin 2017).

innovations to increase access to housing wealth, such as through reverse-mortgage type interventions, affect food insecurity.

Regression results show that new mortgage borrowing is associated with lower food insecurity, and the simulations indicate that additional borrowing substantially reduces observed food insecurity, particularly when borrowing is extended to constrained households who previously were unlikely to be approved for new mortgage borrowing. Taken as a whole, our results suggest that borrowing through a mortgage is a mechanism that links housing wealth to economic security and supports the importance of access to mortgage borrowing to reduce material hardship late in life.

The remainder of the report is structured as follows. After summarizing prior literature on the relationship between food insecurity and housing wealth, we discuss the conceptual and empirical models and describe the data we use for estimation. We then illustrate recent trends in our key variables of interest, followed by a presentation of our regression and simulation results. Finally, we discuss the implications of our findings for future research and policy.

4.1. Relationship between food insecurity and housing wealth

Our study draws from two lines of literature: housing wealth and consumption studies, and studies of food insecurity. There is a relatively large body of literature that estimates the effects of housing wealth on consumption, including food consumption (e.g., Campbell and Cocco 2007, Bostic, Gabriel, and Painter 2009, Cooper 2013). Early studies using data from the Panel Study of Income Dynamics (PSID) estimated the relationship between changes in self-reported house value and food consumption. Skinner (1996) observed a positive relationship, but only for younger

households. Engelhardt (1996), in a study of homeowners under age 65, found that a reduction in self-reported house value was associated with reduced food consumption but found no evidence of an increase in house value on food consumption.

More recent research using richer data finds a consistently positive relationship between housing wealth and total consumption (Campbell and Cocco 2007, Bostic, Gabriel, and Painter 2009, Cooper 2013). Campbell and Cocco (2007) use data on regional house price change combined with micro-data on British homeowners to estimate the impact of changes in house prices on changes in consumption, finding that a 1% increase in house prices is associated with a 0.08% increase in consumption. In a cross-sectional analysis, Bostic, Gabriel, and Painter (2009) estimate the relationship between self-reported house value and the level of consumption, finding that a 1% increase in house value is associated with a 0.04 to 0.06% increase in consumption—more than twice as large as the elasticities for financial wealth. Unlike earlier findings by Skinner (1996), Campbell and Cocco (2007) and Bostic, Gabriel, and Painter (2009) find larger housing wealth elasticities on consumption for older relative to younger adults, as older adults may be more willing to liquidate housing wealth as they age, consistent with the lifecycle hypothesis, which describes spending and saving behavior over a lifetime and posits that people save more than they spend during the years in the workforce while they spend more than save before entering the workforce and during retirement. As a result, spending and saving should be balanced when viewed over a life time (Modigliani and Brumberg, 1954). A reason for these seemingly conflicting findings may be related to the focus of Skinner (1996) on food expenditures as opposed to total expenditures, which were the focus of the other authors. Using panel data from the PSID, Cooper (2013) finds that households consume $0.06 per $1 increase in home equity—an effect similar to prior studies using data on house values. This result was confirmed by a recent study that uses

HRS panel data (Angrisani, Hurd, and Rohwedder 2019). Cooper (2013) further finds larger effects of increased home equity on consumption for those with lower levels of non-housing wealth who may be borrowing constrained. However, these studies do not identify mechanisms through which housing wealth is related specifically to food consumption.

Turning to studies of food insecurity, a positive effect of income on food security is consistently documented (Guo 2011, Gundersen and Gruber 2001). Fewer studies account for wealth, yet those that do find a significant inverse association of financial wealth and food insecurity (Shobe, Narcisse, and Christy 2018) and a smaller effect of income on food insecurity when controlling for asset levels (Guo 2011, Huang, Guo, and Kim 2010).

A primary limitation of studies of wealth and food insecurity is their treatment of housing wealth. Studies often represent housing wealth with a simple binary measure of whether the home is owned (Chang, Chatterjee, and Kim 2013, Huang, Guo, and Kim 2010, Men 2017, Bartfeld and Collins 2017, Ribar and Hamrick 2003, Rose, Gundersen, and Oliveira 1998, McIntyre et al. 2017) or whether a household fell behind with mortgage payments (Alley et al. 2011). These studies find that homeowners are less likely to be food insecure than renters. The reasons offered include homeowners borrowing against equity in their homes, having relatively fixed housing costs, and having higher discretionary income compared to renters of similar means once the mortgage is paid off (Gundersen and Gruber 2001). While these studies highlight the importance of accounting for homeownership when estimating food insecurity, they do not identify the specific mechanisms that underlie this relationship. A primary contribution of our report is to model the financial mechanisms through which housing wealth and its components—home value, home equity, and mortgage debt—affect food insecurity in older age.

4.2. Role of race for the association of housing wealth and food insecurity

Disparities in food insecurity by race are well documented, yet the connection between disparities in food insecurity and disparities in mortgage debt and housing wealth are little understood. Black older adults are about 2.7 times more likely to experience food insecurity than White older adults (Ziliak and Gundersen 2019). In addition, Black older households have substantially lower levels of wealth compared to White older households, much of which can be accounted for by differences in house values and home equity, and are more likely to be borrowing constrained (Butrica and Mudrazija 2016, Krivo and Kaufman 2004). In 2016, according to the Survey of Consumer Finances, as much as 57% of Black older homeowners carry mortgage debt into retirement compared to about 34% of White older homeowners. This background knowledge invites the question of whether additional liquidity from home equity borrowing has a differential effect on food insecurity for Black and White older homeowners. Based on the premise that food is a basic need, additional liquidity should have a similar effect on the food insecurity of older adults, regardless of race. On the other hand, older households who suffer from food insecurity usually report more than one financial hardship (Levy 2015). Food security competes with shelter, clothing, and medical needs and trade-offs in meeting these needs are common (Heflin, Sandberg, and Rafail 2009). If Black older homeowners differed in their allocation of mortgage borrowing proceeds to resolve material hardships from White older homeowners, it should be reflected in the strengths of the association of mortgage borrowing and the likelihood of food insecurity.

4.3. Role of location of residence in the association of housing wealth and food insecurity

In addition to race, the geographic location of an older adult's residence can be linked to the prevalence of food insecurity. An extensive literature investigates whether the availability and accessibility of food is lower in rural locations due to greater travel distances to grocery stores and food pantries, higher food prices, and lesser access to food programs (Dean and Sharkey 2011, Rhone et al. 2019, Walker, Keane, and Burke 2010, Nord and Leibtag 2005). National comparisons of urban versus rural areas show that food insecurity of older adults is higher in non-metropolitan areas compared to metropolitan areas (Ziliak and Gundersen 2009, Durazo et al. 2011). A newer, fine-grained analysis of a large sample of administrative aging-services data of the State of Georgia shows that residence in core urban areas and urban clusters is related to higher food insecurity among older adults compared to rural areas (Shannon et al. 2015). The mixed results indicate that the predictors of geographic differences in food insecurity are not fully understood, similar to many other aspects of food insecurity (Millimet, McDonough, and Fomby 2018). The present research suggests investigating housing wealth and mortgage borrowing as an explanatory variable for the observed geographic heterogeneity, following an emerging line of research that examines the association of financial behaviors and food insecurity (Millimet, McDonough, and Fomby 2018, Gundersen and Garasky 2012).

Similar to food insecurity, access to home equity and the costs and terms of borrowing can differ geographically. While the competition of lenders is similarly high in urban and rural areas (Calhoun, Feltner, and Smith 2018), rural mortgages tend to have higher interest rates and are for smaller amounts, reflecting the fact that incomes are lower and housing debt to income ratios are higher in rural areas, based on data for the general population (Mota 2016). These factors could

lead to differential effects of mortgage borrowing on food insecurity in metropolitan and non-metropolitan areas.

4.4. Role of policy innovations in access to housing wealth

The final step in this study is a simulation of the effect of policy interventions that increase borrowed amounts and relax mortgage borrowing constraints, as well as interventions that eliminate the monthly mortgage payment. An existing policy instrument that can relax constraints and eliminate mortgage payments is the federally insured reverse mortgage, or Home Equity Conversion Mortgage (HECM). A HECM requires no repayment and thus the mortgage payment-to-income constraint is completely relaxed. The financial assessment conducted at origination is considered less stringent than the credit thresholds of standard mortgage borrowing. These features of the HECM provide a framework for multiple realistic simulations to analyze the effects of increased access to housing wealth on food security and build on our considerable expertise in evaluating this policy instrument (Loibl et al. In press, Moulton, Haurin, and Shi 2015, Moulton, Loibl, and Haurin 2017). These simulations can identify which features of a HECM-like policy instrument have the greatest effect on food security, thereby informing future policy and private market product development.

4.5. Research objectives

Based on the literature review, the current study pursues three research objectives, to:

1. Document trends in age-adjusted food insecurity, mortgage debt, and borrowing constraints among older adults from 2000 to 2018.
2. Identify the mechanisms through which financial and housing wealth influences food insecurity and estimate heterogeneity by race and location of residence.
3. Simulate how policy innovations that give access to higher borrowing amounts and greater access to borrowing against housing wealth affect food insecurity.

5. Research Methods

5.1. Conceptual framework

The relationship between housing wealth and food insecurity is complicated by the fact that housing wealth is the net difference between house value—which is relatively exogenous, and mortgage debt—which is endogenous. There are several different approaches in the literature to deal with this complexity. One reduced form approach uses changes in house prices as a proxy for the exogenous components of changes in housing wealth, where house prices are measured with indices such as the Federal Housing Finance Agency's (FHFA) House Price Index (HPI),[3] and differ over both geographic area and time. This approach has been used in studies that examine the effect of economic shocks on material hardship, such as during the 2008 recession (Hamoudi and Dowd 2014, Fichera and Gathergood 2016), but it ignores mortgage debt. It can also be argued that changes in the index are correlated with the economic circumstances of households in a locality, for example, as falling house prices reflect an area in economic decline. House price changes may be a proxy for economic conditions, in addition to measuring changes in housing wealth. We address this concern by including both an indicator of local economic conditions (the unemployment rate) and a series of dummy variables for the year of the survey, which captures time varying macroeconomic factors.

A second reduced form approach includes an indicator for homeownership, as typically found in the food security literature. However, this model conflates home equity and other unobserved homeownership effects. A third approach includes home equity as a measure of

[3] For detailed information on the FHFA House Price Index, see: https://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index.aspx

housing wealth, treating it as exogenous. But the amount of home equity depends on mortgage borrowing, which is a choice variable and thus endogenous. A fourth approach, chosen here, is to model the mechanism by which house value is converted to a liquid asset that can be used for consumption. We focus on mortgage borrowing and treat the amount borrowed as endogenous, thus accounting for borrowing being a choice variable for the older homeowner.

One advantage of modeling mortgage borrowing as endogenous is that it recognizes that home equity cannot affect food insecurity directly because it is illiquid.[4] A second advantage of this approach is that some households may be less able or willing to liquidate housing wealth or may experience different costs and terms, a form of heterogeneity not recognized by reduced-form models. An increase in house prices may have little effect on the food insecurity among groups with reduced access to housing wealth, such as Black older homeowners (Immergluck 2009, Rugh and Massey 2010, Moulton et al. 2017, Killewald 2013). Even if older homeowners have accumulated a substantial share of housing wealth, they may be unable to borrow against it due to an inability to meet lender debt-to-income or credit score requirements (Moulton et al. 2017, Mayer and Moulton 2020), or may pay higher interest rates or fees to borrow the same amount as higher income White homeowners (Lusardi 2012). These differences in credit access and debt costs, which are most salient from a racial lens, are major, often overlooked, elements of the wealth gap in older age (Killewald 2013). Borrowing constraints have, to our knowledge, not been directly examined in relation to food security outcomes.

Our approach to modeling mortgage borrowing accounts for household characteristics known to influence food insecurity among older adults, such as financial characteristics (Wang et

[4] We recognize that there may be indirect effects of housing wealth on food security. For example, a household with increased housing wealth could spend some of their financial assets on food consumption rather than pay the origination cost of a new mortgage.

al. 2015, Pirrie et al. 2020, Barker et al. 2019, Russell et al. 2014), household structure (Park et al. 2019), and location of residence (Dean and Sharkey 2011). Further, we control for characteristics of the individual respondent. Prior literature finds that socio-demographic characteristics (Russell et al. 2014, Dean, Sharkey, and Johnson 2011, Bengle et al. 2010, Grammatikopoulou et al. 2019), access to support networks (Johnson 2013, Burris et al. 2019), and health-related functional limitations (Wolfe, Frongillo, and Valois 2003) are associated with food insecurity among older adults. Finally, our models account for macro-economic indicators, also following common approaches (Gregory and Coleman-Jensen 2013).

5.2. Empirical methods

Research Objective 1 examines the evolution of the key variables, food insecurity and components of financial and housing wealth. We chart food insecurity rates from 2000 to 2018 and financial variables from 2000 to 2016, in line with the lagged structure we employ in the regression analysis, which lags the housing wealth measures by one wave and the control variables by two waves of the HRS. The data points are estimated using linear regression with time-varying indicators for age cohort (65-69, 70-79, 80 or above), year dummies, and age cohort-by-year interactions serving as predictors. All dollar denominated variables are in 2016 constant dollars. We compute means by age cohort in order to adjust the trends in food insecurity and wealth for age. The age cohort is based on the age of the financial respondent. The descriptive analysis is limited to homeowners with a financial respondent age 65 or older, and, to match our regression sample restrictions, we exclude households who split due to a dissolved marriage or partnership or who move, but only

during the period in which borrowing is measured. A household is permanently removed from the sample when the final household member dies.

To address Research Objective 2, we use panel data to estimate the effects of new mortgage borrowing on food security status of homeowners age 65 and older. We consider homeownership an exogenous variable because a high percentage of adults age 65 and older owns their home (Joint Center for Housing Studies 2019) and the home purchase decision was typically made long prior to the sampled period; more than three-quarters, 77.5%, of adults age 65 and older became homeowners before they turned 35 (Choi and Goodman 2018). We employ a fixed effects model that accounts for all time-invariant confounders of the financial respondent, household, and geographic area.[5] Specifically, we use the generalized two-stage least squares fixed-effects estimator G2SLS from Balestra and Varadharajan-Krishnakumar (1987).

