Household Production, Home Improvement, and Housing Investment among Older Americans

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Abstract

We investigate the role of household production in the context of home improvement and investment decision of older Americans. To calculate the total value of home improvement, we apply a household production model where households can either purchase professional services or combine market goods with their time. We find that household production is a significant source of home investment. Failing to account for the value of time provided by household members greatly understates the total allocation of resources to home improvement. Consistent with standard household models, home production is a substitute for market-purchased services—labor supply is negatively related to the former and positively related to the latter.

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1 Introduction

Home equity accounts for a significant share of net household wealth (Eggleston et al., 2020), particularly for low- and middle-income Americans. One way that households can increase home equity is by improving the underlying asset, e.g., renovating a room or replacing aging infrastructure.[1,2] Conversely, equity may erode if such improvements fail to keep pace with physical depreciation. The importance of home improvement is reflected in the nearly $300billion spent by American households in 2017, approximately 1.5% of US GDP (Joint Center for Housing Studies, 2019).

In this article, we investigate how older Americans allocate their resources to home improvements using the Health and Retirement Survey (HRS), drawing on the household production framework introduced by Becker (1965). Because homeowners can make improvements by purchasing professional services or by combining their time with market goods, the latter which we refer to as *do-it-yourself* (DIY), the household production framework will more accurately capture the total investment in home improvement than previous studies that have only considered household expenditure patterns (Begley and Lambie-Hanson, 2015; Davidoff, 2006; Fisher and Williams, 2011; Gyourko and Tracy, 2006; Haughwout, Sutherland and Tracy, 2013).

Accounting for the value of time allocated to improvements is especially important for this group of homeowners as retirement significantly changes the marginal value of time. Indeed, studies of consumption and investment decisions that use expenditure in lieu of consumption can generate conclusions that are incomplete or even misleading. For example, the so-called *retirement-consumption puzzle* identified a decline in food expenditures in retirement (Hamermesh, 1984; Banks, Blundell and Tanner, 1998; Bernheim, Skinner and Weinberg, 2001; Hurd and Rohwedder,

1 Throughout this article, we will refer to any activity undertaken, either directly or indirectly, by a homeowner that alters the tangible physical attributes of a home, including its associated property, and would tend to increase the market value or prevent a decrease in the market value of the home as an *improvement*.

2 The increase in equity may not be greater than the cost of improvements and thus offer a negative net return on investment. Nevertheless, home improvements may be an optimal allocation of household resources once combined with the resulting consumption flow.

2008), a seeming contradiction to the Permanent Income Hypothesis. Subsequent work that approached the issue from the household production framework revealed that this puzzle was almost entirely illusory: households do smooth consumption by substituting away from goods-intensive production toward more time-intensive production methods after retirement. While expenditure falls at retirement, the increase in time allocated to shopping and meal preparation allows households to maintain their pre-retirement consumption levels (Aguiar and Hurst, 2005; Atalay, Barrett and Staneva, 2020; Been, Rohwedder and Hurd, 2020; Hurst, 2007; Schwerdt, 2005; Stancanelli and Van Soest, 2012; Velarde and Herrmann, 2014). To our knowledge, ours is the first study to examine whether similar reallocations of time and monetary resources occur with respect to home improvement.

Unlike food, the canonical non-durable commodity in studies of life-cycle spending, housing is durable. Thus, smoothing of investment or consumption may not be optimal over the life-cycle or even over the post-retirement period. Allocations of time and money to home improvement increase the consumption flow from housing both contemporaneously and in the future. Within a given time unit, retirement increases the opportunity to receive these flows as individuals spend more time at home. We would thus expect overall investment in home improvement to increase around retirement in anticipation of higher total consumption returns per period. On the other hand, as individual's age, the expected number of remaining future periods falls. This would tend to cause households to decrease their home improvement activities.

In addition, some of the activities that generate the largest consumption flows from housing may become less salient as households age. Fewer guests may spend the evening, reducing the utility of extra bedrooms or bathrooms. Dinner parties may be less frequent, reducing the utility of formal dining areas or contemporary kitchen appliances. These factors would also tend to reduce household allocations to home improvements, anticipating lower future consumption flows.

At the same time that the consumption flow from housing may be falling, the marginal productivity of time and money allocated to DIY likely also declines. Specifically, as individuals age, we expect deteriorating health to reduce the types of home improvement activities that individuals can undertake and the speed with which tasks are completed. This process would tend to decrease both the total value of home improvements, as well as the share of home improvement value accounted for by DIY.

Although existing studies find that retired households tend to spend $900-$1,400 per year less than working-age households on home improvements (Begley and Lambie-Hanson, 2015; Davidoff, 2006; Fisher and Williams, 2011; Gyourko and Tracy, 2006; Haughwout, Sutherland and Tracy, 2013), these estimates are incomplete for two reasons. First, a decrease in home improvement expenditure in retirement may be offset by increased time allocations. This would tend to ameliorate the fall in expenditure. If the converse is true and older households are allotting less time to housing maintenance while simultaneously reducing their expenditure, then the previous studies under report the true value of disinvestment in the house.

Second, conditional on reaching age 65, the modal retirement age for Americans, more than 50% of males will reach age 83. Among females who reach age 65, more than half will reach age 86 and more than a quarter will live past their 92nd birthday. Simple means between working-age and retirement-age populations may obscure important patterns within the age-profile of home improvement allocations among older American homeowners. Documenting how household allocations to home improvement activities evolve as households age controlling for the health status of household members is thus a second important contribution of the subsequent analysis.

There are three key results that we present in this manuscript. First, household production is as important as expenditure on professional services when it comes to home improvement. Failing to account for the value of household production will vastly understate the total value of home improvement. Second, home improvement allocations exhibit an inverted U-shape over the last third of the life-cycle, increasing before and just after retirement and then decreasing. The front-loading of home improvement is consistent with retirees anticipating that they will remain in their current residence throughout most of their retirement, which we discussed earlier. Third, household production and market-purchased services for home improvement are substitutes—as labor supply decreases households shift toward the former from the latter. Nevertheless, this appears to be secondary to income and health effects that generate a common inverted-U age profile in both.

2 Data

To examine the home improvement behavior of older Americans, we use the restricted-access geocoded data from the 2004 to 2014 waves of the Health and Retirement Study (HRS). Relative to other data sources, e.g., the American Housing Survey (AHS), the HRS offers several unique advantages for the current investigation.

First, the HRS is a longitudinal survey administered every two years since 1992 with a large, nationally representative sample of approximately 20,000 older households defined by their birth cohort.[3] It is therefore possible to study household resource allocations within a given housing unit as the members of the household age. In contrast, the AHS is a repeated cross-section.

Second, to fully account for the value of home improvements, it is necessary to have data on the allocation of both monetary and time resources within the household. As noted in Dunn (2015), there are few data sources that include both expenditure and time use for all members of a household. The HRS is a notable exception as a subsample of participating households are asked to complete the Consumption and Activities Mail Survey (CAMS) in off-years (the core HRS is administered in even-numbered years; the CAMS in odd-numbered years).

From 2005-2015, CAMS respondents are asked to report annual household expenditure on 1) *home improvement services* (HI-services) described as "home repairs and maintenance services: hiring costs including materials they provided" and 2) *do-it-yourself materials* (DIY-materials)

[3] The original target population for the HRS when the study was initiated in 1992 is adults born between 1931-1941 (designated 'HRS Cohort') and those born before 1924 (AHEAD cohort). Every six years the survey adds a new cohort starting in 1998 with those born between 1924-1930 (Children of the Depression) and 1942-1947 (War Babies Cohort). In 2004 those born between 1948-1953 (Early Baby Boomers Cohort) were added; and the last group added was in 2010 with the addition of those born between 1954-1959 (Mid-Baby Boomers Cohort). For more information on the HRS and its sample selection, see https://hrs.isr.umich.edu/publications/biblio/9047 (HRS Staff, 2008).

described as “home repairs and maintenance: materials your household bought directly.” We sum these values to define the total annual household *home improvement expenditure* (HI-expenditure).[4] In addition, each member of the household (not just the responding member) is asked to provide the number of hours each month engaged in “doing home improvements, including painting, redecorating, or making home repairs.” We sum responses over individual household members and scale by twelve to calculate the total annual household *home improvement time* (HI-time).

Third, the core HRS contains a rich set of demographic information about the household and its constituent members. Variables of particular importance include age, education, marital status, home ownership, house values, labor and non-labor income, assets, cognitive ability, and various measures of physical health.

Based on these measures, we are able to restrict our sample to households that continuously reside in an owner-occupied single-family residence that either 1) only include an opposite sex married couple in which the husband is at least 59 years old or 2) only includes an unmarried single female at least 59 years old. Although younger respondents appear in the HRS, there are too few ($N < 40$) at ages below 59 years to calculate meaningful age-specific statistics. [5] Similarly, there are too few single males to construct age-specific statistics. Age for married households refers to the age of the husband in all analyses.

To abstract from intrahousehold decision processes, married and single households that have other residents living in the household (e.g., children, grandchildren, etc.) are excluded from the sample. We also omit any households that move during their time in the HRS sample period—none of their observations ever enter the analytic sample. This mitigates the potential influence of home improvement activity designed to increase sale price prior to a move. Because older households

[4] The RAND FAT file of the main HRS survey also includes a variable for household spending on major home improvements. This variable does not separate purchases of professional services from materials and does not include routine maintenance. Thus, our preferred results use the expenditure variables from CAMS. Nonetheless, the age-profile of expenditure using the HRS variable is quantitatively similar.

[5] We do include households over age 55 when aggregated into larger age categories or if the measure is not age-dependent.

will have been in the HRS for longer and thus will have had more opportunities to move, however, this restriction does cause the age distribution to thin in the right tail. Finally, we drop household observations if they change structure, either through (re)marriage, divorce, or death. To the extent that these events are foreseeable, households may adjust home improvement allocations accordingly, These restriction do not have a large impact on the subsequent results because most retirees continue to live in their pre-retirement residence throughout the duration of their retirement, with annual transition rates between 1.7 to 9.1 percent (Feinstein and McFadden, 1989; Munnell et al., 2020; Venti and Wise, 1989, 1990, 2001, 2004) and many of these transitions occur following idiosyncratic negative shocks, such as the death of a spouse of divorce, rather than part of a long-term retirement management plan (Ai et al., 1990; Borsch-Supan, Hajivassiliou and Kotlikoff, 1992; Calvo, Haverstick and Zhivan, 2009; Fisher et al., 2007; Poterba, Venti and Wise, 2011; Venti and Wise, 1989, 1990, 2001, 2004).[6]

It is also important to note that house values in the HRS are self-reported. Bucks and Pence (2006) show that most homeowners report their house values reasonable accurately, but Benítez-Silva et al. (2015), Kiel and Zabel (1999), and Goodman Jr and Ittner (1992) show that homeowners over estimate the value of their homes by 5-10 percent. It is possible that individuals who engage in home improvement may tend to be overly optimistic about the subsequent the effect on home values.

We also investigate changes in home improvement in the years prior to and following retirement. While the HRS has a self-reported variable for retirement, "retirement" may mean different things to different households. For the purposes of this study, we define a household to be retired when the individual for single households and the husband for married households stop working (i.e., allocating zero hours to paid labor in all periods $t > T$), acknowledging the potential that household members could unretire in years after the end of our sample period.

Descriptive statistics of all the variables used in this analysis can be found in Table 1 and a

[6] Appendix C includes the descriptive statistics reported in Tables 1, 2, and 3 relaxing these restrictions. The relaxing of these restrictions does not drastically alter the results of this study.

detailed breakdown of all the variables used in this analysis can be found in Appendix A. All monetary values in the HRS and CAMS are reported in nominal dollars and have been converted into 2009 real dollars using the PCE chain-type price index from the Federal Reserve Economic Database.[7] Further, depending on the question, expenditure and time allocations in HRS and CAMS are reported over varying time frames (e.g., monthly, yearly, biyearly, etc.) and have been converted to annual values.

3 Graphical Analysis of Married Households

In this section, we examine home improvement allocations in an intuitive, graphical approach, treating each biennial CAMS wave as a representative sample drawn from the population of older adults in the United States. While intended as a purely descriptive analysis, as will be seen subsequently, the most important stylized facts continue to hold when we move to a regression framework.

The age profile of home improvement activities for married households in our sample are summarized in the six panels of Figure 1. We focus first on married households, as they account for approximately two-thirds of the sample, but will present results for single-female households subsequently.

3.1 Home Improvement Expenditure and Time Allocations

Annual household expenditure on DIY-materials and HI-services are plotted in panels A and B, respectively. The highly skewed nature of the data is immediately apparent. For both series, the mean often approaches or exceeds the 75th percentile. This is driven by two attributes: at any age, a large share of households have zero expenditure, while a small number of households have quite large expenditures. Yet, this pattern of skewness is similar to that seen for other durable goods:

[7] Downloaded from the Federal Reserve Economic Database (https://fred.stlouisfed.org/series/PCEPI) on 5/13/2017 (Bureau of Economic Analysis, 2017).

a probability mass at zero and long tails arises cross-sectionally because within households, large expenditures happen at intervals. Professional services might be hired because of an emergency or a household has saved for many years for a large project, but otherwise they go unused. For example, only 24% of households have zero expenditure on professional services in two consecutive waves, falling to 7% with zero expenditure in four consecutive waves. At the opposite end of the spending distribution, 12% of households have expenditure on professional services greater than $1,000 in two consecutive waves, but only 8% have expenditure greater than $1,000 in four consecutive waves.

In skewed data with high time-series persistence, the neighborhood around the cross-sectional mean describes a small probability mass. In contrast, when skew arises because of time aggregation, the use of the mean as a measure of central tendency in the population still provides meaningful content for a potentially large share of population. Specifically, one can interpret the mean as the amount a randomly selected household would have needed to set aside each year to cover realized home improvement expenditures. For this reason, we focus our remaining discussion on the properties of the cross-section mean across the age distribution.

Expenditures on HI-services and DIY-materials both exhibit three distinct segments: peak expenditure between ages 60 and 65, followed by a very gradual decline through the mid 70s, and thereafter falling more quickly. Looking at annual HI-expenditure (panel C), the three-year moving average peaks around $3,200 at age 63, plateaus at approximately $2,400 between ages 65 and 72, then steadily declines at a rate of $100 per year to age 82. These results are consistent with those reported by Bogdon (1996) and Davidoff (2006).

Annual HI-time (panel D) follows a similar pattern to expenditure, though with a more exaggerated inverted U-shape and peak allocations for both male and female members of the household occurring later. The mean total time allocation at age 65 is roughly 110 hours per year. For context, assuming individuals sleep 8 hours per day, this is approximately 3.8% of non-sleeping time. By age 80, however, time allocated to home improvement has fall by nearly half.

3.2 Value of Household Production of Home Improvement

Calculating the value of household production requires a means of combining two flow variables with fundamentally different units: time (measured in hours per year) and expenditure on DIY-materials (measured in dollars per year). We approach this problem two ways. First, we use the analogy of a job quote that allocates cost into two categories: "parts" and "labor." For example, a homeowner may get a quote for a new fence in the form: "wood plank costs \$$x$ per linear foot and we charge \$$z$ per linear foot for installation." When purchased from a contractor, these costs are reported together as professional services. If instead the owner engages in home production, we observe the cost of wood as DIY materials and the time allocated to installation as hours on home improvement. In the parts-and-labor approach, we require a dollar value of this time.

The shadow wage is one candidate, but identifying the value of time for older household members is difficult as the individuals who work in the formal labor market into their 70s and 80s are a highly selected sample. The median usual weekly earnings for a full-time worker reported from the CPS averaged over the four quarters of 2009 was $684, or approximately $19.54 per hour assuming a 35-hour full-time workweek.

An alternative we consider is calculating the value of homeowner time relative to purchasing market labor. The *Home Advisor's True Cost Guide* reports that the average cost of a repairperson is $77.[8] Bridgman (2016) estimates that labor in home production is approximately one-third as productive as market labor. Assuming this ratio holds for home maintenance implies a value of time of approximately $25 per hour.

Finally, we attempt to estimate the value of home production directly. Assume that the value of housing stock evolves according to the following:

$$v_{hy} = (1+\delta_h)v_{hy-1} + \alpha p_{hy} + f(d_{hy}, t_{hy}) \quad (1)$$

where h denotes the household (and house), y denotes year, v denotes home value, p denotes

[8] See https://www.homeadvisor.com/cost/handyman/#closing-article (visited 6/23/2020).

expenditure on home improvement services, d denotes expenditure on do-it-yourself materials, and t denotes home maintenance time. Depreciation in the underlying physical stock of housing and market-level fluctuations in home values are captured in the home-specific parameter δ.

We then specify the home production function, f, as a linear interaction of home improvement time and DIY materials, generating the following:

$$v_{hy} - v_{hy-1} = \alpha p_{hy} + \beta_1 d_{hy} + \beta_2 t_{hy} + \beta_3 d_{hy} t_{hy} + \delta v_{hy-1} \quad (2)$$

For our preferred analysis, we specify this relationship with the following estimating equation restricted to positive values of p_{hy}, d_{hy}, and t_{hy}:

$$v_{hy} - v_{hy-1} = \alpha p_{hy} + \beta_1 d_{hy} + \beta_2 t_{hy} + \beta_3 d_{hy} t_{hy} + \gamma_h + \tau_t + \varepsilon_{hy} \quad (3)$$

where γ_h is a household fixed-effect and τ_t is an annual linear trend. Because the auto-regressive component of the housing stock equation is not the primary concern of our study, we opt for a fixed-effects specification as a parsimonious but robust method to capture home-specific depreciation, while simultaneously controlling for time-invariant location, home, and homeowner attributes that are associated with changes in home values and the resource allocations of homeowners.[9] Using the estimated parameters reported in Appendix Table B1, we estimate the value of home production relative to market purchased maintenance as[10]:

[9] We did consider two alternative specifications: a linear lagged dependent variable without a household fixed-effect and an Arellano-Bond GMM estimator with a lagged dependent variable and a household fixed-effect. As expected, the former does not adequately capture time-invariant household attributes, resulting in unreasonably large values of household production. The latter estimator suffers from a weak instruments problem and performs poorly.

[10] While we acknowledge that some home improvement projects end disastrously [Are you familiar with the economist who began his project with "Let's assume the wall is not load-bearing"?], we impose a floor of zero for H and record negative predicted values as such.

$$H_{hy} = \frac{\hat{\beta}_1 d_{hy} + \hat{\beta}_2 t_{hy} + \hat{\beta}_3 d_{hy} t_{hy}}{\hat{\alpha}} \tag{4}$$

and the associated value of time as H_{hy}/t_{hy}.