Our primary model is of the form[6]:

$$FI_{it} = \beta_0 + \beta_1 MortgageBorrowing_{it-1} + \beta_2 \mathbf{A}_{it-2} + \beta_3 \mathbf{X}_{it-2} + \alpha_i + u_{it} \quad (1)$$

$$MortgageBorrowing_{it-1} = \beta_0 + \beta_1 \mathbf{A}_{it-2} + \beta_2 \mathbf{X}_{it-2} + \beta_3 \Delta HPI_{it-1} + \beta_4 LTV_{it-2} + \alpha_i + u_{it} \quad (2)$$

where FI_{it} in Equation (1) is a binary indicator of food insecurity in year t for the i-th older adult, with t-1 representing a lag of 2 years due to the biannual nature of the HRS. $MortgageBorrowing_{it-1}$ is a lagged, time-varying measure of new mortgage borrowing; the vector A_{it-2} includes lagged, time-varying measures of non-housing wealth; and the vector X_{it-2} includes

[5] For our primary model, a Hausman test reveals that the null hypothesis that the random-effects error term is uncorrelated with the explanatory variables is rejected (chi2(32)=1456.13, p<0.001), indicating that fixed-effects are preferred (Wooldridge 2013).

[6] Equations (1) and (2) assume that the time means of the idiosyncratic errors are homoscedastic, i.e., there is no serial correlation present. We tested for serial correlation using the first-differences approach (Wooldridge 2013). The autocorrelation of the first-differenced errors is -0.507, which is not statistically different from -0.500 (F = 0.11, p = 0.739), indicating that the idiosyncratic errors are homoscedastic and serial correlation is not present.

lagged, time-varying socio-demographic characteristics. The term α_i is the household fixed-effect that represents time-invariant factors associated with food insecurity, such as sex, race, ethnicity, immigration status, and educational attainment (Wooldridge 2013), and the random error u_{it} is a time-varying error term which represents unobserved time-varying factors that we assume are uncorrelated with mortgage borrowing and food insecurity.

The explanatory variables are lagged to account for the retrospective nature of the survey instrument, which asks respondents whether they always had enough money to buy the food they needed during the past two years (food insecurity) and whether they ever ate less than they felt they should because there wasn't enough money to buy food during the past 12 months (severe food insecurity). The vectors A and X are lagged two waves, reflecting a concern that the mortgage variables could affect assets if measured at the same time in Equation (1). Our focal models are estimated using a linear probability specification. As described in Equation (1), the new mortgage borrowing variable is a positive value only if borrowing occurs in t-1; thereafter it is reset to $0 unless there is subsequent borrowing. The coefficient β_1 thus reflects the short-term response of food insecurity to new mortgage borrowing. It does not measure the longer-term responses of food insecurity in periods t+1, t+2, etc. to borrowing in t-1, which is a topic for future research.

The first stage is shown in Equation (2), where the instrumental variables include ΔHPI_{it-1}, the percent change in local house prices from year t-2 to t-1 for the i-th older adult, and LTV_{it-2}, a binary indicator of mortgage constraints due to a mortgage loan balance to home value ("loan-to-value" or LTV) ratio of 90% and higher, a common market indicator of borrowing constraints. We assess heterogeneity in the effects of new mortgage borrowing via sub-sample regressions (Black vs. White and metropolitan vs. non-metropolitan homeowners). For comparison purposes, we also estimate models similar to those in prior literature. One alternative is to replace the

measure of new mortgage borrowing with an exogenous measure of FHFA house price change (ΔHPI). Another alternative is to replace new mortgage borrowing with the intertemporal change in home equity, treated as endogenous.

To address Research Objective 3, we simulate the effect of a policy intervention that provides certain homeowners in our sample with a borrowing amount equal to 50 percent of their available home equity—the typical amount of home equity available through a reverse mortgage.[7] We apply this borrowed amount to two groups of homeowners in our sample: (1) those who borrowed through a mortgage in 2012, and (2) those who did not borrow in 2012 and were borrowing constrained in 2010. We then simulate the effects of this additional borrowing on food insecurity in 2014—the period in our sample when food insecurity was its highest, for the full sample (with non-borrowers with mortgage payment-to-income ratio (PTI) < 20% kept at $0 borrowing amounts), and in interaction models for race and location of residence. We use the PTI ratio as a proxy for borrowing constraints.[8] We therefore simulate the effects of granting a reverse mortgage to PTI-constrained households and define PTI-constrained homeowners as those with monthly mortgage payments, excluding property taxes and homeowners insurance, in excess of 20% of monthly income. This threshold is based on conventional mortgage underwriting guidelines that limit mortgage, property tax, and homeowner's insurance payments to be no more than 36% of monthly gross income (Wells 2020).

[7] The amount of home equity that a homeowner can borrow through a reverse mortgage is a function of the borrower's age, the house value, and a factor set by the U.S. Department of Housing and Urban Development (HUD,), typically limited to 50 to 60 percent of the house value (Mayer and Moulton 2020).

[8] While loan-to-value (LTV) constraints are also barriers to mortgage borrowing, such households are by definition more likely to be ineligible to borrow additional funds against the equity in their homes. This is particularly true for our definition of LTV constraints—a loan-to-value ratio of 90 percent or higher. Policies to relax credit constraints are therefore unlikely to permit LTV constrained households to borrow. In contrast, policy innovations to that do not require monthly repayment (e.g., HECM reverse mortgages) are likely to facilitate borrowing for PTI constrained households. We therefore simulate the effects of granting a reverse mortgage to PTI constrained households.

6. Data

6.1. The Health and Retirement Study (HRS)

Data for this study come from the Health and Retirement Study (HRS), a long-running panel survey of American adults age 50 and older that began in 1992. Respondents are surveyed every two years, with new birth cohorts added to the existing sample every three waves. The average baseline response rate is 73% across the cohorts, and follow-up response rates are above 80%. Each wave has about 20,000 respondents (Sonnega et al. 2014). The HRS has detailed wealth information and contains two food insecurity questions. A small number of food insecurity studies have used the HRS, including research predicting food insecurity on the basis of food deserts (Fitzpatrick, Greenhalgh-Stanley, and Ver Ploeg 2016) and among veterans (Brostow, Gunzburger, and Thomas 2017), reflecting the overall dearth of research on the food insecurity of older adults. In other HRS research, food insecurity has been used as a predictor of food assistance program participation (Kim and Frongillo 2009, Kim and Frongillo 2007), mental health condition, and functional limitations (Bishop and Wang 2018, Brostow, Gunzburger, and Thomas 2017).

For our analysis, we tailor the HRS data in several ways. First, our sample is limited to one respondent per household because food security questions are asked on behalf of the household. When there are multiple respondents in a household, we include the person identified as the financial respondent. The financial respondent answers all income and asset questions in addition to the questions about housing and food insecurity on behalf of the household. If households do not have a designated financial respondent, we designate the member that participated in the survey the longest. If a household experiences the death of a household member during the study period,

we designate the longest living respondent as the financial respondent to avoid censoring the household prematurely. When the final household member dies, the household is removed permanently from the sample. Modelling the relationship between home equity borrowing and food insecurity in the case of death during the borrowing period is complicated in the HRS and would justify a separate study (Engelhardt and Eriksen 2021).

Second, we limit the data to those households that have been in the HRS at least since 2012 (the whole range is 2006 to 2018), have three waves of consecutive data so that data for lagged predictors is available, and have a measure of food insecurity in t=0. This results in 76,204 household-years remaining for analysis (25.9% of the full HRS sample). Third, we restrict the sample to those who are homeowners in t-2 (N=51,751 household-years). Fourth, we restrict the analysis sample to homeowners who did not move during the three consecutive survey waves, and who did not separate from their spouse or partner (for reasons other than death) during the three survey waves. Focusing on non-movers and intact households during this period eliminates instances of mortgage increases due to relocation and the purchase of a new home or changes in marital status from our new mortgage borrowing variable (Begley and Chan 2019).

In a final step, we limit the sample to households in which the financial respondent is age 65 or older in time t-2 to focus our analysis on older households (N=30,675 household-years), and drop older adults living in a mobile home, nursing home or institution, or who consider themselves to live rent free (N=26,212 household-years). We also drop older adults those who defaulted on mortgage debt in time t-1 or t-2 (N=26,042).[9] Borrowers in default on their mortgages would bias our key explanatory variable because after the 2008 recession, the households could receive loan modifications that increase the total mortgage amount. The HRS data do not allow us to isolate

[9] Questions about mortgage foreclosure and delinquency start with the 2008 wave of the HRS.

increases in the mortgage amount due to borrowing from increases due to modifications. Thus, we drop the small number of individuals in default on their mortgages from the primary regression sample. Observations with missing values are also dropped from the sample except for two variables with a larger number of missing values: help with future needs and number of living children. For these two variables we code the missing values as zero and add a binary indicator for missing. It is important to note for the design and interpretation of the results that the homeowner sample restrictions result in a sample that is at relatively low risk of food insecurity. The baseline percentage of food insecure homeowners age 65 and older (based on N=31,275 household-years) is 4.3%, compared to the 3.3% in the current regression sample.

After trimming extreme values and omitting missing data on the focal housing and financial variables as described in the next sub-sections, the final sample consists of 20,421 household-years, representing 6,319 households. The number of observations per respondent ranges from 1 to 7, with an average number of observations being 3.2 observations.

6.2. Food insecurity

Food insecurity is measured with two questions. The focus of the main analysis is on the question "(Since your last interview/in the last two years), have you always had enough money to buy the food you need?" This variable is coded as 0 for no and 1 for yes. Don't know responses and refusals are coded as missing. This question has been part of the HRS Core Questionnaire since 1995 (Q415) and has been posed to all HRS respondents. Food insecurity is measured from 2006 to 2018 due to the lagged structure of the explanatory variables and includes households that were food insecure or food secure in a given wave.

We also use a second measure of food insecurity, which is asked only of HRS respondents who answered "yes" to the first question, "In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?" This variable is again coded as 0 for no and 1 for yes. Non-responses are also coded as 0; don't know responses and refusals are coded as missing. This question has been part of the HRS Core Questionnaire since 2010 (Q516). We treat the second measure as an indicator of severe food insecurity (Marshall et al. 2021, Pak and Kim 2020).

6.3. Housing characteristics

Changes in house prices are measured as percent changes in the Federal Housing Finance Agency five-digit ZIP code level House Price Index (HPI) from t-2 to t-1 (FHFA 2020). The HPI is available for 18,053 ZIP codes in the U.S., about 43.2% of all ZIP codes as of 2019 (Bogin, Doerner, and Larson 2019). Observations with missing data on HPI at the 5-ZIP code level are replaced with annual county estimates, or state non-metropolitan averages (averaged over four quarters per year) if the county is missing. The HPI is considered largely exogenous of an individual household's choices as it is averaged across a ZIP code and is a market-level measure of changes in single-family house prices (FHFA 2020).

The home value of the primary residence and outstanding mortgage balances on the primary residence are based on HRS respondents' self-reported estimates. Home equity is calculated as the difference between respondents' estimate of the home value and their outstanding mortgage balance. The change in home equity is calculated as the difference between two waves. New mortgage borrowing is calculated as the amount of the increase in the mortgage balance on

the primary residence between two waves. Negative values, which represent mortgage repayments, are set to $0. We censor repayments because the focus of the current study is on the effect of borrowing on food insecurity.

The new mortgage borrowing measure combines four types of mortgage debt into one measure, including first mortgages, home equity lines of credit (HELOCs), second mortgages, and other mortgages on the primary residence. We use the non-imputed RAND HRS mortgage debt dat. Observations with imputed values for the mortgage amount in the RAND HRS data files are set to missing.[10] The RAND HRS files provide researchers with user-friendly access to the HRS survey waves; RAND cleans and processes HRS data and replaces missing values with imputed values.[11] Using imputed values for mortgage amounts can yield false indications of increased borrowing from one wave to another. Outliers are set to missing, including households with home equity (84 cases), total housing costs (6 cases), house value (130 cases), or mortgage debt (3 cases) greater than 2 million dollars. We also limit the analysis to respondents with changes in home equity (37 cases) and mortgage increases (4 cases) of less than 10 million dollars.

6.4. Household characteristics

Household financial characteristics in our specifications include monthly household income, net financial assets (including cash and investment assets), net other assets (including non-housing real estate, transportation, and business assets), and net non-housing debt (e.g., medical debt, credit card debt, loans to friends and family, etc.). Outliers set to missing include monthly household

[10] We lose 1,949 household-year observations due to mortgage debt imputations.
[11] Detailed information about the RAND HRS data products is available here: https://www.rand.org/well-being/social-and-behavioral-policy/centers/aging/dataprod.html

income higher than $50,000 per month (186 cases); or total financial assets greater than $2,000,000 (1,205 cases). The mortgage debt-to-income (PTI) ratio is calculated by dividing annual mortgage payments (principal and interest) by annual gross household income. The HRS question on housing costs asks whether property taxes and homeowners insurance amounts are included. For the majority of respondents, one or both amounts are included in the response. We subtract property tax amounts where given (or 2.5% of home value) and 0.35% of home value for homeowner's insurance premiums from the housing costs to obtain the mortgage payment.

Multiple studies of food insecurity estimate the causal impact of the Supplemental Nutrition Assistance Program (SNAP) (e.g., Swann 2017, Nam and Hyo 2008, Gundersen, Kreider, and Pepper 2017). Rather than include observed SNAP participation in our model, which would require another instrumental variable treatment, we use an exogenous measure of eligibility for SNAP. A common net income limit for all households, including households with older adults, is 100% of the Federal Poverty Level (FPL), adjusted by household size (Food and Nutrition Service 2018). The HRS reports for each respondent the ratio of family income to the applicable Federal Poverty Level, which we compare to the 100% level,[12] yielding a dummy variable measure of eligibility for SNAP for older adults (St.Clair et al. 2011).

We further control for the number of household members and include nine Census regional indicators (New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific (omitted)). For the geographic comparison of food insecurity, we use the 2013 USDA rural-urban continuum codes to classify

[12] The FPL cutoff for SNAP eligibility may not always be 100% FPL for older adults. As an alternative to SNAP eligibility based on 100% FPL, we tested a series of FPL controls, <100% FPL, 100-200% FPL, 200-400% FPL, >400% FPL. We included the FPL series in addition to the continuous income variable in our primary mortgage borrowing regression. None of the FPL categories are significant (relative to below 100% FPL). Our mortgage borrowing results are robust to this modification. For parsimony, we present only the 100% FPL dummy.

metropolitan or non-metropolitan county residence (omitted), which are available in the restricted HRS files (HRS 2019).