Table 2 reports the mean values for home production and home improvement time calculated from each of three methods described above. Our results are robust with similar results using all three methods with our estimated values of time being $23.33 for married households and $21.77 for single households.

The age profile of the mean annual value of household production (Figure 1, Panel E) exhibits a distinctive inverted U-shape that is similar to HI-services expenditure with two notable differences. First, the value of household production peaks later: age 67 versus 63. Second, the rate of decline is much more pronounced, falling 50% from its peak to age 75, compared to a 25% decline for HI-services.

3.3 Summary

Two notable results emerge from the preceding analysis. First, homeowner time is a major component to home improvement in the United States. Panel A of Table 3 summarizes the annual HI-time and HI-expenditure allocations to home improvement by age-group for married households. It is clear that previous analyses that have focused solely on household expenditure fail to capture more than half of the total value of home improvement inputs that arise through home production. The second notable feature of the age profiles plotted in Figure 1 is the general tendency of these series to move together, particularly in households above age 70 who exhibit falling allocations of both time and money to home improvement activities.

Although the age profiles of expenditure on professional services and the value of household production generally move together, there is some evidence that households may substitute between them as they age. First, expenditure on HI-services peaks two years prior to the modal retirement age of 65, while the value of home production peaks two year after. This is consistent with individuals leaving the labor force and allocating households resources to home production activities. We investigate this mechanism in a subsequent section. Second, while expenditure on HI-services falls by 50% from its peak to age 84, the value of home production falls 75%. Assuming that worsening health makes home improvement activities more difficult, this is consistent with the predictions standard household productions models of substitution from the latter toward the former even as both are decreasing overall.

4 Variation across Household Types

4.1 Single Women

Figure 2 repeats the analysis for single-female households. There is a notable increase in mean expenditure on DIY-materials between ages 63 and 67 (panel A) with an accompanying increase in HI-time over those same ages (panel D). As a result, there is a significant spike in the value of household production of home improvement around age 65, followed by a long plateau until age 77, after which it declines through to age 84 (panel E). This is broadly consistent with increasing home production with an increase in available time around retirement.

In contrast, mean expenditure on professional services remains stable at approximately $1,000 per year until age 77 (panel B), after which it also declines. Indeed, it is noteworthy that 77 acts as somewhat of a watershed age for both married and single-female households in the sample with respect to home improvement activities. Panel B of Table 3 summarizes the annual HI-time and HI-expenditure allocations to home improvement by age-group for households of single women. As with married households, failing to capture the value of household production causes the value of home improvement to be understated.

4.2 Household Income, Housing Wealth, and Health Status

Mayer and Lee (1981) and Reschovsky and Newman (1991) suggest that declines in maintenance and the quality of retiree homes is due to declining incomes with age. Therefore, Figure B1 plots home improvement age profiles for married households by income quartile.

Many of the standard predictions of household production models are readily apparent in these panels. First, market goods and services are very clearly normal, though differences across the income distribution are more pronounced for HI-services (panel B) than DIY-materials (panel A). Second, the shadow cost of home improvement time should be positively related to income, and we indeed observe that before age 65 those in the highest quartile generally allocate less time to home improvement than households in lower quartiles (panel D). Up to age 68, households in the third quartile generate substantially greater home production value than households in the upper quartile (panel E).

Also noteworthy is that the inverted-U shape in home improvement activity is evident within each income band (panel F). The peak value of total home improvement occurs progressively later as household income increases, which could reflect later retirement ages for higher income households or longer conditional life expectancy: high-income workers tend to be in better health and thus fully retire at older ages (Bosworth, Burtless and Zhang, 2016; Gustman and Steinmeier, 2005, 2014). Nevertheless, income disparities in the annual value of home improvement decrease significantly after age 78, consistent with lower expected future consumption flows for all household types.

Given the correlation between income and housing wealth, it is unsurprising that the same patterns emerge when replacing the income distribution with the home value distribution (Figure B2).

Figure 3 reports age profiles, splitting the sample by health status. Reflecting the positive association of health with both marginal productivity and income, home improvement activity before age 72 is greater for those in good health and poor health. After that age, however, these groups behavior similarly in allocations of time and monetary resources.

5 Retirement

Retirement presents a discontinuous change in the marginal value of time and is a natural setting to test the importance of substitution between purchase of professional services and home production of home improvement. Because of the age of retirement varies across households (and members within households), these effects may be obscured when looking solely at age profiles. Therefore, Figure 4 plots time and monetary allocations in two-person married households in the years before and after the male earner works zero hours.

Assuming a discrete change in labor hours, standard household production models would predict a discrete increase in HI-time and a discrete decrease in expenditure on HI-services. There is some (highly) qualified support in these results. Expenditure on HI-services is relatively constant at $1,500 per year prior to reaching the labor supply threshold with a small, but still identifiable decreasing beginning in the subsequent year. HI-time follows a hump-shape with a peak spanning the year before and after the labor supply threshold, but this again lacks a discrete jump.

It is important to point-out that these rather modest allocation responses are observed regardless of the choice of labor supply threshold (we examined all thresholds between zero and twenty-five hours in five-hour intervals). One possible explanation for the lack of distinct allocation shifts is that a sufficient number of households gradually adjust their labor supply as they age so that at any particular threshold, the effect of large, discrete shifts are attenuated. In the next section, this possibility leads us to directly estimate the mean of time and expenditure allocations as a function of labor supply.

6 Regression Analysis

The preceding graphical analysis makes clear that home improvement activities undertaken by households vary with the time, monetary, and health resources available to homeowners. The observed fall in expenditure on HI-services and value of household production may simply reflect reduced income and/or deteriorating health associated with aging. We turn to regression analysis to further understand the relationship between home improvement and housing appreciation over the age-profile. We estimate a series of nonparametric local-linear regressions to better understand the relationship between age and home improvement; age and housing appreciation; and hours worked and home improvement. These regressions use the Epanechnikov kernel and control for household attributes that may influence decisions on time and expenditure on home improvement while avoiding assumptions about the shape of the age-profile. The optimal bandwidth fore each regression is determined using cross-validation as suggested by Li and Racine (2004).

6.1 Household Expenditure and Time Allocations

Our first set of regressions estimate the relationship between age and home improvement activities. These regressions take the following form:

$$Y_{it} = g(Age_{it}, X_{it}, \phi_i, \lambda_t) + \varepsilon_{it} \tag{5}$$

where Y_{it} denotes the measure of home improvement activity (HI-services, household production, and home improvement); X_{it} denotes household characteristics (home value, household income, non-housing wealth, urban location, and indicator for mobility); ϕ_i denotes a state fixed-effect; and λ_t denotes a year fixed-effect.

6.2 Retirement and Hours Worked

Applying the standard predictions of the household production model to home improvement, we would expect hours worked to vary positively with allocations to goods-intensive production and negatively with allocations to time-intensive production. Thus, as households decrease the number of hours worked, we should observe that HI-time increases, while expenditure on HI-services decreases. To test these predictions, we estimate a final set of nonparametric local-linear regressions that take the following form:

$$Y_{it} = g(LaborHours_{it}, Age_{it}, X_{it}, \phi_i, \lambda_t) + \varepsilon_{it} \quad (6)$$

where $LaborHours_{it}$ is the total number of hours worked for pay in the preceding week. For married households this is the sum over both members.

Labor supply is lumpy at round numbers and multiples of eight, while notably sparse at prime numbers: almost no one reports working 19 or 31 hours per week. The latter attribute can generate influential observations in the kernel density estimator that yield unreasonable spikes, including non-sensical negative values for hours and expenditure even when applying an optimal bandwidth algorithm. To overcome this issue, we first estimate the kernel density estimator applying the Li and Racine (2004) algorithm for the bandwidth. We then re-estimate scaling the optimal bandwidth parameter by a factor of $1+\lambda$, allowing λ to increase in increments of .01 until spikes that generate negative predicted values in all series disappear. This approach generates a bandwidth 11% greater than that suggested by the Li and Racine (2004).

6.3 Appreciation of House Values

Lastly, we expect that decreases in time and money spent on home improvement activities will negatvley impact the value of a house. However, Davidoff (2006) notes the difficulty in linking home maintenance directly to the value of housing as an investment vehicle because "painting a room... may add nothing to the resale value of one's home, but fixing a leaky pipe almost certainly enhances resale value." He suggests an alternative empirical approach that examines whether the homes of older owners appreciate more or less slowly than the homes of younger households. We therefore also estimate a second set of regressions to estimate the relationship between age and home appreciation which we will use to make non-causal inference on the relationship between home improvement and housing appreciation:

$$APPRECIATION_{it} = g(Age_{it}, X_{it}, \phi_i, \lambda_t) + \varepsilon_{it} \quad (7)$$

We use similar measures of appreciation as in Davidoff (2006) and Rodda and Patrabansh (2007): log differences and compounded annual growth rate (CAGR), which are defined as:

$$Log\ Differences = log\left(\frac{House\ Value_{t+1}}{House\ Value_t}\right) \tag{8}$$

$$CAGR = \left(\frac{House\ Value_{t+1}}{House\ Value_t}\right)^{\frac{1}{n}} - 1 \tag{9}$$

Since the HRS is administered biennially, $n = 2$ for this calculation.