6.5. Financial respondent characteristics

We control for financial respondents' characteristics, including age (both linear and quadratic), marital status (married or partnered (omitted), separated/ divorced/ widowed, never married), and number of living children of the respondent or spouse. The social support network is measured with a dummy variable that indicates whether the respondent has friends or relatives to provide help if needed (Cheng 2017). Functional limitations are measured with a five-item summed measure that adds up the number of activities of daily living for which a respondent needs help (ADLs; walking across a room, dressing, getting out of bed, bathing, eating) (e.g., Capistrant et al. 2014).

6.6. Macroeconomic indicators

In order to account for unobserved local economic shocks and macroeconomic trends that may be correlated with both new mortgage borrowing and food insecurity, we add year dummies for the seven HRS waves from 2006 to 2018 for the year that food insecurity is measured (2006 is omitted). We also control for the lagged average annual county unemployment rates and the percentage point change in these rates between t-2 and t-1 (Bureau of Labor Statistics 2019).

6.7. Instruments

We identify the causal effect of home equity and new mortgage borrowing on food insecurity using an instrumental variable approach. Good instruments should be theoretically and empirically correlated with the change in home equity and new mortgage borrowing, but uncorrelated with the error term in the estimation of food insecurity. We include two instruments, FHFA HPI percent change and an indicator for having a high loan-to-value (LTV) ratio of 90% or higher.[13] The first instrument is house price change between t-2 and t-1, measured using the change in the Federal Housing Finance Agency's five-digit ZIP code level house price index (FHFA 2020). The HPI change ranges from negative to positive values. The second instrument measures borrowing constraint in t-2 in terms of households' mortgage loan-to-home value (LTV) ratio. Households are considered constrained if their LTV ratio is 90% or higher, following other literature (Smith, Finke, and Huston 2011) and market reports that it is more difficult to be approved for borrowing with LTVs at and above 90%. We expect that an LTV above 90% only influences food insecurity through older homeowners' ability to borrow against the equity in their homes.

[13] We tested several instruments, such as debt-to-income (PTI) ratio ≥ 20% or twice-lagged HPI. PTI constraints passed the instrument tests, but we have concerns about the quality of the measure due to data limitations. We have higher confidence in the quality of the LTV constraints measure.

7. Results

7.1. Research Objective 1: Trends in food insecurity, housing wealth, and financial wealth

The first step in this research is to document the trends for the measures we use in the subsequent analysis. Figures 1 and 2 illustrate the dependent variables in the analysis, food insecurity and severe food insecurity. Figures 3, 4, 5 and 6 depict the focal explanatory variables: average home equity, percent new mortgage borrowing, average new mortgage borrowing amount, and average net financial assets. Figure 7 shows the average LTV ratio. The figures also display the 95% confidence intervals by age group (65-69, 70-79, 80 and older) and use constant 2016 dollar values. A note about the display of the figures: we off-set the values to facilitate interpretation of the 95% confidence intervals although values for each age group are measured at the same time.

Figure 1 shows that food insecurity rates are similar among older homeowners across age groups from 2000 to 2008, ranging from 2.64 to 4.61% for our sample. Food insecurity then increases with the 2008 recession, particularly for homeowners age 65 to 69. Rates of severe food insecurity, shown in Figure 2, also increase after 2008 for all but the oldest homeowners, reaching 3.84% in 2012 for the youngest group of homeowners. The trends presented here are positively correlated with Current Population Survey estimates of food insecurity among adults age 60 and older (food insecurity: Pearson r=0.582; severe food insecure: Pearson r=0.465) (Ziliak and Gundersen 2019).

Figure 1:
Food insecurity rates among homeowners age 65 and older, Health and Retirement Study

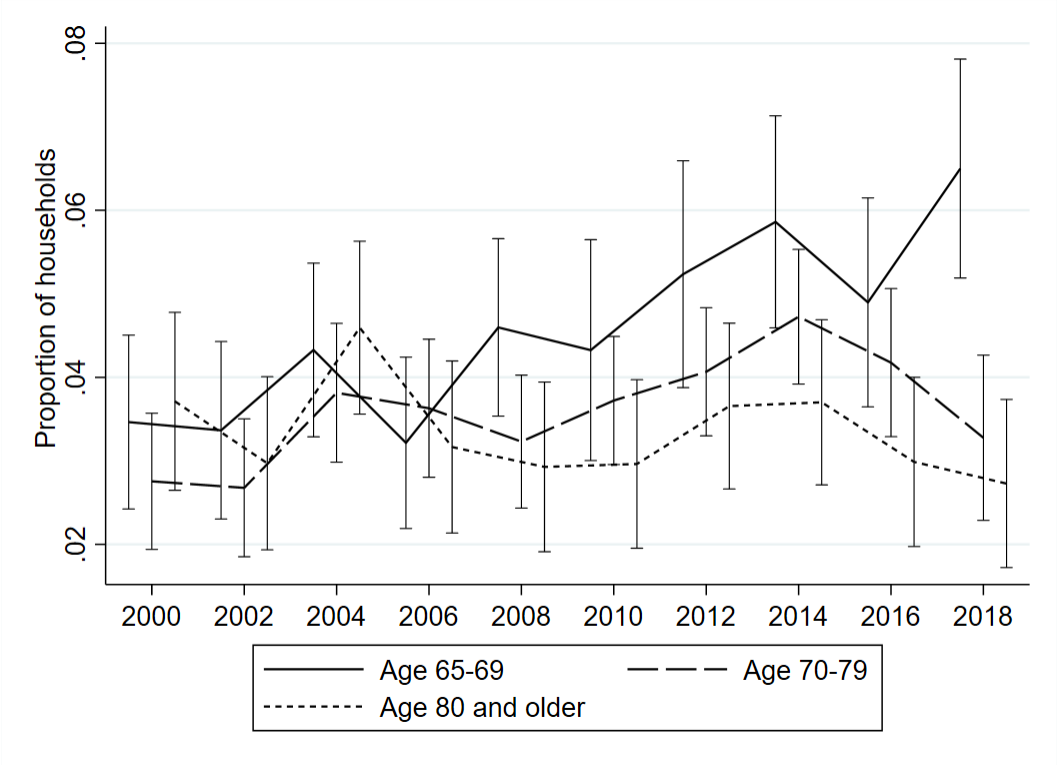


Figure 2:
Severe food insecurity rates among homeowners age 65 and older, Health and Retirement Study

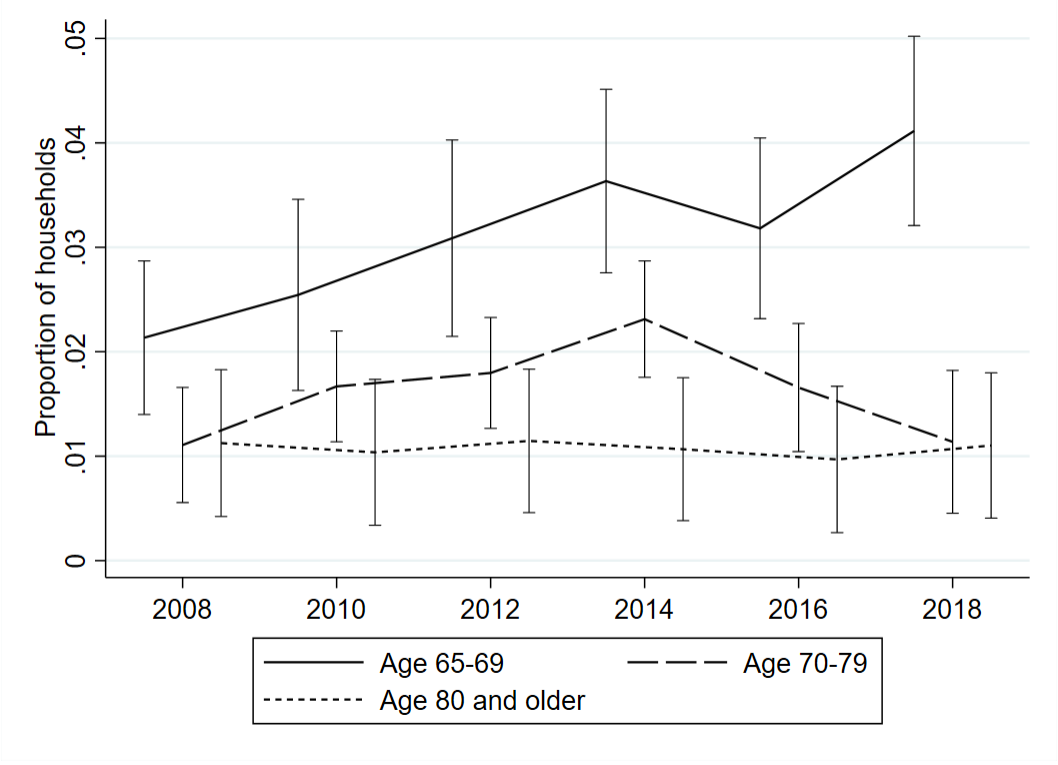


Figure 3 shows that average home equity (in constant 2016 dollars) increases from 2000 to 2006, reaching $222,000 to $227,000 at the height of the housing boom, before falling sharply from 2008 to 2012. As of 2018, home equity levels among older adults have yet to recover to 2006 levels.

Figure 4 shows that the proportion of older adults aged 65 to 69 who newly borrow through a mortgage increases from 2000 to 2004, when interest rates fell and lender's credit standards were relaxed, and then decline until 2012. New mortgage borrowing is less common among the older two age groups. For those age 80 and older, new borrowing trends upward during the period. For those age 70-79, the rate is stable from 2008 to 2016.

Figure 5 indicates the average amount borrowed among borrowers varies over time, but there are few statistically significant differences from year to year. Confidence intervals for the oldest age cohort are particularly wide in certain years (e.g., 2000, 2002, and 2008), reflecting relatively small sample sizes.

Figure 6 shows that average net financial assets trend upward for the oldest age group, with few significant differences across time for homeowners aged 65 to 69 and 70 to 79. This trend analysis indicates that the 2008/2009 recession had only limited impact on the financial assets of older homeowners.

Figure 3:
Average home equity among homeowners age 65 and older, Health and Retirement Study

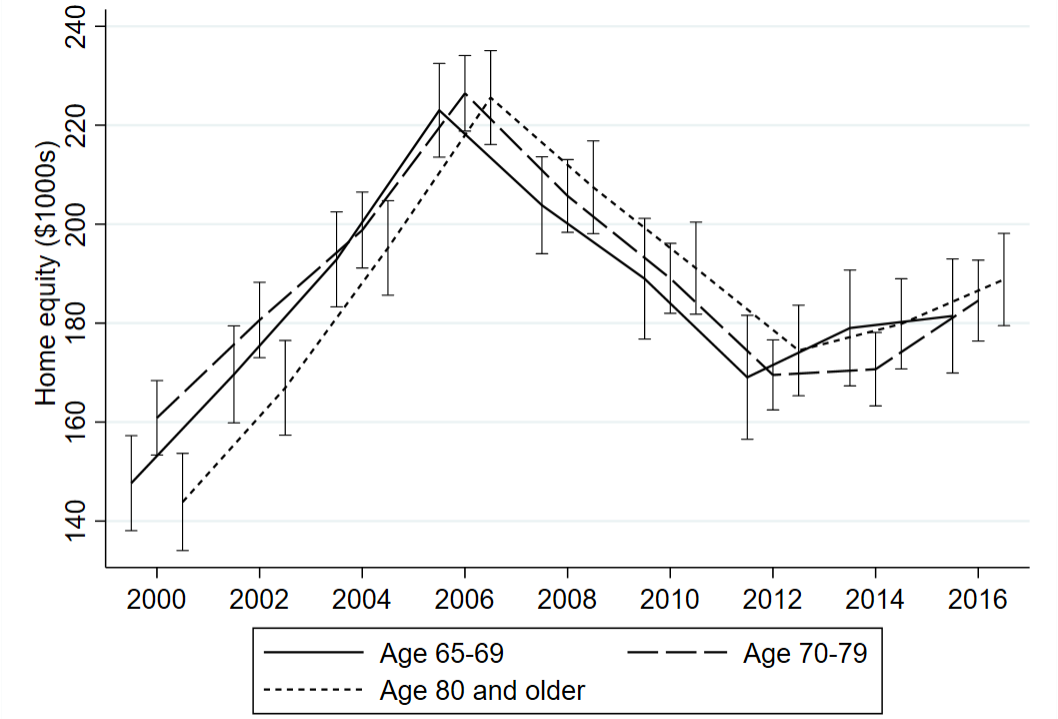


Figure 4:
Percent of homeowners age 65 and older with new mortgage borrowing,
Health and Retirement Study

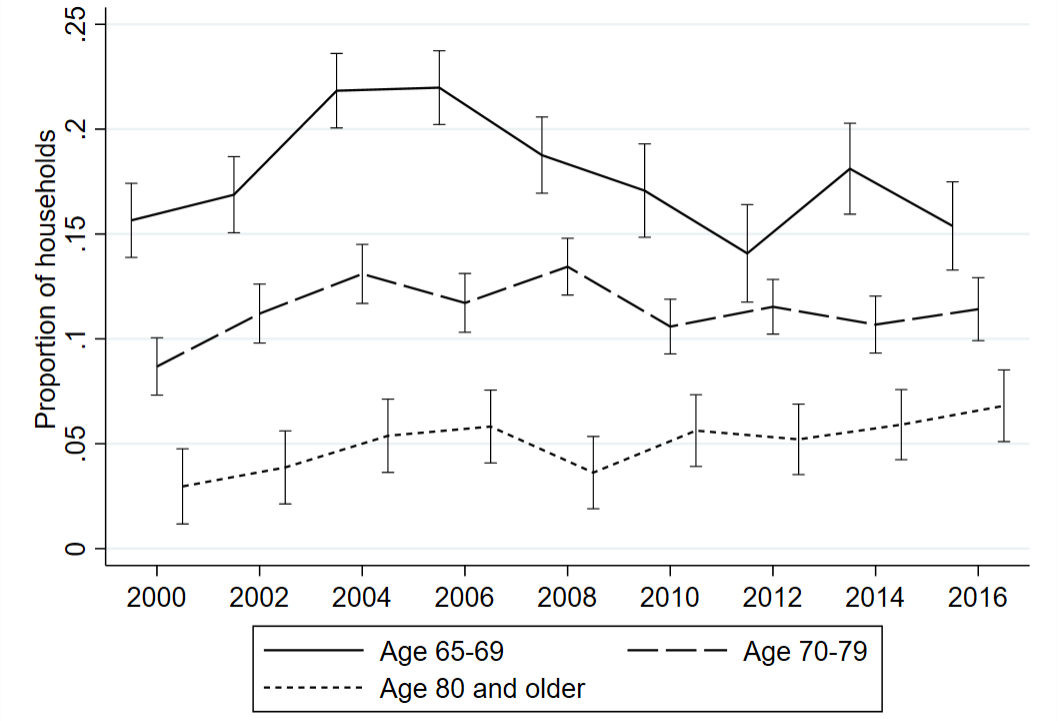


Figure 5:
Average amount of new mortgage borrowing among homeowners age 65 and older who borrowed, Health and Retirement Study

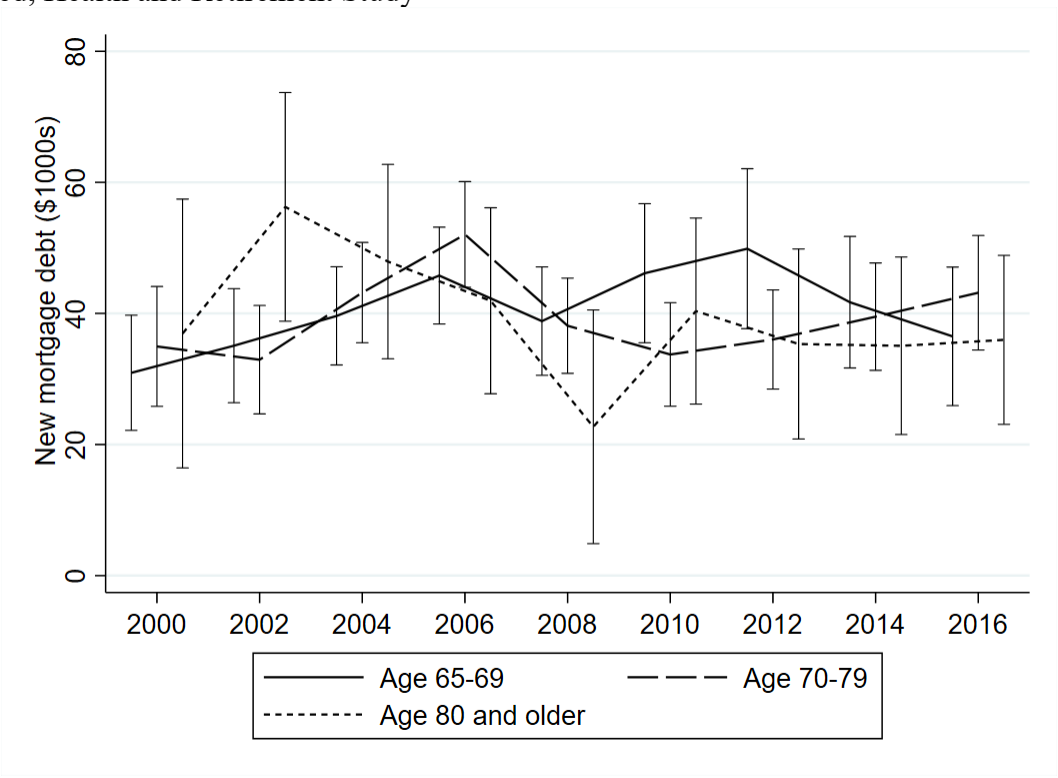


Figure 6:
Average net financial assets among homeowners age 65 and older, Health and Retirement Study

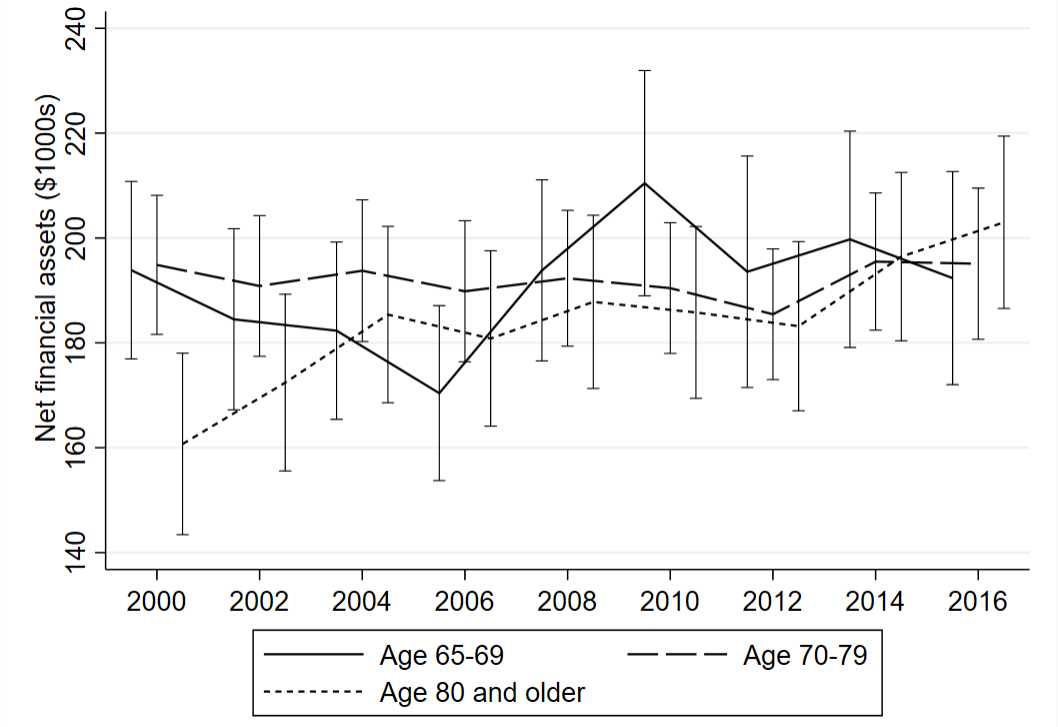


Figure 7 indicates that the proportion of homeowners facing credit constraints through loan-to-value ratios is highest for the youngest age group in all years, with the gap between the age groups widening over time. Credit constraints increase for all age groups starting in the 2008 recession.

Figure 7:
Percent of homeowners age 65 and older with mortgage loan-to-home value ratio of 90% or higher, Health and Retirement Study

7.2. Research Objective 2: Association of housing wealth and food insecurity

7.2.1. Descriptive analysis

Table 1, Columns 2 and 3 report the sample means for food secure and food insecure households for each explanatory variable. In the HRS, food insecurity identifies households who haven't always had enough money to buy the food they need in the last two years (1 for "yes" and 0 for "no" responses). Column 2 includes households that were food secure in a given wave; Column 3 includes households that were food insecure in a given wave. The table also flags significant differences in means based on a t-test for the equality of means between food secure and food insecure households. The statistics are unweighted. All explanatory variables are lagged one or two HRS waves (2 or 4 years) from the wave in which food security is measured.

Food insecurity is experienced by 3.3% of our sample of older homeowners (n=679 household years). Food insecure and secure households differ in many ways. Most important for the current study, they differ in their housing characteristics. Food insecure older homeowners report lower home values, at $168,200, and lower home equity, at $120,800 compared to $274,500 and $208,800, respectively, for food secure homeowners. While there is no difference in the amount of new mortgage borrowing, food insecure older homeowners are more likely to hold mortgage debt, but the amounts borrowed among debtors are lower compared to food secure older homeowners, on average.

Food insecure and secure older homeowners further differ with regard to their household characteristics. Food insecure homeowners report about a quarter of the net financial assets and half the monthly household incomes of food secure older homeowners. Compared to food secure older homeowners, food insecure homeowners are almost five times more likely to have income

below the 100% federal poverty threshold. There is no difference in the percentage of food insecure and secure respondents with regard to their residence in metropolitan or non-metropolitan counties. However, food insecure older homeowners live in more economically distressed areas, based on county unemployment rates, compared to food secure homeowners.

Finally, food insecure and secure older homeowners differ with regard to almost all characteristics of the financial respondent in our sample. Food insecure older homeowners are younger, one-third more often female, twice as more likely to be of Hispanic ethnicity, and three times more likely to be Black. About one-third of food insecure financial respondents have not completed high school. Half are separated, divorced, widowed, or never married. As a result, food insecure respondents are more likely to have less than a high school education and are less likely to be married or partnered compared to food secure counterparts. Food insecure financial respondents report three times as many problems with activities of daily living as food secure financial respondents.

Appendix Table 1 shows the means for the small number of severely food insecure older homeowners (n=236 household-years) and the results of means comparison tests between food secure and severely food insecure older homeowners in our sample. In the 2008-2018 survey waves, in which the measure of severe food insecurity is available, about 41% of food insecure older homeowners, 1.4% of the full sample, experience severe food insecurity. Severely food insecure homeowners differ from food secure homeowners in ways similar to the larger sample of food insecure older homeowners. With regard to their housing characteristics, this small group reports half the average home values, at $148,100, and only 49% of the home equity, at $101,500, of food secure older households. Similar to the larger sample of food insecure older households, new mortgage borrowing amounts are not significantly higher than among food secure households.

Different from the larger food insecure sample, severely food insecure homeowners do not borrow at significantly higher rates than food secure older homeowners. However, severely food insecure older homeowners report carrying mortgage debt 41% more often. If they carry mortgage debt, the amount is about three-quarters of that of food secure older borrowers.

Table 1:
Sample descriptive statistics of the full sample and of food secure and food insecure older homeowners, Health and Retirement Study, 2002-2018

	(1) Full sample		(2) Food secure		(3) Food insecure		
	Mean	(SD)	Mean	(SD)	Mean	(SD)	*t*-test
Food insecure (0,1)	0.033	0.179	0	-	1	-	
Severe food insecurity (0,1)	0.014	0.116	0	-	0.406	0.492	
Housing characteristics							
Home value change ($100,000), t-1-t-2	-0.026	0.956	-0.026	0.959	-0.022	0.861	
Home value ($100,000), t-2	2.710	2.351	2.745	2.367	1.682	1.536	***
Home equity change ($100,000), t-1-t-2	0.084	0.987	0.086	0.990	0.032	0.898	
Home equity ($100,000), t-2	2.058	1.881	2.088	1.892	1.208	1.259	***
Any new mortgage borrowing (0,1), t-1-t-2	0.106	0.307	0.105	0.306	0.134	0.341	*
New mortgage borrowing ($100,000), t-1-t-2	0.042	0.223	0.041	0.220	0.061	0.296	
Any mortgage debt (0,1), t-2	0.285	0.451	0.283	0.451	0.334	0.472	**
Mortgage debt balance among debtors ($100,000), t-2	0.960	1.037	0.969	1.045	0.729	0.770	***
Household characteristics							
Household income ($100,000), t-2	0.599	0.608	0.609	0.612	0.325	0.393	***
Household income <100% FPL (0,1), t-2	0.050	0.218	0.044	0.206	0.209	0.407	***
Net financial assets ($100,000), t-2	2.594	4.577	2.662	4.621	0.618	2.240	***
Net other assets ($100,000), t-2	1.239	3.454	1.265	3.488	0.465	2.096	***
Net other debts ($100,000), t-2	0.029	0.231	0.028	0.221	0.059	0.426	
Household size, t-2	1.941	0.907	1.931	0.890	2.215	1.290	***
Metropolitan residence (0,1), t-2	0.784	0.412	0.785	0.411	0.758	0.428	
Financial respondent characteristics							
Age, t-2	73.782	6.294	73.801	6.297	73.247	6.197	*
Male (0,1), baseline	0.409	0.492	0.413	0.492	0.302	0.459	***
White (0,1), time invariant	0.857	0.350	0.865	0.341	0.630	0.483	***
Black (0,1), time invariant	0.113	0.317	0.106	0.308	0.315	0.465	***
Other (0,1), time invariant	0.030	0.169	0.029	0.167	0.054	0.227	**
Hispanic (0,1), time invariant	0.064	0.245	0.062	0.241	0.127	0.333	***
Married or partnered (0,1), t-2	0.489	0.500	0.494	0.500	0.349	0.477	***
Separated, divorced, or widowed (0,1), t-2	0.367	0.482	0.361	0.480	0.523	0.500	***
Never married (0,1), t-2	0.025	0.156	0.025	0.156	0.031	0.173	
Number of living children, t-2	3.223	2.136	3.205	2.111	3.739	2.724	***
Immigrant (0,1), time invariant	0.078	0.269	0.077	0.267	0.118	0.323	**
Less than high school (0,1), time invariant	0.181	0.385	0.173	0.379	0.412	0.493	***
GED (0,1), time invariant	0.038	0.191	0.037	0.189	0.062	0.241	**
High school diploma (0,1), time invariant	0.342	0.474	0.344	0.475	0.286	0.452	**
Some college (0,1), time invariant	0.217	0.412	0.219	0.413	0.159	0.366	***
College degree or more (0,1), time invariant	0.227	0.419	0.232	0.422	0.088	0.284	***
Help with future needs (0,1), t-2	0.573	0.495	0.574	0.494	0.530	0.499	*

	(1) Full sample		(2) Food secure		(3) Food insecure		
	Mean	(SD)	Mean	(SD)	Mean	(SD)	*t*-test
Problems with activities of daily living, t-2	0.162	0.559	0.151	0.533	0.467	1.027	***
Local macroeconomic conditions							
Change in county unemployment rate, t-1-t-2	0.041	2.231	0.035	2.228	0.229	2.313	*
County unemployment rate, t-2	6.824	2.534	6.814	2.535	7.093	2.503	**
Instruments							
FHFA HPI percent change (cont.), t-1-t-2	0.004	0.158	0.004	0.158	-0.008	0.165	
Loan-to-value ratio ≥ 90% (0,1), t-2	0.014	0.119	0.014	0.116	0.034	0.181	**
Debt-to-income ratio ≥ 20% (0,1), t-2	0.079	0.269	0.075	0.264	0.178	0.383	***
N (household-years)	20,421		19,742		679		

Notes: Column 2 includes households that were food secure in a given wave. Column 3 includes households that were food insecure in a given wave. Reference group for t-tests is food secure households. Dollar denominated variables are in 2016 constant dollars. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

7.2.2. Regression analysis

This section presents the results of a series of regression analyses which regress food insecurity on different predictors of housing wealth, controlling for the financial and socio-demographic measures introduced in Table 1. Table 2 shows the coefficient from three linear probability models predicting food insecurity, first as a function of change in FHFA House Price Index (HPI; Column 1), and then with home equity change (Column 2), and new mortgage borrowing (Column 3). Home equity change and new mortgage borrowing are treated as endogenous variables in these regressions by using instrumental variables. The coefficients in these linear probability models can be interpreted directly, similar to marginal effects, as the within-household change in the probability of food insecurity in response to changes in the explanatory variables.