Rodda and Patrabansh (2007) suggest that one possible explanation for older households reporting lower appreciation rates could be that older households simply lack the ability to process local housing market activity. We therefore include in the set of explanatory variables, X_{it}, a measure of cognition that is available in the HRS. We also estimate these regression separately by marital status and gender for single households.

7 Results

7.1 Home improvement

We present results from the nonparametric local-linear regressions of the mean function in two ways. First, we graph the estimated mean over the age-profile (Figure 5). Second, Table 5 reports the observed margins and contrasts for three age groups: 55-64, 65-74, and 75-84. The margins are the estimated mean annual value of the given measure of home improvement within each age range, while the contrasts capture the change between the starting and end points of each age range. The former allows us to determine whether allocations are higher or lower after the modal retirement age. The latter reveal whether allocations are increasing or decreasing.

Panel A of Figure 5 shows the estimated mean over the age-profile for married households. For expenditure on HI-services, the value of home production, and the total value of home improvement, the inverted U-shaped pattern is unmistakable. Panel A of Table 4 shows the observed margins and contrasts for married households. The mean of the annual total value of home improvement from ages 55-64 is $4,115, falling to $2,865 from ages 75-84. The mean of the total value of maintenance increases by $3,162 from ages 55 to 64 and decreases by $2,945 from ages 75 to 84. These results show that even when controlling for differences in household attributes that may influence the decision to engage in home improvement activities, the patterns are the same as those shown in Section 3 and that the total value of home improvement is more than double that of expenditure on HI-services, noting the importance of household production in home improvement for older Americans.

Panel B of Figure 5 and Panel B of Table 4 report analogous results for single women. The results are qualitatively similar to married households, though less precisely estimated at certain ages. There is an inverted U-shaped pattern for all three measures of home improvement for single women as with married households. Although allocations are smaller for single women than for married households, expenditure on HI-services accounts for only half of the total value of home improvement, indicating that the value of household production is important to consider for both household types.

7.2 Appreciation of House Values

Figure 6 plots the age-profile of annual home appreciation rates by household type for CAGR (in Panel A) and log differences (in Panel B). The trend in appreciation rates is similar for all household types. CAGR shows a positive growth rate in house values until around age 70 and log differences shows a positive growth rate until around age 63. Table 5 reports the observed margins and contrasts for house value appreciation. Annual appreciation rates generally fall throughout the age profile. Houses owned by married households appreciate between one and three percentage points less per year after age 75-84 compared to those under age 75. For single females, the appreciation rates fall even more dramatically: up to five percentage points less per year after age 75 compared to before age 75. Since house values in the HRS are self-reported and it is possible that households who engage in home improvement may be more optimistic about their house values, it is possible the the calculated appreciation rates overstate the true appreciation rate for some households. Nevertheless, the magnitude of our findings are similar to Davidoff (2006) and Rodda and Patrabansh (2007).

7.3 Labor Supply

Figure 7 Panel A plots home improvement allocations by hours worked controlling for differences in household attributes and age for married households and Figure 7 Panel B repeats the analysis for single women. These figures provide the strongest evidence supporting the predictions of the household production framework. HI-time is decreasing in hours worked with a clear break in the relationship at approximately 20 hours per week. This is mirrored by a positive relationship between hours worked and expenditure on HI-services. These findings suggest that HI-time and expenditure on HI-services are substitutes.

8 Conclusion

The preceding analysis established important new stylized facts about the housing investment decisions of older Americans. First, we have demonstrated that the value of household production is nearly as important as the purchase of professional services. Moreover, failing to account for the value of time in home improvement will vastly understate the total value of home improvement. Future work in this area must recognize the limitations of working with data that lacks information about both household monetary and time allocations to activities that increase the value of housing stock.

Second, the age-profile of home improvement exhibits a clear inverted U-shape. Allocations of time and monetary resources to home improvement peak between ages 64 and 68, decline slightly until approximately age 78, and then fall steeply in subsequent years. This is consistent with households frontloading home improvement in anticipation of spending most of their remaining years in their existing residence, a well-documented stylized fact (Binette and Vasold, 2018; American

Association of Retired Persons, 1996; Munnell, Soto and Aubry, 2007; Venti and Wise, 2004).

Third, home production and market-purchased services are substitutes: the former increases as labor supply falls, while the latter decreases. Nonetheless, substitution effects appear to be of secondary importance over the last quarter of the lifecycle, as all home improvement allocations exhibit the same inverted U-shape in the aggregate. We hypothesize that income and health effects are sufficiently strong to cause these to move broadly together. The consumption flows from home improvements are likely greatest during early retirement, when households have both a larger endowment of time and relatively good health to enjoy it. This leads to an overall increase in demand for home improvement, some purchased and some produced. As individuals age and health declines, the consumption flow from housing falls. Further, the expected number of years over which returns to new improvements would accrue also fall. These forces that depress the incentive for any home improvement are ultimately stronger than the substitution effect of worsening health forcing households to shift from home production to professional services.

These results clearly indicate that household allocations of time and monetary resource to home maintenance and improvement are economically meaningful and highly dynamic over the last third of the life-cycle. The determinants of the magnitude and timing of these allocations remain understudied and may be critical to understanding the patterns of consumption and investment we observe in older populations. In particular, future research incorporating household allocations to home improvement within a formal intertemporal household production framework may inform well-known "puzzles" in the life-cycle model, including the tendency for older households to remain in their home throughout retirement puzzle and to eschew financial instruments such as reverse mortgages that would allow them extract home equity, i.e., the housing equity puzzle.

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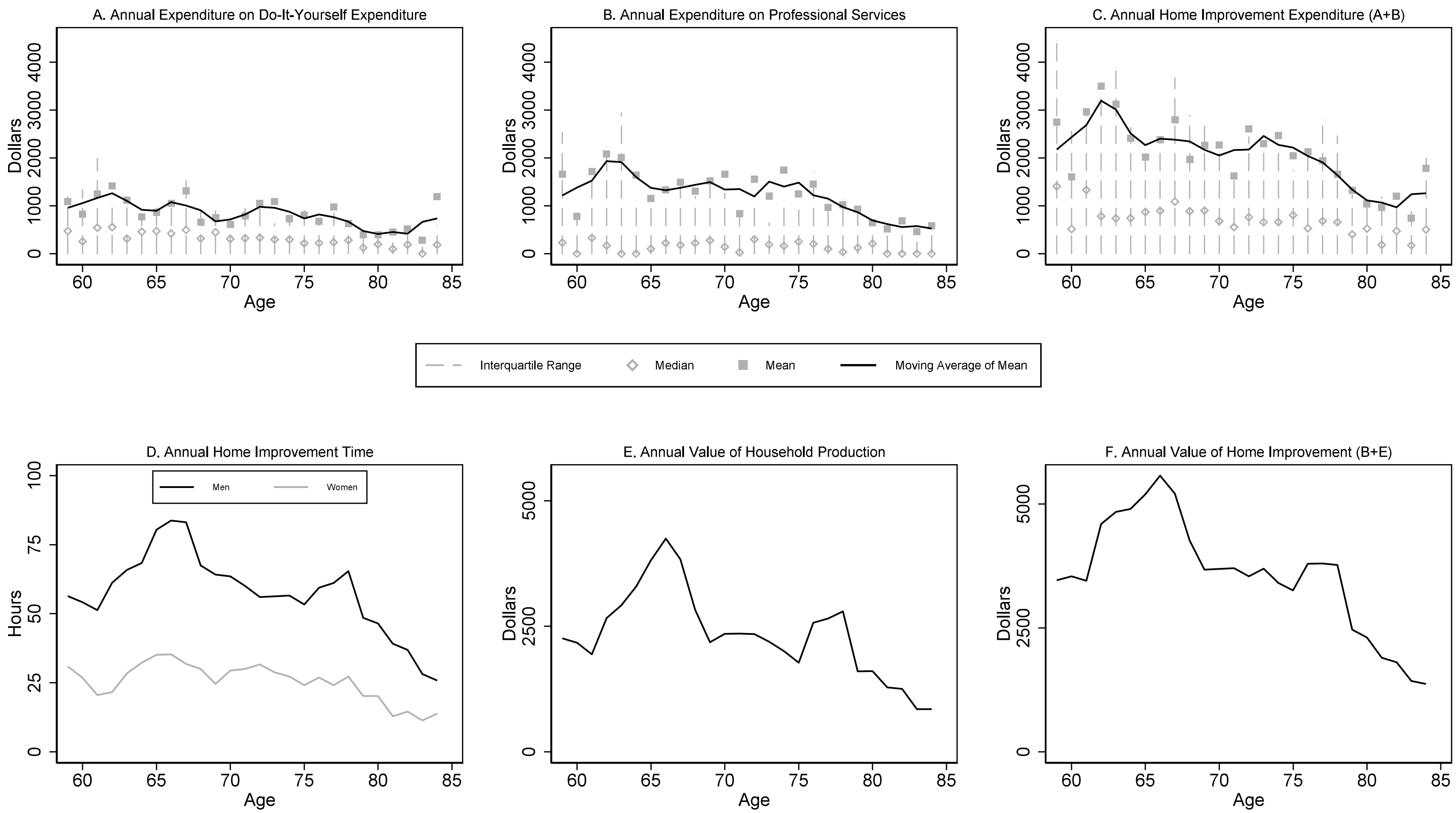
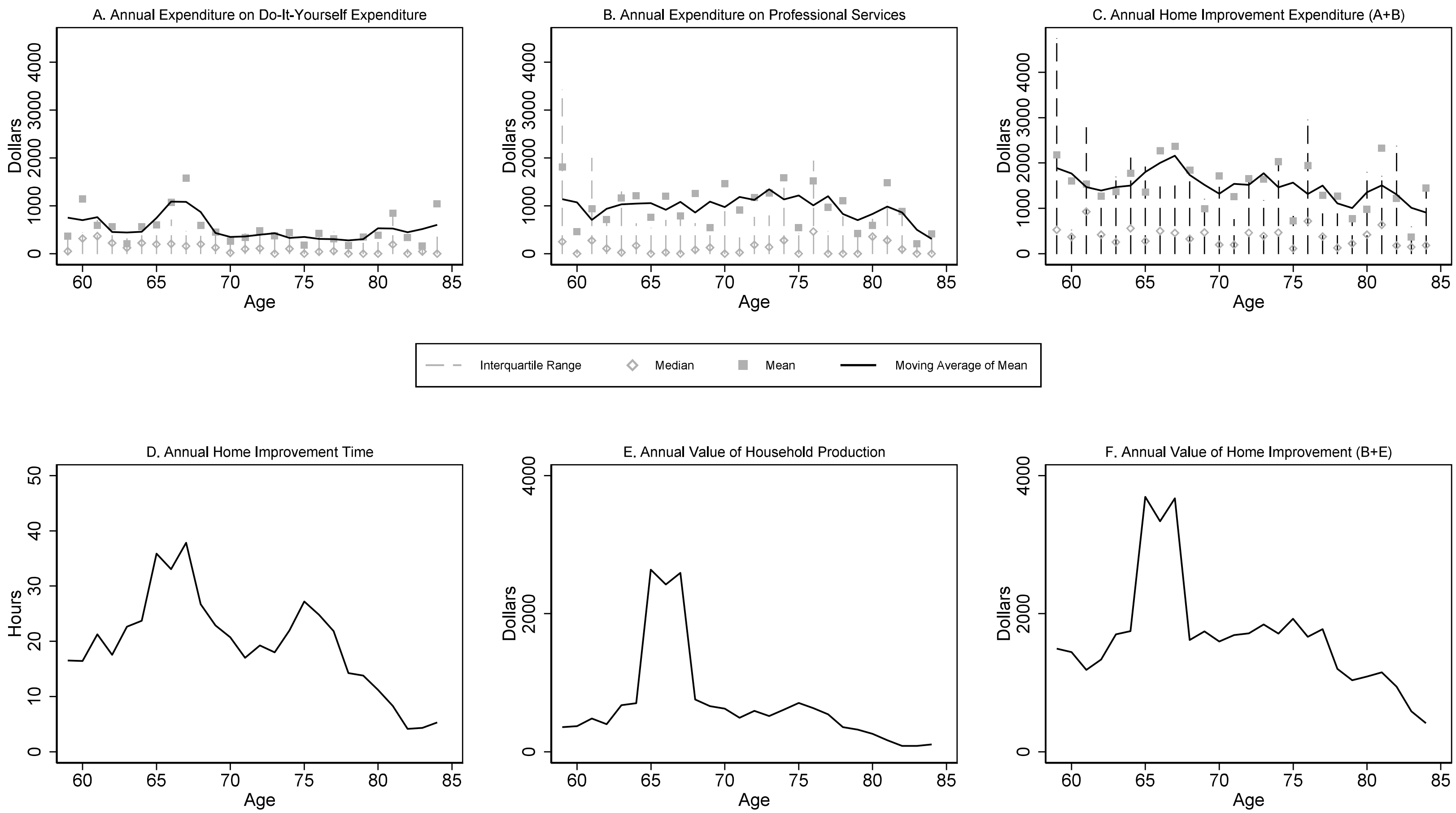
Figure 1: Age Profile of Home Improvement for Married Households



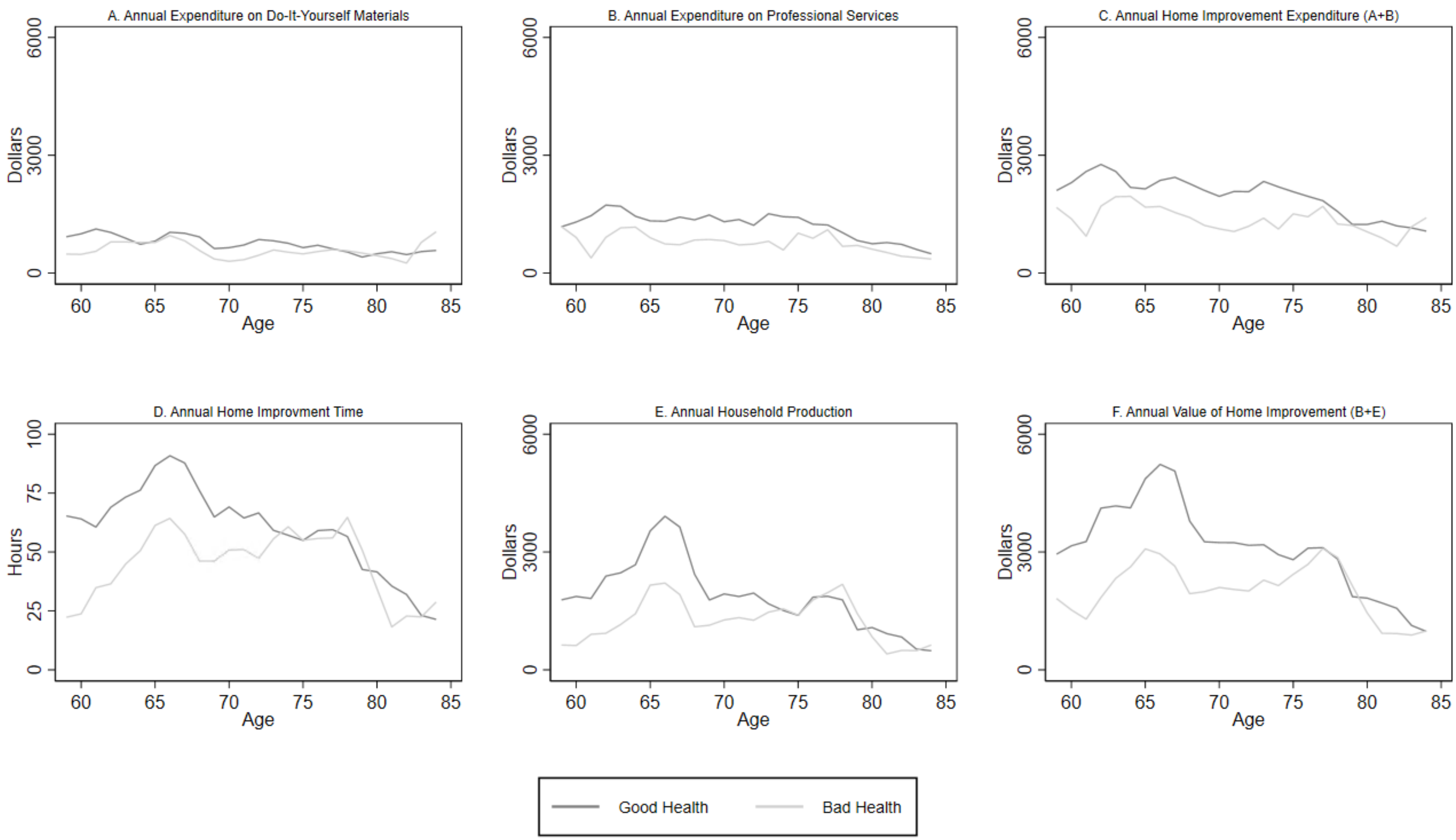
Notes: This figure shows the age-profile of annual expenditure on professional services, do-it-yourself materials, total maintenance expenditure, time spent on home improvement, annual value of home production, and annual value of home improvement for married households. The interquartile range the 25th to 75th percentile. Age is the age of the husband and is restricted to between 59–85 as there are few observations at each age level between ages 55–58 ($N < 40$)