We first explore how changes in HPI are related to food insecurity. The results in Table 2, Column 1 show that there is a negative and statistically insignificant relationship between the change in HPI from t-2 to t-1 and food insecurity in t among older homeowners (beta=-0.015 (S.E.=0.010), p=0.140). While the direction of this result is consistent with prior housing research which found effects for physical and mental health (Hamoudi and Dowd 2014, Fichera and

Gathergood 2016), we do not find a significant effect of HPI change in the context of food insecurity using the conventional criteria of p=0.05. We next replace the change in HPI with the change in home equity from t-2 to t-1. Change in home equity is a household choice and should therefore be treated as endogenous. The direction of the coefficient on home equity change from t-2 to t-1 is negative as expected (beta=-0.020 (S.E.=0.013)), but it is not statistically significant (p=0.123; Table 2, Column 2). The first stage results of the linear probability IV regression are presented in Appendix Table 2, Column 1.

The main specification (Column 3) replaces the change in home equity with the amount of new mortgage borrowing, which is also treated as endogenous. New mortgage borrowing represents the intensive margin of the effect of an additional $1 of mortgage borrowing on food insecurity. The first stage results from the linear probability IV regression are shown in Appendix Table 2, Column 2. The coefficient for new mortgage borrowing is negative and statistically significant (beta=-0.219 (S.E.=0.100) p=0.029).[14,15,16] Wald tests confirm that the variable should be treated as endogenous (chi^2 = 5.568, p = 0.018).[17] With regard to the control variables in the new mortgage borrowing estimation in Table 2, Column 3, only marital status is significantly associated with food insecurity. Single households, whether due to separation, divorce, widowhood, or never-married status are more likely to experience food insecurity compared to

[14] As a robustness check, we re-estimate the main specification with the imputed mortgage data. The coefficient for new mortgage borrowing is smaller but shows the same direction and significance level (beta=-0.121, p=0.048).
[15] If PTI constraints are also included as a third first-stage instrument, the coefficient on endogenous mortgage borrowing retains a negative sign but is reduced in size and becomes marginally significant (b=-0.122, p=0.080). However, as noted above, instrument tests reveal that adding PTI constraints results in over identification.
[16] In preliminary analysis using our new mortgage borrowing specification, we tested for longer-term effects of new mortgage borrowing on food insecurity beyond the one-wave, two-year time frame past the borrowing date. We do not find a longer-term effect (new mortgage borrowing t-3 to t-2: beta=-0.022 (S.E.=0.058); new mortgage borrowing t-4 to t-3: beta=0.025 (S.E.=0.052)).
[17] In an alternative specification, we include a separate variable for mortgage decrease amount. In this model, both components are associated with lower food insecurity (new mortgage borrowing (endogenous): beta=-0.404, p=0.017 and repayment (exogenous): b=-0.091, p=0.014).

married or partnered households, holding all else constant. Other variables are not statistically significant using the conventional criteria of p=0.05 in the fixed-effects model.[18] The lack of significance of the control variables is likely driven by the variables' low intertemporal variability within this sample of household of older homeowners. In the context of household fixed effects, low intertemporal variability reduces the ability to detect the effects of the control variables.[19]

When new mortgage borrowing is treated as exogenous, the sign of the coefficient changes to positive and is not statistically significant (beta=0.001 (S.E.=0.007), p=0.840). These results underscore our approach to treat new mortgage borrowing as endogenous, similar to the approaches taken in the evaluation of SNAP participation (Gundersen, Kreider, and Pepper 2017, Swann 2017). To better interpret the effect of the dollar change in mortgage borrowing on food insecurity based on this set of results, we calculate the change in the probability of being food insecure in response to a $10,000 increase in new mortgage borrowing. For this exercise, we set the values of the explanatory variables to be representative of the median food insecure household in our sample.[20] The median food insecure household has financial assets of $800, annual household income of $20,632, and has income that falls below 100% of the federal poverty level. The financial respondent is a 72-year-old woman that is separated, divorced, or widowed, and has three children. The resulting probability of food insecurity is 60.1%. We calculate that a $10,000 increase in new mortgage borrowing reduces the probability of food insecurity for this household

[18] Several control variables are significant if the primary endogenous mortgage borrowing regression is re-estimated with random effects. Specifically, the coefficient for net financial assets is negative and significantly associated with food insecurity. Positive and significant effects are found for the square of net financial assets, being below 100% of the FPL, net other debts, household size, ADLs, number of living children, and never being married (relative to currently married).

[19] As a robustness check, the results of a first-differences specification (b = -0.158, S.E. = 0.085, p = 0.062; N (obs.) =13,530) support the fixed effects main results.

[20] Dummy variables are set to modal values.

to 57.9%, which represents a reduction in the probability of food insecurity of 2.2 percentage points.

Table 2:
Linear probability regression models predicting food insecurity among homeowners age 65 and older, Health and Retirement Study 2002-2018

	(1) Food insecurity (0,1) Coeff. (SE)	p-value	(2) Food insecurity (0,1) Coeff. (SE)	p-value	(3) Food insecurity (0,1) Coeff. (SE)	p-value
Housing characteristics						
FHFA HPI percent change (cont.) (exogenous), t-1-t-2	-0.015 (0.010)	0.140				
Home equity change ($100,000) (endogenous), t-1-t-2			-0.020 (0.013)	0.123		
New mortgage borrowing ($100,000) (endogenous), t-1-t-2					-0.219* (0.100)	0.029
Household characteristics						
Household income ($100,000), t-2	-0.000001 (0.002)	0.999	-0.0001 (0.002)	0.963	0.00004 (0.002)	0.872
Household income <100% FPL, t-2	0.007 (0.013)	0.604	0.007 (0.013)	0.605	0.008 (0.014)	0.579
Net financial assets ($100,000), t-2	-0.0004 (0.001)	0.573	-0.001 (0.001)	0.441	0.0001 (0.001)	0.936
Net financial assets squared ($100,000), t-2	0.000004 (0.0004)	0.803	0.00001 (0.00002)	0.679	-0.000001 (0.00003)	0.961
Net other assets ($100,000), t-2	0.001 (0.0004)	0.257	0.0004 (0.0004)	0.412	0.001 (0.001)	0.228
Net other debt (100,000), t-2	0.013 (0.012)	0.279	0.016 (0.012)	0.186	0.010 (0.014)	0.483
Household size, t-2	0.0004 (0.005)	0.924	0.0004 (0.005)	0.936	0.001 (0.005)	0.871
Metropolitan residence (0,1), t-2	0.002 (0.023)	0.948	0.002 (0.023)	0.926	0.006 (0.024)	0.798
9 Census regions, t-2	Yes		Yes		Yes	
Financial respondent characteristics						
Age, t-2	0.014 (0.008)	0.071	0.014 (0.008)	0.061	0.008 (0.008)	0.346
Age squared, t-2	-0.0001 (0.00004)	0.200	-0.0001 (0.0004)	0.181	-0.00001 (0.0001)	0.802
Never married (0,1), t-2	0.057 (0.043)	0.180	0.056 (0.045)	0.213	0.073 (0.043)	0.092
Separated, divorced, or widowed (0,1), t-2	0.014 (0.007)	0.060	0.014 (0.007)	0.058	0.015* (0.007)	0.048
Number of living children (0,1), t-2	0.002 (0.003)	0.549	0.002 (0.003)	0.522	0.001 (0.003)	0.810
Help with future needs (0,1), t-2	-0.001 (0.003)	0.763	-0.002 (0.004)	0.617	-0.001 (0.004)	0.790
Problems with ADLs, t-2	-0.0001 (0.006)	0.989	-0.0003 (0.006)	0.959	-0.001 (0.006)	0.898

	(1) Food insecurity (0,1) Coeff. (SE)	p-value	(2) Food insecurity (0,1) Coeff. (SE)	p-value	(3) Food insecurity (0,1) Coeff. (SE)	p-value
Macroeconomic conditions						
Change in county unemployment rate, t-1 - t-2	0.0002 (0.002)	0.885	-0.001 (0.002)	0.573	0.00004 (0.002)	0.981
County unemployment rate, t-2	-0.001 (0.002)	0.750	-0.002 (0.002)	0.406	-0.001 (0.002)	0.616
7 year dummies (2006 to 2018)	Yes		Yes		Yes	
Constant	-0.669+ (0.360)	0.063	-0.684 (0.362)	0.059	-0.437 (0.385)	0.257
Instrument tests						
Cragg-Donald Wald F-statistic	-		191.377		75.832	
Underidentification test (Kleibergen-Paap rk LM statistic)	-		127.996***		28.101***	
Overidentification test (Sargan-Hansen statistic)	-		0		1.476	
N (household-years)	20,421		20,421		20,421	
n (households)	6,319		6,319		6,319	

Notes: First-stage results for Columns (2) and (3) are shown in Appendix Table 2. First-stage instruments are (1) FHFA HPI percent change (cont.) from t-1 to t-2 and (2) loan-to-value ratio ≥ 90% (0,1) in t-2. Dollar denominated variables are in 2016 constant dollars. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

7.2.3. Evaluation of instrumental variables

The results of standard instrument tests for our endogenous specifications indicate that test statistics for under-identification (Kleibergen-Paap rk LM statistics = 28.10) and weak identification (Kleibergen-Paap rk Wald F statistics = 16.814) show acceptable values and indicate that the equations are identified and our IV estimates are unlikely to be biased due to weak instruments. In our main specification, in Table 2, the Sargan-Hansen statistics regarding the over-identifying restrictions are not rejected at p = 0.05 (Sargan-Hansen = 1.476, p = 0.224), indicating that the instruments are valid and excluded correctly from the equation. The results of the first-

stage regressions also indicate that our instruments behave as expected for our main specification. As shown in Appendix Table 2, the instrument HPI change from t-2 to t-1 is positively associated with the level of change in home equity from t-2 to t-1 at $p<0.001$. With regard to new mortgage borrowing, HPI change from t-2 to t-1 is positively and LTV $\geq$ 90% in t-2 is negatively associated with new mortgage borrowing, but only the loan-to-value ratio is significant at the conventional criteria of $p = 0.05$.[21]

7.2.4. Results for severely food insecure older homeowners

Table 3 presents the results of our specification predicting severe food insecurity (the respondent ate less because there "wasn't enough money to buy food"), focusing on the new mortgage borrowing estimations. The estimation model is the same as above, with the focal variables again treated as endogenous.[22] Results of the first stage are shown in Column (2). In the severe food insecurity regression, the coefficient of new mortgage borrowing is insignificant at the 5% level (beta=-0.030 (S.E.=0.064), p=0.635), as shown in Column (1). This null result may reflect the very small number of severely food insecure older homeowners in our sample who borrow in a given wave (N = 35 household-waves). Combined with the very low rates of severe food insecurity we observe, these few observations of borrowing reduce statistical power, making it difficult to detect significant effects.

[21] We also tested DTI constraints, which is based on less precise data than the measure of LTV constraints. The measure of DTI constraints has a statistically significant, negative effect on new mortgage borrowing. Including HPI as well as LTV and DTI constraints in the first stage, or including only DTI and LTV constraints results in overidentification (Sargan-Hansen statistic = 4.933, p = 0.085; 2.903, p = 0.084, respectively). Including HPI and DTI constraints as instruments is supported by the instrument tests. The coefficient for new mortgage borrowing, however, turns insignificant (b = -0.025 (S.E. = 0.085), p = 0.768).

[22] The Wald tests indicate that endogeneity is not present ($chi^2 = 0.145$, p = 0.704). We tested the relationship between severe food insecurity and mortgage borrowing, treating the latter as exogenous. Surprisingly, in this model we find a negative effect of new mortgage borrowing (b = -0.007, p = 0.076).