Figure 2: Age Profile of Home Improvement for Single Women



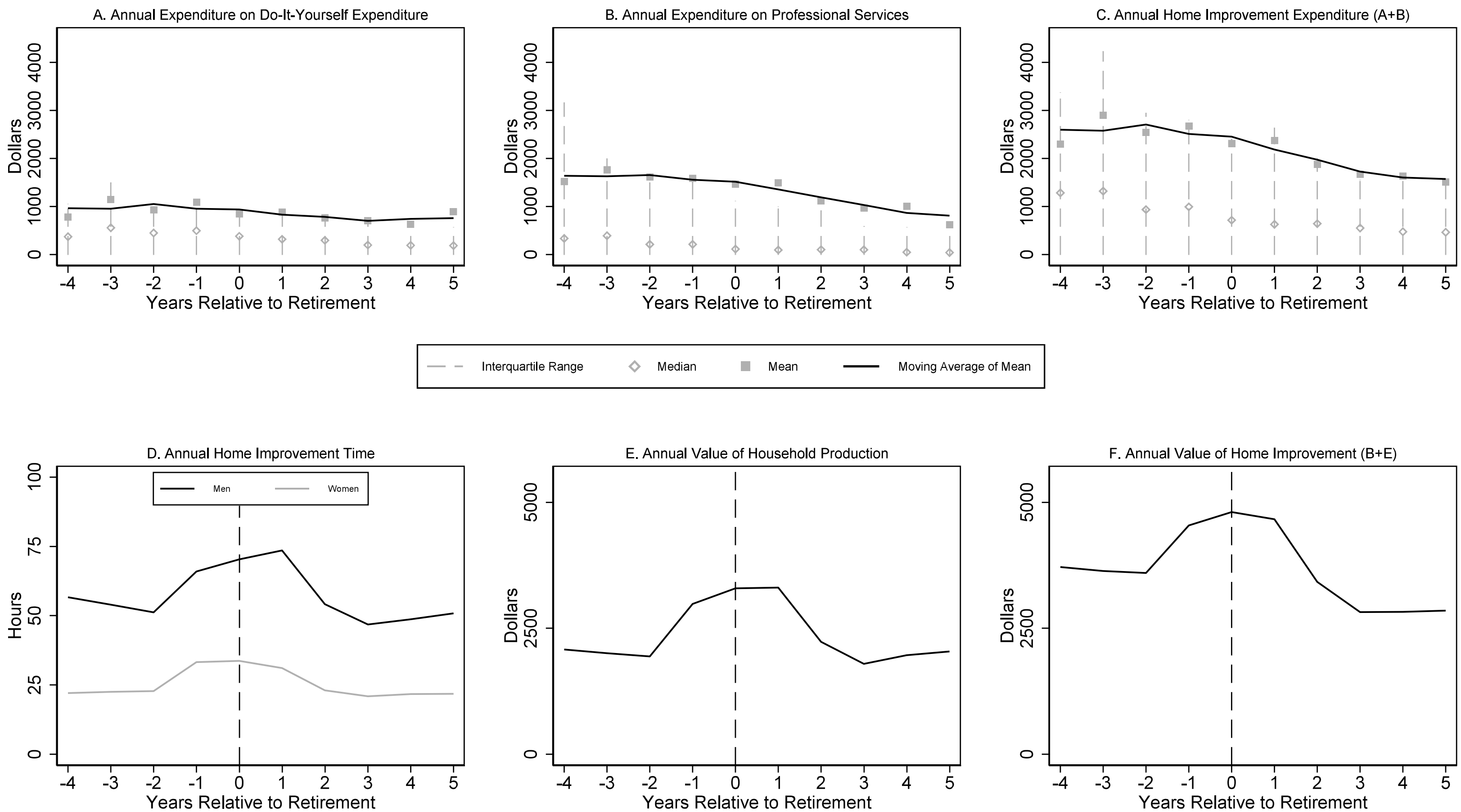
Notes: This figure shows the age-profile of annual expenditure on professional services, do-it-yourself materials, total maintenance expenditure, time spent on home improvement, annual value of home production, and annual value of home improvement for single women households. The interquartile range the 25th to 75th percentile. Age is restricted to between 59–85 as there are few observations at each age level between ages 55–58 ($N < 40$).

Figure 3: Age Profile of Home Improvement by Health Status



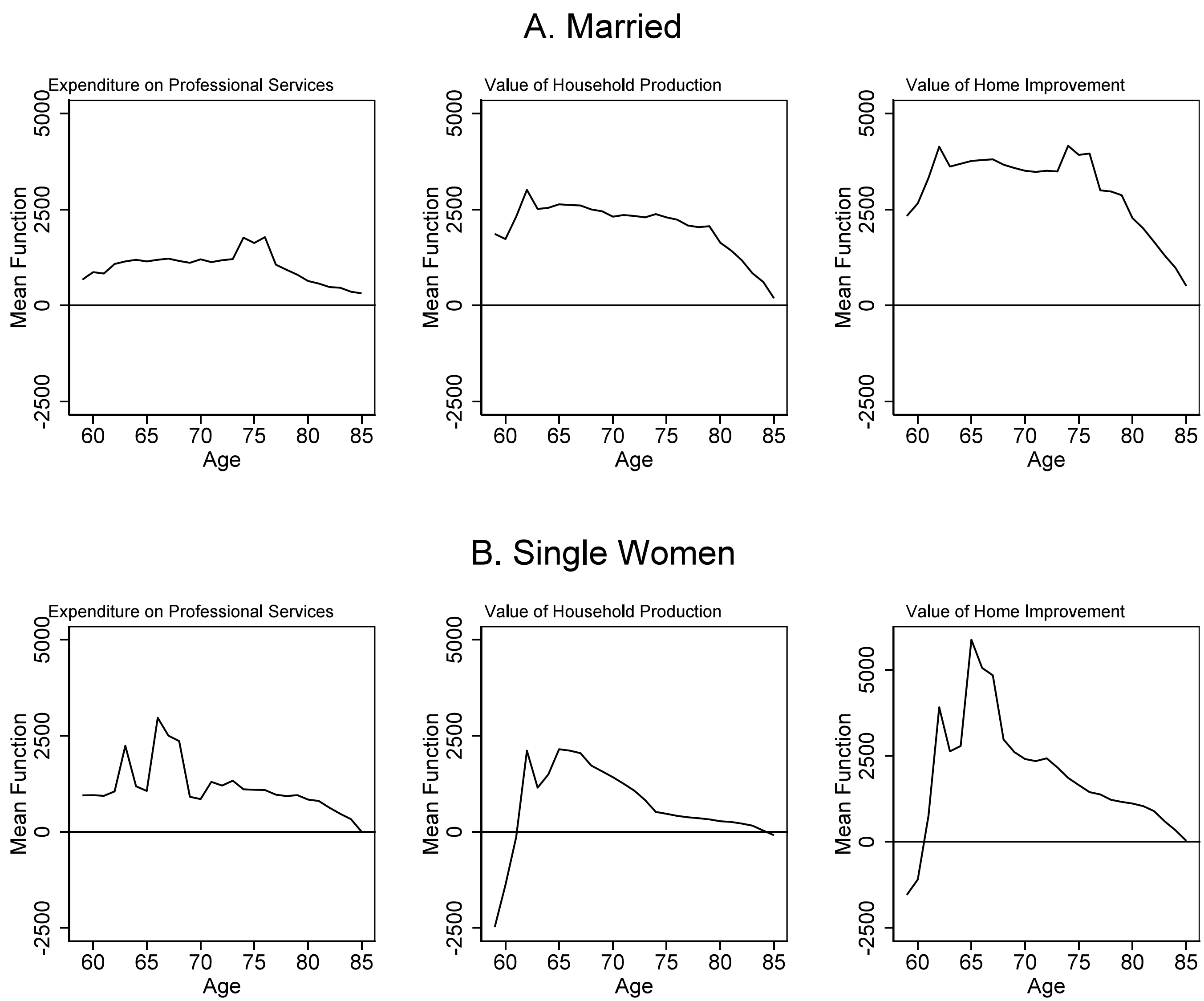
Notes: This figure shows the age-profile of annual expenditure on professional services, do-it-yourself materials, total maintenance expenditure, time spent on home improvement, annual value of home production, and annual value of home improvement by health status. Age is the age of the man in a married household and the age of the individual in a single household and is restricted to between 59–85 as there are few observations at each age level between ages 55–58 ($N < 40$).

Figure 4: Home Improvement for Married Households, Years Relative to Retirement



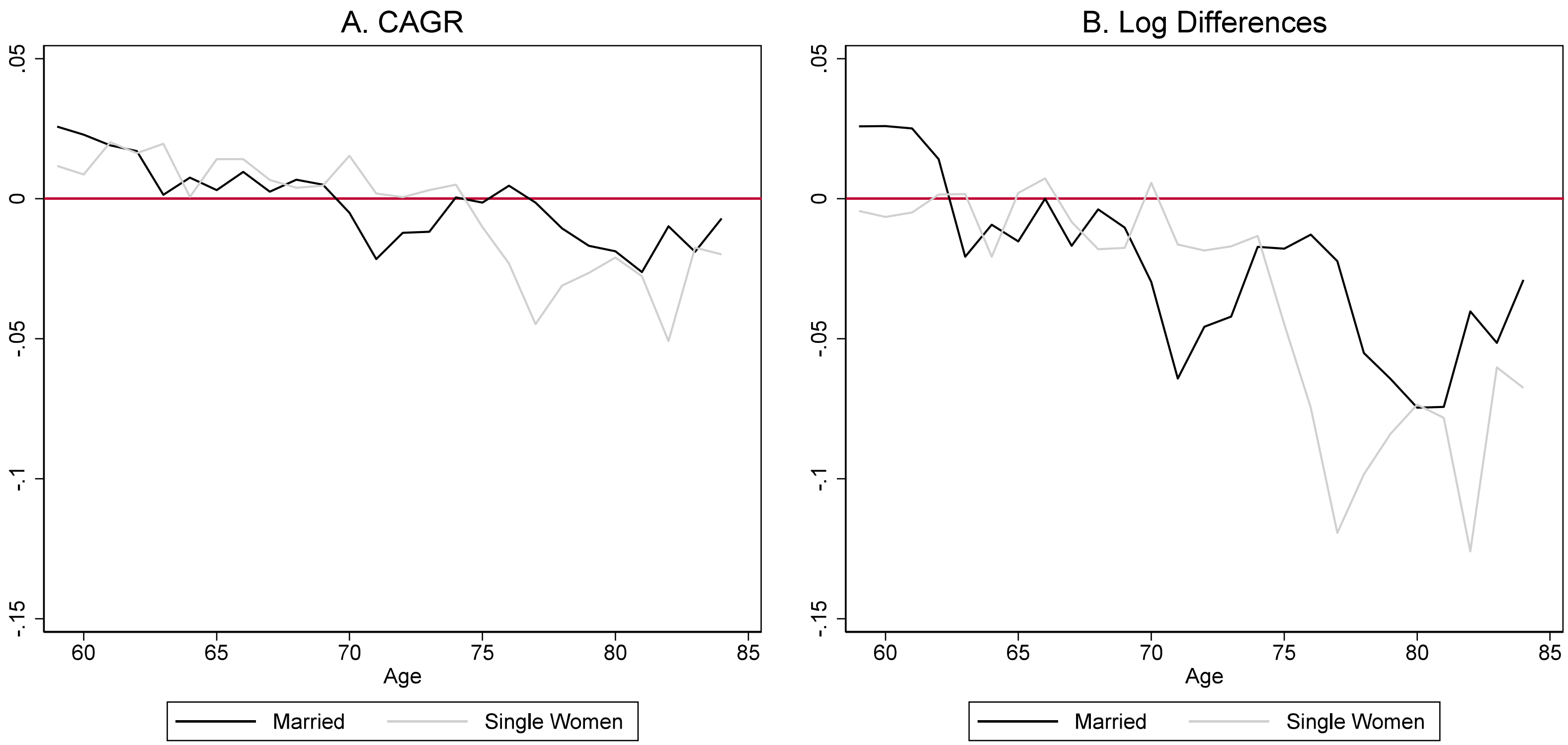
Notes: This figure shows the annual expenditure on professional services, do-it-yourself materials, total maintenance expenditure, time spent on home improvement, annual value of home production, and annual value of home improvement for married households in years relative to retirement. Retirement (year = 0) is defined as weekly hours worked equalling zero for the husband in married households and the individual in single households.