Table 3
Linear probability regression models predicting severe food insecurity among older homeowners, Health and Retirement Study 2002-2018

	(1) Severe food insecurity (0,1) Coeff. (SE)	p-value	(2) New mortgage borrowing, t-1-t-2 Coeff. (SE)	p-value
Housing characteristics				
New mortgage borrowing ($100,000) (endogenous), t-1-t-2	-0.030	0.635		
	(0.064)			
Household characteristics				
Household income ($100,000), t-2	0.0002	0.833	-0.004	0.475
	(0.001)		(0.006)	
Household income <100% FPL, t-2	0.0002	0.985	-0.002	0.797
	(0.010)		(0.007)	
Net financial assets ($100,000), t-2	0.0001	0.675	0.003	0.373
	(0.0003)		(0.003)	
Net financial assets squared ($100,000), t-2	-0.000002	0.734	-0.00004	0.780
	(0.00001)		(0.0001)	
Net other assets ($100,000), t-2	-0.00001	0.341	-0.0004	0.781
	(0.0001)		(0.001)	
Net other debt (100,000), t-2	0.022	0.156	-0.034	0.384
	(0.015)		(0.039)	
Household size, t-2	0.004	0.207	-0.003	0.753
	(0.003)		(0.008)	
Metropolitan residence (0,1), t-2	0.0001	0.971	0.045	0.195
	(0.003)		(0.034)	
9 Census regions, t-2	Yes		Yes	
Financial respondent characteristics				
Age, t-2	0.005	0.344	0.0002**	0.001
	(0.005)		(0.0001)	
Age squared, t-2	-0.00001	0.706	-0.032**	0.002
	(0.00003)		(0.010)	
Separated, divorced, or widowed (0,1), t-2	0.007	0.183	0.004	0.742
	(0.005)		(0.012)	
Never married (0,1), t-2	0.010	0.146	0.073	0.123
	(0.007)		(0.047)	
Number of living children (0,1), t-2	0.002	0.567	-0.007	0.277
	(0.003)		(0.007)	
Help with future needs (0,1), t-2	-0.003	0.233	-0.001	0.888
	(0.002)		(0.006)	
Problems with ADLS, t-2	-0.003	0.487	0.0001	0.984
	(0.004)		(0.006)	
Macroeconomic conditions				
Change in county unemployment rate, t-1-t-2	0.001	0.443	-0.004*	0.027
	(0.001)		(0.002)	
County unemployment rate, t-2	0.0002	0.881	-0.004	0.103
	(0.001)		(0.003)	
7 year dummies (2006 to 2018)	Yes		Yes	
Constant	-0.280	0.245	1.439**	0.003
	(0.240)		(0.490)	

	(1) Severe food insecurity (0,1) Coeff. (SE)	p-value	(2) New mortgage borrowing, t-1-t-2 Coeff. (SE)	p-value
Instruments				
HPI change (cont.), t-1 - t-2			0.010	0.356
			(0.011)	
Loan-to-value ratio ≥ 90%			-0.221***	<0.001
(0,1), t-2			(0.044)	
Instrument tests				
Cragg-Donald Wald F-statistic	59.541			
Underidentification test (Kleibergen-Paap rk LM statistic)	21.471***			
Overidentification test (Sargan-Hansen statistic)	0.063			
N (household-years)	17,323			
n (households)	5,785		17,323	

Notes: Dollar denominated variables are in 2016 constant dollars. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

7.2.5. Results for Black and White older homeowners

The food security literature suggests greater food insecurity among Black older adults which aligns with the housing literature that identified housing wealth disparities between Black and White older homeowners. Appendix Table 3 presents the descriptive comparison of Black and White food insecure older homeowners and Table 4 below presents the regression results. Results of the first stage are shown in Appendix Table 4. We focus on the main specifications with new mortgage borrowing, treated as endogenous and interact race with the new mortgage borrowing variable, with the interaction term also treated as endogenous. The coefficient for the interaction term is negative and not significant (beta = -0.057 (SD = 0.287), p = 0.842), indicating that each dollar borrowed has a similar effect on food security for Black and White older homeowners. The instrument tests meet standard thresholds.

Table 4

Linear probability regression models predicting food insecurity among Black and White older homeowners, Health and Retirement Study, 2002 to 2018

	(1) Food insecurity (0,1) Coeff. (SE)	p-value	(2) Amount of new mortgage borrowing Coeff. (SE)	p-value	(3) New mortgage borrowing*Black Coeff. (SE)	p-value
Housing characteristics						
New mortgage borrowing ($100,000) (endogenous), t-1 - t-2	-0.198* (0.098)	0.044				
New mortgage borrowing * Black ($100,000) (endogenous), t-1-t-2	-0.057 (0.287)	0.842				
Household characteristics						
Monthly household income ($10,000), t-2	0.0004 (0.002)	0.876	0.001 (0.005)	0.810	0.0001 (0.002)	0.940
Household income < 100% FPL, t-2	0.008 (0.014)	0.577	-0.00001 (0.007)	0.999	0.0002 (0.003)	0.942
Net financial assets ($100,000), t-2	0.00003 (0.001)	0.976	0.002 (0.003)	0.412	0.00002 (0.0004)	0.953
Net financial assets ($100,000), t-$2^2$	-0.000001 (0.00002)	0.978	-0.00003 (0.0001)	0.792	-0.0000004 (0.00001)	0.967
Net other assets ($100,000), t-2	0.001 (0.001)	0.224	0.001 (0.001)	0.635	0.00001 (0.0003)	0.976
Net other debt (100,000), t-2	0.010 (0.014)	0.455	-0.011 (0.033)	0.732	0.002 (0.003)	0.343
Household size, t-2	0.001 (0.005)	0.864	0.001 (0.007)	0.857	0.002 (0.002)	0.447
Metropolitan residence (0,1), t-2	0.006 (0.024)	0.813	0.024 (0.026)	0.367	0.0002 (0.001)	0.819
Region, t-2	Yes		Yes		Yes	
Financial respondent characteristics						
Help with future needs (0,1), t-2	-0.001 (0.004)	0.762	0.001 (0.005)	0.892	-0.003 (0.002)	0.187
Problems with ADLS (0,1), t-2	-0.001 (0.006)	0.882	-0.002 (0.005)	0.661	-0.003 (0.001)	0.059
Age, t-2	0.008 (0.008)	0.312	-0.027** (0.009)	0.002	0.001 (0.002)	0.732
Age, t-2^2	-0.00002 (0.0001)	0.749	0.0002*** (0.0001)	0.000	0.00002 (0.00001)	0.178
Number of living children (0,1), t-2	0.001 (0.004)	0.857	-0.005 (0.005)	0.353	-0.004 (0.003)	0.155
Separated, divorced, or widowed (0,1), t-2	0.0146* (0.007)	0.050	0.004 (0.009)	0.670	-0.002 (0.005)	0.661
Never married (0,1), t-2	0.072 (0.043)	0.099	0.072 (0.042)	0.091	-0.002 (0.005)	0.708

	(1) Food insecurity (0,1) Coeff. (SE)	p-value	(2) Amount of new mortgage borrowing Coeff. (SE)	p-value	(3) New mortgage borrowing*Black Coeff. (SE)	p-value
Macroeconomic conditions						
Change in county unemployment rate, t-1 - t-2	0.0001 (0.002)	0.938	-0.003* (0.002)	0.047	-0.001 (0.001)	0.417
County unemployment rate, t-2	-0.001 (0.002)	0.643	-0.004 (0.002)	0.113	-0.001 (0.001)	0.600
Year	Yes		Yes		Yes	
Constant	-0.465 (0.389)	0.232	1.027* (0.451)	0.023	-0.111 (0.131)	0.398
Instruments						
HPI change (cont.), t-1 - t-2			0.020 (0.013)	0.112	-0.003 (0.003)	0.336
Loan-to-value ratio ≥ 90% (0,1), t-2			-0.218*** (0.042)	0.000	0.0001 (0.001)	0.819
HPI change * Black			-0.028 (0.021)	0.172	-0.001 (0.018)	0.979
Loan-to-value ratio ≥ 90% * Black			-0.074 (0.118)	0.532	-0.301** (0.110)	0.006
Instrument tests						
Cragg-Donald Wald F statistic	31.783		-		-	
Kleibergen-Paap rk Wald F statistic	7.733		-		-	
Underidentification test (Kleibergen-Paap rk LM statistic)	26.883***		-		-	
Overidentification test (Sargan-Hansen statistic)	1.689		-		-	
N (household-years) =	20,417		20,417		20,417	
n (households) =	6,317		6,317		6,317	

Notes:
Column (1) shows second-stage results, Columns 2 and 3 show first-stage results; first-stage instruments are HPI percent change (cont.) from t-1 to t-2; loan-to-value ratio ≥ 90% (0,1) in t-2; as well as the interactions of the two variables with an indicator of Black race
Region is measured with dummy variables for each of the 9 Census Regions and Divisions of the U.S., Western Region Pacific Division is the omitted category
Year dummies control for the year that food insecure is measured, 2006 is the omitted category
Cluster- and heteroscedasticity-robust standard errors in parentheses
Dollar denominated variables are adjusted for inflation to 2016 dollars
*** p<0.001, ** p<0.01, * p<0.05

7.2.6. Results for older homeowners in metropolitan and non-metropolitan counties

Similar to race, the food security literature finds greater food insecurity among older adults who live in non-metropolitan areas, which aligns with the housing literature that identified housing wealth disparities between metropolitan and non-metropolitan households. Appendix Table 5 presents the descriptive comparison of food insecure older homeowners in living in metropolitan and non-metropolitan counties and Table 5 below presents the regression results.

We focus on the main specifications with new mortgage borrowing treated as endogenous and interact location of residence (metropolitan counties are coded as 1, non-metropolitan counties are coded as 0), with the new mortgage borrowing variable, with the interaction term also treated as endogenous. The coefficient for the interaction term is positive and not significant (beta = 0.205 (SD = 0.484), p = 0.671), indicating that each dollar borrowed has a similar effect on the food security for older homeowners in metropolitan and non-metropolitan counties, see shown in Column 1. The first-stage results are shown in Column 2. The Cragg-Donald Wald F-statistic is weak for this interaction model, indicating a less robust specification.

Table 5
Linear probability regression models predicting food insecurity among non-metropolitan and metropolitan homeowners, Health and Retirement Study 2006-2018

	(1) Food insecurity (0,1)		(2) New mortgage borrowing		(3) New mortgage borrowing * metro	
	Coef. (SE)	p-value	Coef. (SE)	p-value	Coef. (SE)	p-value
Housing characteristics						
New mortgage borrowing ($100,000; endogenous), t-1 - t-2	-0.357 (0.351)	0.309				
New mortgage borrowing * metro	0.205 (0.484)	0.671				
Household characteristics						
Monthly household income ($10,000), t-2	0.001 (0.003)	0.847	0.003 (0.012)	0.785	0.003 (0.011)	0.774
Gross household income below 130% of poverty line, t-2	0.010 (0.014)	0.471	0.012 (0.009)	0.177	0.010 (0.009)	0.253
Net financial assets ($100,000), t-2	0.0002 (0.001)	0.849	0.003 (0.004)	0.539	0.002 (0.004)	0.686
Net financial assets ($100,000), t-$2^2$	-0.00001 (0.00003)	0.738	-0.0001 (0.0001)	0.744	-0.00001 (0.0001)	0.944
Net other assets ($100,000), t-2	0.001 (0.001)	0.247	0.003 (0.003)	0.308	0.002 (0.003)	0.315
Net other debt (100,000), t-2	0.015 (0.015)	0.319	0.023 (0.044)	0.600	0.029 (0.044)	0.51
Household size, t-2	0.003 (0.005)	0.597	0.010 (0.008)	0.235	0.007 (0.008)	0.401
Metropolitan residence (0,1), t-2	-0.001 (0.053)	0.989	0.079 (0.072)	0.272	0.144* (0.066)	0.03
Region, t-2	Yes		Yes		Yes	
Financial respondent characteristics						
Help with future needs (0,1), t-2	0.004 (0.008)	0.626	0.004 (0.013)	0.741	0.012 (0.013)	0.362
Problems with ADLs (0,1), t-2	-0.001 (0.008)	0.875	-0.013 (0.009)	0.175	-0.019* (0.010)	0.049
Age, t-2	-0.00001 (0.0001)	0.862	0.0004** (0.0001)	0.001	0.0003** (0.0001)	0.001
Age, t-2^2	0.008 (0.011)	0.457	-0.038* (0.017)	0.023	-0.040* (0.016)	0.012
Number of living children (0,1), t-2	0.002 (0.004)	0.603	-0.001 (0.006)	0.916	-0.002 (0.006)	0.793
Separated, divorced, or widowed (0,1), t-2	0.016 (0.009)	0.085	0.017 (0.017)	0.334	0.019 (0.016)	0.209
Never married (0,1), t-2	0.086 (0.057)	0.129	0.185 (0.133)	0.164	0.184 (0.133)	0.166
Macroeconomic conditions						
Change in county unemployment rate, t-1 - t-2	0.001 (0.002)	0.673	-0.003 (0.003)	0.424	-0.004 (0.003)	0.212
County unemployment rate, t-2	-0.001 (0.003)	0.619	-0.009* (0.004)	0.027	-0.010** (0.004)	0.009
Year	Yes		Yes		Yes	
Constant	-0.465 (0.514)		1.534 (0.900)	0.085	1.681* (0.839)	0.045

	(1) Food insecurity (0,1)		(2) New mortgage borrowing		(3) New mortgage borrowing * metro	
	Coef. (SE)	p-value	Coef. (SE)	p-value	Coef. (SE)	p-value
Instruments						
HPI change (cont.), t-1 - t-2			0.048	0.729	-0.011	0.569
			(0.137)		(0.019)	
Loan-to-value ratio ≥ 90%			-0.152***	<0.001	-0.021	0.085
(0,1), t-2			(0.031)		(0.012)	
HPI change * metro			-0.052	0.694	-0.002	0.923
			(0.131)		(0.022)	
Loan-to-value ratio ≥ 90% * metro			-0.096	0.054	-0.167***	<0.001
			(0.049)		(0.029)	
Instrument tests						
Cragg-Donald Wald F-statistic	2.61		-		-	
Kleibergen-Paap rk Wald F-statistic	2.971		-		-	
Underidentification test	10.354*		-		-	
Overidentification test	1.89		-		-	
N (household-years) =	20,417		20,417		20,417	
n (households) =	6,317		6,317		6,317	

Notes:
Column (1) shows second-stage results, Columns 2 and 3 show first-stage results; first-stage instruments are HPI percent change (cont.) from t-1 to t-2; loan-to-value ratio ≥ 90% (0,1) in t-2; as well as the interactions of the two variables with an indicator of metropolitan residence
Region is measured with dummy variables for each of the 9 Census Regions and Divisions of the U.S., Western Region Pacific Division is the omitted category
Year dummies control for the year that food insecure is measured, 2006 is the omitted category
Cluster- and heteroscedasticity-robust standard errors in parentheses
Dollar denominated variables are adjusted for inflation to 2016 dollars
*** p<0.001, ** p<0.01, * p<0.05

7.3 Research Objective 3: Simulation of policy innovations in access to housing wealth

The results of the simulations are shown in Table 6 and illustrated in Figure 8 and 9. In the first simulation step, homeowners who borrow in 2012 are simulated to adjust their borrowing amount to be equal to 50% of their home equity, which is a common threshold in reverse mortgage borrowing.[23] With this adjusted borrowing amount, food insecurity is at 2.39%, which is 1.18

[23] For 16% of borrowers in the simulation this amount is lower than their actual amount of new mortgage borrowing; for the other borrowers, the amount is higher than their actual borrowed amount.

percentage points lower than the predicted rate of 3.57% in 2014. The reduction in food insecurity is driven by the ($9,480 - $3,632 = $5,848) $5,848 increase in average borrowing, see Figure 8.

In the second simulation step, we assign a borrowing amount equal to 50% of available home equity in 2010 to PTI constrained homeowners who did not borrow in 2012 (borrowed amount was previously $0). With this additional step, average borrowing in the full sample (borrowers and non-borrowers) increases by $9,549 to $13,191 and reduces food insecurity by 1.94 percentage points to 1.63%, compared to the predicted baseline (46% change in the base rate).

Table 6
Simulations of access to housing wealth through new mortgage borrowing and implications for food insecurity, Health and Retirement Study, 2002 to 2018

	Full sample	Black	White	Metro-politan	Non-metropo litan
New mortgage borrowing					
Mean predicted new mortgage borrowing, 2012	$3,632	$6,050	$3,168	$4,146	$1,788
Step 1) Simulation of mean if borrowers take out 50% of 2010 home equity, in 2012 [a]	$9,480	$8,531	$9,568	$10,448	$6,004
Step 2) Simulation of mean if borrowers plus non-borrowers with PTI ≥ 20% take out 50% of 2010 home equity, in 2012 (non-borrowers with PTI<20% are kept at $0) [b]	$13,191	$12,517	$13,140	$14,509	$8,459
Food insecurity					
Predicted food insecurity, 2014	3.57%	8.98%	2.61%	3.48%	3.89%
Food insecurity if no mortgage borrowing, in 2014	4.33%	10.52%	3.24%	4.38%	4.15%
Step 1) Simulation of food insecurity if borrowers take out 50% of 2010 home equity, in 2014 [a]	2.39%	8.34%	1.35%	2.10%	3.27%
Step 2) Simulation of food insecurity if borrowers plus non-borrowers with PTI ≥ 20% take out 50% of 2010 home equity, in 2014 (non-borrowers with PTI<20% are kept at $0) [b]	1.63%	7.33%	0.64%	1.23%	2.91%
N for food insecurity measured in 2014	3,278	407	2,766	2564	714

Notes:
[a] Reverse mortgages typically allow homeowners to borrow up to 50% of available home equity. 0.5*home equity in 2010 is calculated only for those with new mortgage borrowing in 2012. Households who didn't report new mortgage borrowing were kept at $0 for this measure.
[b] Replaces observed amounts borrowed with reverse mortgage as defined in a) for households who borrow in 2012 and households who do not borrow in 2012 but have mortgage payment-to-income (PTI) ratios of 20% or higher. Households without a mortgage balance and PTI ratios of <20% were kept at a $0 mortgage balance.

While we find that additional borrowing reduces food insecurity for the sample as a whole, it reduces food insecurity more for White than Black older homeowners and for those living in metropolitan than for non-metropolitan counties. Black older homeowners and older homeowners living in non-metropolitan areas have substantially lower levels of home equity at baseline than White homeowners and those living in metropolitan counties, reducing their predicted borrowing amount through the simulations and thus the effects of relaxing borrowing constraints on food insecurity.

For Black homeowners, the rate of predicted food insecurity is higher prior to borrowing, at 8.98% compared to 2.61% for White homeowners. Black homeowners also have lower average home equity than White homeowners in 2010 ($134,863 vs $206,950). The borrowing simulation (Step 1) reduces the predicted rate of food insecurity by 0.64 percentage points for Black homeowners (from 8.98% to 8.34%), compared to 1.26 percentage points for White homeowners (from 2.61% to 1.35), see also Figure 9. Step 2 of the borrowing simulation reduces food insecurity by an additional 1.01 percentage point to 7.33% of the Black older homeowners in our sample.

With regard to location of residence of the older homeowners, the borrowing simulation (Step 1) reduces the predicted rate of food insecurity by 1.38 percentage points for metropolitan homeowners (from 3.48% to 2.10%) compared to 0.62 percentage points for non-metropolitan homeowners (from 3.89% to 3.27%). Step 2 of the borrowing simulation reduces food insecurity by an additional 0.87 percentage point to 1.23% of the older homeowners in the metropolitan counties in our sample. The food insecurity rate of the older homeowners in the non-metropolitan counties drops to 2.91 percentage points in Step 2 of the simulation.

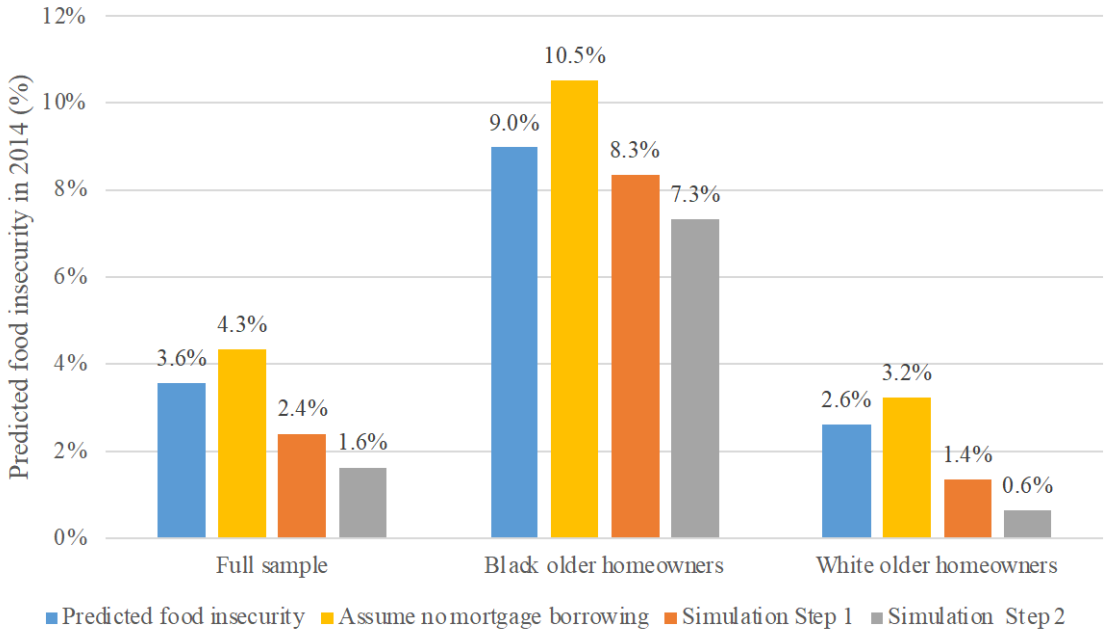
Figure 8:

Simulation of new mortgage borrowing for the full sample as well as by race

Notes:
Simulation Step 1: Simulation of means if borrowers take out 50% of 2010 home equity in 2012. Reverse mortgages typically allow homeowners to extract up to 50% of home equity. Households who did not borrow in 2012 were kept at $0.
Simulation Step 2: Simulation of means if borrowers plus non-borrowers with PTI ≥ 20% take out 50% of 2010 home equity in 2012. Mortgage borrowing values are replaced for households who borrow in 2012 and households who do not borrow in 2012 but have PTI ≥ 20%. Borrowing amounts for households who did not borrow or have a PTI<20% are kept at $0.

Figure 9:

Simulation of food insecurity for the full sample as well as by race



Notes:
Simulation Step 1: Simulation of means if borrowers take out 50% of 2010 home equity in 2012. Reverse mortgages typically allow homeowners to extract up to 50% of home equity. Households who did not borrow in 2012 were kept at $0.
Simulation Step 2: Simulation of means if borrowers plus non-borrowers with PTI ≥ 20% take out 50% of 2010 home equity in 2012. Mortgage borrowing values are replaced for households who borrow in 2012 and households who do not borrow in 2012 but have PTI ≥ 20%. Borrowing amounts for households who did not borrow or have a PTI<20% are kept at $0.

8. Discussion

This study contributes new knowledge about predictors of food insecurity in older age. Using the Health and Retirement Study data of older homeowners and following their food security status for 10 years, the results of our analysis identify new mortgage borrowing as a mechanism that contributes to the relationship between food insecurity and housing wealth for older homeowners. General house price changes or changes in home equity, treated as endogenous, are not statistically significantly related to food insecurity, pointing to the need to liquefy and consume this asset in order to affect food insecurity. When adding interaction terms to the regressions to examine the role of race and location of residence, we do not find that an additional $1 of borrowing has different effects for Black and White older homeowners or those living in metropolitan and non-metropolitan areas. There is little evidence that the racial and geographic discrepancies are driven by behavioral differences in the use of the mortgage borrowing proceeds because the coefficient of the interaction terms of new mortgage borrowing and race or location of residence are insignificant.

There are limitations to our analyses. The food insecurity measures are based on study participants' recall over a two-year period and rely on accurate recollection of these stressful events (for detailed discussion, see Brown, Mitchell, and Ailshire 2018). A second limitation is the quality of the financial data, which also rely on recall. The HRS has instituted a reconciliation and cross-wave imputation approach for wealth measures (Hurd et al. 2016), but not for mortgage debt measures. As a result, we use the non-imputed RAND mortgage measures, not the imputed measures, to avoid distortion in the data and we carefully assess outliers and set extreme values to missing. A third limitation is that mortgage borrowing is not measured directly in the survey data,

but rather we estimate the amount borrowed by observing changes in the reported mortgage amount from one wave to the next, two years apart. Thus, a respondent could borrow small amounts in between the survey waves and completely pay off the balance within two years and we would not observe this borrowing, as the mortgage balance would not increase. In addition, we do not directly observe the cost or terms of borrowing, such as the interest rate or length of time remaining on a mortgage.

A fourth limitation is the finding that our results are sensitive to instrument choice. We tested a number of instruments, and the use of HPI change plus PTI≥20% constraints passed weak instrument tests, in addition to using HPI change and LTV≥90% constraints. The results of new mortgage borrowing on food insecurity are insignificant when PTI and HPI are used as instruments. However, for the majority of the sample, the numerator of the PTI ratio is based on estimates, which affects the reliability of the measure. A final limitation is that our current empirical specification focuses only on the short-term effects of borrowing on food insecurity, measured as of the wave immediately after borrowing. This assumes there is no long-term effect of borrowing. Related to this discussion is the Time Horizon Model, which posits that people use short-term solutions to address food and bill-paying hardships, while housing and health hardships require long-term solutions (Heflin, Sandberg, and Rafail 2009). Future research is needed to assess effects of longer-term borrowing on food insecurity, and in turn overall financial security, in older age. This analysis should focus on the relationship of mortgage repayment burden as compared to the liquidity gained through mortgage borrowing. This approach requires reliable data on housing costs, which is a limitation of the HRS. This future research may also examine the different types of expenses that older adults cover with the proceeds of new mortgage borrowing, presenting another limitation of the HRS. With regard to recommendations for subgroup analysis,

the current study is limited in the analysis of severely food insecure older homeowners, due to the small size of this group in our sample after we applied our sample restrictions. Future research should examine the role of housing wealth for food insecurity of this highly distressed group of older adults by using approaches that preserve sample size.

9. Conclusion

Prior research indicates that homeownership is associated with lower levels of food insecurity. Homeowners' ability to borrow from the equity in their homes is often cited as the primary causal mechanism underlying this relationship (Gundersen and Gruber 2001); but to our knowledge, our study is the first to empirically investigate this mechanism. The results document the critical role of housing wealth as a "protective buffer" (Ziliak, Gundersen, and Haist 2008) for material hardship and as an indicator of economic security. For older adults, borrowing from home equity can provide a means to smooth consumption in the presence of income or health shocks, thereby allowing for households to meet basic needs—in this case, sufficient resources to buy food. The significance of home equity in the wealth portfolio of older adults is only expected to increase over the next few decades, especially as the baby boomer generation enters retirement with higher levels of financial debts, and thus financial insecurity, than previous generations (Rutledge and Sanzenbacher 2019). Our study highlights the importance of providing this population with affordable and accessible instruments to convert home equity into a more liquid form.

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Appendix Tables

Appendix Table 1

Sample descriptive statistics of food secure and severely food insecure older homeowners, Health and Retirement Study 2002-2018

	(1) Food secure		(2) Severely food insecure		
	Mean	(SD)	Mean	(SD)	*t*-test
Housing characteristics					
Home value change ($100,000), t-1-t-2	-0.026	0.959	0.002	0.961	
Home value ($100,000), t-2	2.745	2.367	1.481	1.265	***
Home equity change ($100,000), t-1-t-2	0.086	0.990	0.090	0.948	
Home equity ($100,000), t-2	2.088	1.892	1.015	1.044	***
Any new mortgage borrowing (0,1), t-1-t-2	0.105	0.306	0.148	0.356	
New mortgage borrowing ($100,000), t-1-t-2	0.041	0.220	0.044	0.170	
Any mortgage debt (0,1), t-2	0.283	0.451	0.398	0.491	**
Mortgage debt balance among debtors ($100,000), t-2	0.969	1.045	0.713	0.700	***
Household characteristics					
Household income ($100,000), t-2	0.609	0.612	0.286	0.284	***
Household income below 100% of poverty line (0,1), t-2	0.044	0.206	0.216	0.412	***
Net financial assets ($100,000), t-2	2.662	4.621	0.145	0.522	***
Net other assets ($100,000), t-2	1.265	3.488	0.184	0.626	***
Net other debts ($100,000), t-2	0.028	0.221	0.112	0.708	
Household size, t-2	1.931	0.890	2.352	1.441	***
Metropolitan residence (0,1), t-2	0.785	0.411	0.775	0.418	
Financial respondent characteristics					
Age, t-2	73.801	6.297	72.513	5.912	***
Male (0,1) time invariant	0.413	0.492	0.284	0.452	***
White (0,1) time invariant	0.865	0.341	0.593	0.492	***
Black (0,1) time invariant	0.106	0.308	0.314	0.465	***
Other (0,1) time invariant	0.029	0.167	0.093	0.291	***
Hispanic (0,1) time invariant	0.062	0.241	0.144	0.352	***
Married or partnered (0,1), t-2	0.494	0.500	0.316	0.466	***
Separated, divorced, or widowed (0,1), t-2	0.361	0.480	0.555	0.498	***
Never married (0,1), t-2	0.025	0.156	0.008	0.092	**
Number of living children, t-2	3.205	2.111	3.992	2.843	***
Immigrant (0,1) time invariant	0.077	0.267	0.115	0.320	
Less than high school (0,1) time invariant	0.173	0.379	0.436	0.497	***
GED (0,1) time invariant	0.037	0.189	0.051	0.220	
High school diploma (0,1) time invariant	0.344	0.475	0.288	0.454	
Some college (0,1) time invariant	0.219	0.413	0.174	0.380	
College degree or more (0,1) time invariant	0.232	0.422	0.055	0.229	***
Help with future needs (0,1), t-2	0.574	0.494	0.538	0.500	
Problems with activities of daily living, t-2	0.151	0.533	0.559	1.138	***
Local macroeconomic conditions					
Change in county unemployment rate, t-1-t-2	0.035	2.228	0.275	2.479	
County unemployment rate, t-2	6.814	2.535	7.311	2.564	
Instruments					
FHFA HPI percent change (cont.), t-1-t-2	0.004	0.158	-0.021	0.167	
Loan-to-value ratio ≥ 90% (0,1), t-2	0.014	0.116	0.038	0.192	
Debt-to-income ratio ≥ 20% (0,1), t-2	0.075	0.264	0.225	0.418	***
N (household-years)	19,742		236		