Figure 5: Kernel Regression of Home Improvement by Age



Notes: These graphs show the observed mean of the nonparametric local-linear regressions on the given measure of home improvement (expenditure on professional services, value of home production, and value of home improvement) over the age-profile. Controls include age, house value, income, non-housing wealth, mobility index, an indicator for urban status, a year fixed-effect, and a state-fixed effect. *N*: 1,797 (married professional services); 1,797 (married home production); 1,797 (married total value of maintenance); 791 (single women professional services); 779 (single women home production); 779 (single total value of maintenance).

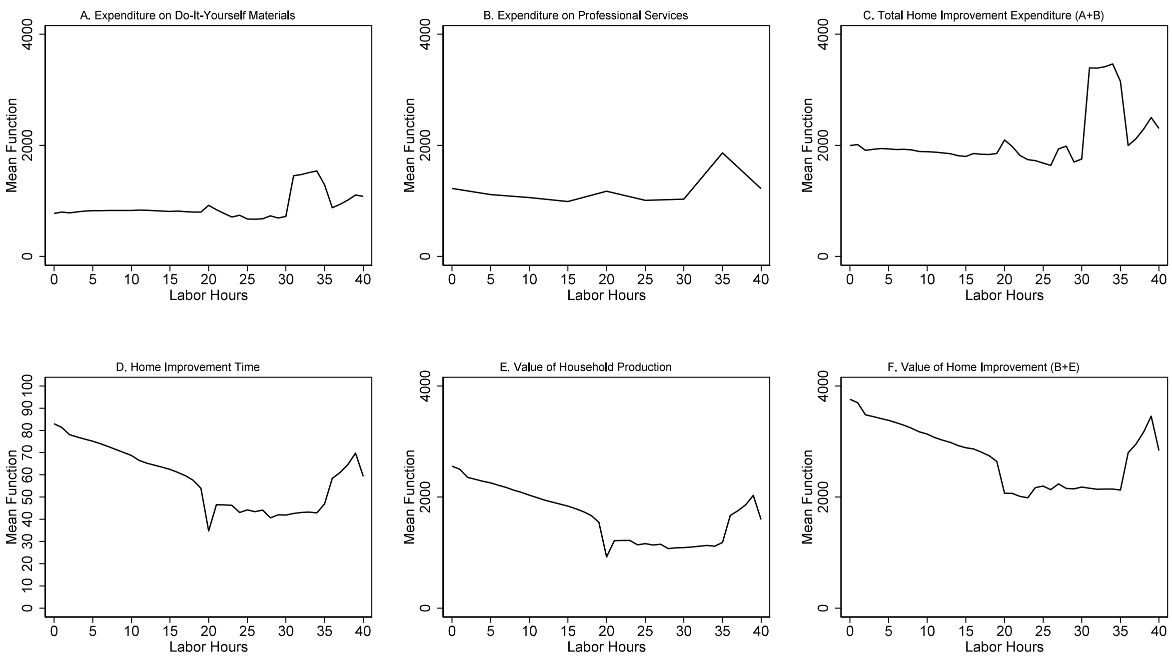
Figure 6: Annual Home Appreciation



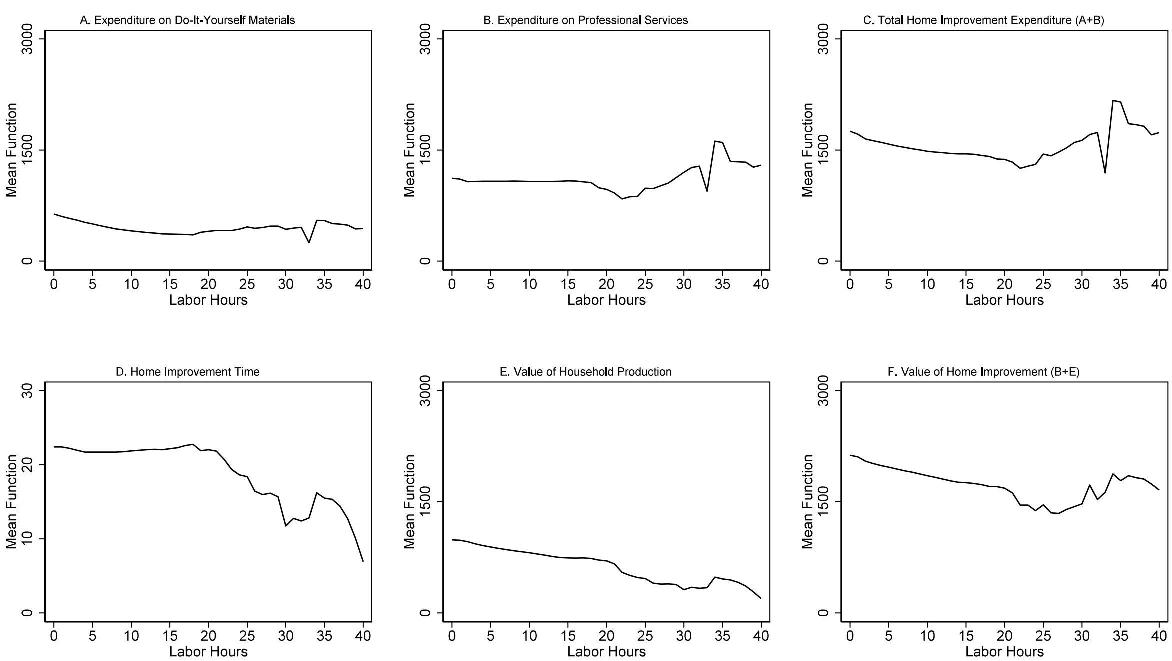
Notes: This figure shows the age profile for the annual house appreciation of house values using log differences and compound annual growth rate with a three-period moving average separated by marital status and gender for single households. Log difference = $\log(FutureValue/PresentValue)$. *CAGR* = compound annual growth rate = $(\frac{Future\ Value}{Present\ Value})^{\frac{1}{n}}-1$. N is the number of years and is equal to 2 since the HRS is a biennial survey. Age is the age of the man in a married household and the age of the individual in a single household and is restricted to between 59–85 as there are few observations at each age level between ages 55–58 ($N < 40$).

Figure 7: Kernel Regression of Value of Maintenance by Hours Worked

(a) Married Households



(b) Single Women



Notes: These graphs show the observed mean of the nonparametric local-linear regressions on the given measure of home improvement (expenditure on professional services, value of home production, and value of home improvement) based on labor hours for married and single women households. Controls include age, house value, income, non-housing wealth, mobility index, an indicator for urban status, a year fixed-effect, and a state-fixed effect. *N*: 1,804 for married and 808 for single women.