Note: Column 1 includes households that were food secure in a given wave. Column 2 includes households that were severely food insecure in a given wave. Reference group for t-tests is food secure households. Dollar denominated variables are in 2016 constant dollars. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Appendix Table 2

First-stage results of Table 2, Linear probability regression models predicting food insecurity among older homeowners, Health and Retirement Study 2002-2018

	(1) Home equity change, t-1-t-2 Coeff. (SE)	p-value	(2) New mortgage borrowing, t-1-t-2 Coeff. (SE)	p-value
Household characteristics				
Household income ($100,000), t-2	-0.005	0.856	0.001	0.803
	(0.026)		(0.005)	
Household income < 100% FPL, t-2	-0.002	0.969	0.0004	0.951
	(0.053)		(0.007)	
Net financial assets ($100,000), t-2	-0.009	0.360	0.002	0.416
	(0.010)		(0.003)	
Net financial assets squared ($100,000), t-2	0.0002	0.566	-0.00003	0.795
	(0.0003)		(0.0001)	
Net other assets ($100,000), t-2	-0.006	0.406	0.001	0.645
	(0.007)		(0.001)	
Net other debt (100,000), t-2	0.133	0.238	-0.011	0.735
	(0.112)		(0.032)	
Household size, t-2	-0.003	0.867	0.001	0.872
	(0.020)		(0.007)	
Metropolitan residence (0,1), t-2	0.032	0.889	0.024	0.361
	(0.226)		(0.026)	
9 Census regions, t-2	Yes		Yes	
Financial respondent characteristics				
Age, t-2	0.030	0.489	-0.026***	0.002
	(0.043)		(0.009)	
Age squared, t-2	-0.0001	0.534	0.0002***	0.000
	(0.0002)		(0.00005)	
Separated, divorced, or widowed (0,1), t-2	0.009	0.835	0.004	0.673
	(0.045)		(0.009)	
Never married (0,1), t-2	-0.083	0.655	0.071+	0.092
	(0.186)		(0.043)	
Number of living children (0,1), t-2	0.007	0.700	-0.004	0.358
	(0.017)		(0.005)	
Help with future needs (0,1), t-2	-0.037	0.139	0.001	0.916
	(0.025)		(0.005)	
Problems with ADLs, t-2	-0.011	0.598	-0.002	0.682
	(0.020)		(0.005)	
Macroeconomic conditions				0.029
Change in county unemployment rate,	-0.069***	0.000	-0.004*	
t-1-t-2	(0.015)		(0.002)	0.094
County unemployment rate, t-2	-0.060***	0.000	-0.004+	
	(0.015)		(0.002)	
7 year dummies (2006 to 2018)	Yes		Yes	
Instruments				
FHFA HPI percent change (cont.), t-1-t-2	0.776***	0.000	0.014	0.162
	(0.208)		(0.010)	
Loan-to-value ratio ≥ 90% (0,1), t-2			-0.231***	0.000
			(0.040)	
Constant	-0.781		1.029*	
	(2.287)		(0.451)	
N (household-years) =	20,421		20,422	

Note: Dollar denominated variables are in 2016 constant dollars. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Appendix Table 3

Characteristics of food insecure older homeowners only by race (N=632)

	(1) Black homeowners		(2) White homeowners		
	Mean	(SD)	Mean	(SD)	t-test
Food insecure (0,1)	1	-	1	-	
Severe food insecurity (0,1)	0.420	0.495	0.377	0.485	
Housing characteristics					
Home value change ($100,000), t-1-t-2	0.033	0.759	-0.055	0.833	
Home value ($100,000), t-2	1.137	1.054	1.959	1.684	***
Home equity change ($100,000), t-1-t-2	0.105	0.771	-0.011	0.887	
Home equity ($100,000), t-2	0.785	0.804	1.419	1.402	***
New mortgage borrowing (0,1), t-1-t-2	0.136	0.343	0.136	0.343	
New mortgage borrowing ($100,000), t-1-t-2	0.038	0.137	0.069	0.331	
Any mortgage debt (0,1), t-2	0.322	0.469	0.334	0.472	
Mortgage debt balance among debtors ($100,000), t-2	0.572	0.578	0.826	0.856	*
Household characteristics					
Household income ($100,000), t-2	2.069	1.612	3.941	4.667	***
Household income <100% FPL (0,1), t-2	0.346	0.477	0.140	0.348	***
Net financial assets ($100,000), t-2	0.085	0.379	0.936	2.760	***
Net other assets ($100,000), t-2	0.149	0.540	0.642	2.591	***
Net other debts ($100,000), t-2	0.045	0.107	0.070	0.531	
Household size, t-2	2.336	1.437	2.138	1.210	
Metropolitan residence (0,1), t-2	0.743	0.438	0.778	0.416	
Financial respondent characteristics					
Age, t-2	73.121	5.686	73.287	6.525	
Male (0,1) time invariant	0.224	0.418	0.327	0.470	**
White (0,1) time invariant	0.000	0.000	1.000	0.000	
Black (0,1) time invariant	1.000	0.000	0.000	0.000	
Other (0,1) time invariant	0.000	0.000	0.000	0.000	
Hispanic (0,1) time invariant	0.014	0.118	0.150	0.357	***
Married or partnered (0,1), t-2	0.248	0.433	0.387	0.488	***
Separated, divorced, or widowed (0,1), t-2	0.645	0.480	0.467	0.500	***
Never married (0,1), t-2	0.047	0.212	0.026	0.158	
Number of living children, t-2	4.397	3.059	3.320	2.447	***
Immigrant (0,1) time invariant	0.038	0.191	0.136	0.343	***
Less than high school (0,1) time invariant	0.543	0.499	0.326	0.469	***
GED (0,1) time invariant	0.042	0.201	0.072	0.260	
High school diploma (0,1) time invariant	0.234	0.424	0.318	0.466	*
Some college (0,1) time invariant	0.131	0.338	0.182	0.386	
College degree or more (0,1) time invariant	0.051	0.221	0.110	0.313	**
Help with future needs (0,1), t-2	0.514	0.501	0.549	0.498	
Problems with activities of daily living, t-2	0.579	1.183	0.376	0.869	*
Local macroeconomic conditions					
Change in county unemployment rate, t-1-t-2	0.267	2.265	0.239	2.331	
County unemployment rate, t-2	0.726	0.231	0.693	0.252	
Instruments					
FHFA HPI percent change (cont.), t-1-t-2	-0.002	0.145	-0.011	0.171	
Loan-to-value ratio ≥ 90% (0,1), t-2	0.000	0.000	0.000	0.000	
Debt-to-income ratio ≥ 20% (0,1), t-2	0.190	0.394	0.167	0.373	
N (household-years)	214		428		

Notes: Column 1 includes households with a Black financial respondent that were food insecure in a given wave. Column 2 includes households with a White financial respondent that were food insecure in a given wave. T-tests test for statistical differences in means between Black and White households. Dollar denominated variables are in 2016 constant dollars. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Appendix Table 4

First-stage results of Table 4, Linear probability regression models predicting food insecurity among Black and White older homeowners, Health and Retirement Study 2002-2018

	(1) New mortgage borrowing, t-1-t-2 Black Coeff. (SE)	p-value	(2) New mortgage borrowing, t-1-t-2 White Coeff. (SE)	p-value
Household characteristics				
Household income ($100,000), t-2	0.002 (0.028)	0.933	0.0003 (0.005)	0.960
Household income < 100% FPL, t-2	0.003 (0.011)	0.784	-0.006 (0.009)	0.479
Net financial assets ($100,000), t-2	0.0004 (0.016)	0.982	0.002 (0.003)	0.543
Net financial assets squared ($100,000), t-2	0.0001 (0.001)	0.941	-0.00002 (0.0001)	0.880
Net other assets ($100,000), t-2	0.001 (0.009)	0.894	0.0004 (0.001)	0.751
Net other debt (100,000), t-2	0.074 (0.069)	0.283	-0.013 (0.035)	0.715
Household size, t-2	0.008 (0.011)	0.453	-0.001 (0.008)	0.931
Metropolitan residence (0,1), t-2			0.022 (0.026)	0.399
9 Census regions, t-2	Yes		Yes	
Financial respondent characteristics				
Age, t-2	0.011 (0.024)	0.652	-0.032*** (0.009)	0.001
Age squared, t-2	0.0001 (0.0001)	0.367	0.0002*** (0.0001)	0.000
Separated, divorced, or widowed (0,1), t-2	-0.026 (0.037)	0.492	0.006 (0.010)	0.560
Never married (0,1), t-2	-0.023 (0.042)	0.578	0.095 (0.060)	0.113
Number of living children (0,1), t-2	-0.022 (0.017)	0.196	-0.001 (0.005)	0.804
Help with future needs (0,1), t-2	-0.030 (0.021)	0.163	0.001 (0.005)	0.765
Problems with ADLS, t-2	-0.012 (0.007)	0.086	-0.004 (0.005)	0.474
Macroeconomic conditions				
County unemployment rate, t-2	-0.006 (0.010)	0.587	-0.004 (0.002)	0.103
Change in county unemployment rate, t-1-t-2	-0.006 (0.007)	0.376	-0.003 (0.002)	0.095
7 year dummies (2006 to 2018)	Yes		Yes	
Instruments				
HPI percent change (cont.), t-1-t-2	-0.008 (0.015)	0.611	0.028*	0.035
Loan-to-value ratio ≥ 90% (0,1), t-2	-0.299** (0.108)	0.006	-0.214*** (0.045)	0.000
Constant	-1.080 (1.260)		1.309** (0.485)	
N (household-years)	2,307		17,506	

Note:

Cluster- and heteroscedasticity-robust standard errors in parentheses

Dollar denominated variables are adjusted for inflation to 2016 dollars

*** p<0.001, ** p<0.01, * p<0.05

Appendix Table 5
Characteristics of food insecure older homeowners only by location of residence (N=679), Health and Retirement Study 2002-2018

	(1) Metropolitan homeowners		(2) Non-metropolitan homeowners		
	Mean	(SD)	Mean	(SD)	t-test
Food insecure (0,1)	1	-	1	-	
Severe food insecurity (0,1)	0.408	0.492	0.402	0.492	
Housing characteristics					
Home value change ($100,000), t-1-t-2	-0.001	0.936	-0.086	0.561	
Home value ($100,000), t-2	1.843	1.616	1.176	1.113	***
Home equity change ($100,000), t-1-t-2	0.054	0.983	-0.040	0.548	
Home equity ($100,000), t-2	1.297	1.327	0.930	0.967	***
New mortgage borrowing (0,1), t-1-t-2	0.163	0.370	0.043	0.203	***
New mortgage borrowing ($100,000), t-1-t-2	0.076	0.331	0.015	0.124	***
Any mortgage debt (0,1), t-2	0.381	0.486	0.189	0.393	***
Mortgage debt balance among debtors ($100,000), t-2	0.786	0.805	0.365	0.316	***
Household characteristics					
Household income ($100,000), t-2	3.320	3.886	3.034	4.083	
Household income <100% FPL (0,1), t-2	0.208	0.406	0.213	0.411	
Net financial assets ($100,000), t-2	0.574	1.866	0.757	3.141	
Net other assets ($100,000), t-2	0.481	2.310	0.415	1.202	
Net other debts ($100,000), t-2	0.064	0.483	0.044	0.133	
Household size, t-2	2.282	1.352	2.006	1.048	**
Metropolitan residence (0,1), t-2	1.000	0.000	0.000	0.000	
Financial respondent characteristics					
Age, t-2	73.045	6.132	73.884	6.374	
Male (0,1) time invariant	0.309	0.462	0.280	0.451	
White (0,1) time invariant	0.647	0.478	0.579	0.495	
Black (0,1) time invariant	0.309	0.462	0.335	0.474	
Other (0,1) time invariant	0.045	0.207	0.085	0.280	
Hispanic (0,1) time invariant	0.146	0.353	0.067	0.251	**
Married or partnered (0,1), t-2	0.352	0.478	0.340	0.475	
Separated, divorced, or widowed (0,1), t-2	0.515	0.500	0.549	0.499	
Never married (0,1), t-2	0.033	0.179	0.024	0.155	
Number of living children, t-2	3.507	2.461	4.470	3.326	***
Immigrant (0,1) time invariant	0.146	0.353	0.031	0.173	***
Less than high school (0,1) time invariant	0.387	0.487	0.491	0.501	*
GED (0,1) time invariant	0.056	0.231	0.079	0.271	
High school diploma (0,1) time invariant	0.301	0.459	0.238	0.427	
Some college (0,1) time invariant	0.169	0.375	0.128	0.335	
College degree or more (0,1) time invariant	0.093	0.291	0.073	0.261	
Help with future needs (0,1), t-2	0.526	0.500	0.543	0.500	
Problems with ADLs, t-2	0.485	1.065	0.409	0.899	
Local macroeconomic conditions					
Change in county unemployment rate, t-1-t-2	0.246	2.374	0.175	2.115	
County unemployment rate, t-2	0.701	0.249	0.737	0.254	
Instruments					
FHFA HPI percent change (cont.), t-1-t-2	-0.008	0.179	-0.006	0.103	
Loan-to-value ratio ≥ 90% (0,1), t-2	0	0	0	0	
Debt-to-income ratio ≥ 20% (0,1), t-2	-0.02	0.208	0.085	0.280	***
N (household-years)	515		164		

Notes: Column 1 includes households residing in a metropolitan county that were food insecure in a given wave. Column 2 includes households residing in a non-metropolitan county that were food insecure in a given wave. T-tests test for statistical differences in means between Black and White households and between metropolitan and non-metropolitan households. Dollar denominated variables are in 2016 constant dollars. *** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$