Table 1: Descriptive Statistics

	All		Married		Single		Single Men		Single Women	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Demographics										
Age	71.64	7.19	71.41	7.11	72.35	7.38	70.99	7.08	72.72	7.42
Male	0.43	0.49	0.49	.050	0.21	0.41	1.00	0.00		
Female	0.57	0.49	0.51	0.50	0.79	0.41			1.00	0.00
Married	0.76	0.42								
Urban	0.78	0.42	0.79	0.41	0.75	0.44	0.79	0.41	0.73	0.44
Good Mobility	0.90	0.31	0.91	0.29	0.85	0.36	0.90	0.30	0.83	0.37
Good Cognition	0.93	0.26	0.94	0.24	0.89	0.31	0.89	0.31	0.89	0.31
Good Health	0.80	.40	0.81	0.39	0.78	0.42	0.76	0.43	0.78	0.42
Wealth Measures										
House Value	$206,864	178,677	$217,838	180,645	$170,232	166,877	$211,467	230,788	$159,351	143,619
Income	$65,634	78,325	$75,019	84,211	$35,257	42,813	$46,492	59,161	$32,210	36,612
Non-Housing Wealth	$345,856	710,927	$390,212	783,857	$202,298	354,705	$304,029	473,247	$174,704	309,575
Home Improvement Expenditure										
Do-It-Yourself Materials	$764	1,757	$847	1,814	$497	1,525	$451	995	$509	1,640
Professional Services	$1,241	3,154	$1,326	3,346	$965	2,410	$852	2,200	$995	2,464
Total (DIY + Prof Services)	$2,005	3,865	$2,173	4,063	$1,462	3080	$1,303	2,491	$1,505	3,221
Time Spent on Home Improvement										
Men	58.16	122.69	59.43	81.02	39.94	90.15	39.94	90.15		
Women	25.10	78.83	26.43	81.02	19.83	69.30			19.83	69.30
Total	67.87	151.64	81.26	166.03	24.13	74.66	39.94	90.15	19.83	69.30
House Value Appreciation										
Compound Annual Growth Rate	-0.005	0.15	-0.004	0.15	-0.007	0.17	-0.013	0.18	-0.005	0.17
Log Differences	-0.031	0.30	-0.028	0.29	-0.04	0.33	-0.060	0.36	-0.036	0.32
Observations	4,944		3,777		1,167		249		918	

Table 2: Valuation of Home Production

	(1)		(2)		(3)	
	Married	**Single**	**Married**	**Single**	**Married**	**Single**
Household Production	$2,871	$1,135	$2,429	$997	$2,509	$844
	(4695)	(2720)	(3878)	(2383)	(7363)	(7241)
Value of Time	$25.00		$19.54		$23.22	$21.77
					(11.05)	(11.18)
Total Investment	$4,220	$2,095	$3,779	$1,957	$3,859	$1,803
	(6019)	(3971)	(5394)	(3712)	(8228)	(8024)
Observations	1,943	1,105	1,943	1,105	1,940	1,094

Notes: This table shows the value of home production, value of time, and total investment calculated using the following three methods outlined in section 3.3. Numbers in parenthesis are the standard deviation.
a) According to *Home Advisor's True Cost Guide*, https://www.homeadvisor.com/cost/handyman/#closing-article (6/23/2020), they average cost of a handyman is $77 per hour. In (1) we assume people are about $\frac{1}{3}$ as productive as a professional regardless of age or gender. Therefore, we assign the value of time to be $25 per hour.
b) In (2) we use the CPS hourly average for full-time workers in 2009, which is $19.54 per hour
c) In (3) we estimate the value of home production, H, from equation 4. We calculate Value of Time = home production / hours spent on maintenance for each household.

Table 3: Annual Households Improvement Expenditure by Age and Household Type

	Panel A: Married			Panel B: Single Women		
	55-64	**65-74**	**75-84**	**55-64**	**65-74**	**75-84**
Household Expenditure						
Professional	$1,913	$1,406	$932	$1,027	$1,124	$848
Services	(4716)	(3434)	(2103)	(2442)	(2809)	(2014)
Do-It-Yourself	$1,029	$919	$669	$502	$595	$400
Materials	(1745)	(1992)	(1576)	(1039)	(2032)	(1174)
Total Improvement	$2,942	$2,325	$1,601	$1,530	$1,718	$1,247
Expenditure	(5424)	(4172)	(2877)	(2751)	(3848)	(2423)
(Prof Services + DIY)						
Hours Spent on Home Improvement						
Men	61	68	49			
	(108)	(143)	(102)			
Women	27	30	22	22	25	15
	(75)	(92)	(66)	(51)	(91)	(40)
Value of Household Production						
Men	$2,749	$3,047	$1,992			
	(6544)	(8671)	(6323)			
Women	$2,661	$2,999	$1,926	$634	$1,128	$376
	(8491)	(9202)	(6574)	(1948)	(11294)	(1121)
Total Value of	$4,562	$4,359	$2,864	$1,662	$2,242	$1,229
Home Improvement	(8491)	(9202)	(6574)	(3202)	(12278)	(2383)
Observations	625	1,941	1,057	125	436	300

Notes: Age is the age of the man in a married household and the age of the individual in a single household. Home production is the estimated value, H, from equation 4 (method 3 from Table 2).

Table 4: Nonparametric Regression Margins and Contrasts: Value of Home Improvement

	Professional Services	**Household Production**	**Total Value of Improvement**
		Panel A: Married	
Observed Margin			
Age 55-64	1,575.3	2,531.9	4,115.1
	(244.04)	(532.41)	(651.78)
Age 65-74	1,392.2	2,695.5	4,101.0
	(106.67)	(210.58)	(257.05)
Age 75-84	911.9	1,945.4	2,865.5
	(97.02)	(374.30)	(386.12)
Observed Contrast			
Age 55-64	1,001.3	2,198.9	3,162.9
	(1,345.73)	(3,554.28)	(3,931.89)
Age 65-74	625.3	-251.8	395.6
	(168.28)	(1,043.83)	(1,316.30)
Age 75-84	-1,264.0	-1,681.2	-2,945.6
	(277.68)	(1,044.48)	(1,991,28)
Observations	791	779	779
R^2	0.55	0.50	0.51
		Panel B: Single Women	
Observed Margin			
Age 55-64	1,117.5	1,281.3	2,465.9
	(277.05)	(287.22)	(397.71)
Age 65-74	1,262.7	1,303.3	2,563.5
	(195.92)	(930.45)	(1,009.32)
Age 75-84	880.6	353.3	1,232.2
	(132.69)	(80.83)	(151.05)
Observed Contrast			
Age 55-64	740.2	2,216.6	3,325.8
	(5,884.40)	(1,461.53)	(3,204.51)
Age 65-74	43.2	-1,630.5	-4,011.8
	(261.33)	(1,502.31)	(1,614.43)
Age 75-84	-761.7	-434.8	-1,315.1
	(822.69)	(114.53)	(508.92)
Observations	791	779	779
R^2	0.62	0.51	0.49

Notes: The observed margins are the estimated mean annual value of the given measure of home improvement within each age range, while the contrasts capture the change between the starting and end points of each age range. The former allows us to determine whether allocations are higher or lower after the modal retirement age. The latter reveal whether allocations are increasing or decreasing. Standard errors are bootstrapped with 100 replications. Controls for all regressions include age, house value, income, non-housing wealth, mobility index, an indicator for urban status, a year fixed-effect, and a state-fixed effect.

Table 5: Nonparametric Margins and Contrasts: Housing Appreciation

	CAGR	**Log Differences**
	Panel A: Married	
Observed Margin		
Age 55-74	0.001	-0.018
	(0.00)	(0.01)
Age 75-84	-0.010	-0.040
	(0.01)	(0.01)
Observed Contrast		
Age 55-74	0.208	0.393
	(0.00)	(0.00)
Age 75-84	-0.036	-0.041
	(0.02)	(0.04)
Observations	1,361	1,361
$\mathbf{R}^2$	0.16	0.15
	Panel B: Single Women	
Observed Margin		
Age 55-74	0.007	-0.008
	(0.01)	(0.02)
Age 75-84	-0.014	-0.056
	(0.01)	(0.02)
Observed Contrast		
Age 55-74	0.000	0.000
	(0.00)	(0.00)
Age 75-84	0.008	0.018
	(0.03)	(0.06)
Observations	625	625
$\mathbf{R}^2$	0.25	0.24

Notes: The observed margins are the estimated mean annual value of the given measure of home appreciation within each age range, while the contrasts capture the change between the starting and end points of each age range. The former allows us to determine whether allocations are higher or lower after the modal retirement age. The latter reveal whether allocations are increasing or decreasing. Standard errors are bootstrapped with 100 replications. Controls include an indicator for cognitive ability, a year fixed-effect, and a state fixed-effect.

Appendix A: Description of the Variables

Variables from the HRS are taken from two sources. The first is the Enhanced FAT files compiled by the RAND Center for the Study of Aging, which compiles the raw data from the survey into one file for each wave making it easier to merge with other waves. The second is from the RAND HRS data file. Developed at RAND with funding from the National Institute on Aging and the Social Security Administration, it is a cleaned file containing HRS data from all waves of the survey (RAND HRS Data, 2016). RAND takes the raw responses from the HRS — in some cases, questions vary across waves — and combine them into a variable that is consistent across waves.

House Value

House Value comes from the RAND HRS file. Several changes were made to this variable by the authors. There are many instances where there were incredibly large percent changes in house value between waves. Upon visual inspection, much of this was caused by what appears to be input error from the respondent where zeros were left off. One example would be, if a respondent reported in 2000 a house value of \$350,000, then in 2002 a house value of \$400, and in 2004 a house value of \$450,000 – it is most likely the respondent meant \$400,000 in 2002. A second example would be, if a respondent reported in 2000 a house value of \$350,000, then in 2002 house value was missing, and in 2004 a house value of \$450,000 but reported owning a home but not moving in 2002. To find and correct as many of these possible errors as possible, we searched for house values where the ratio of $\frac{HV_t}{HV_{t-1}} > 1$ and manually inspected these values for irregularities these year over year for households that did not move. In cases such as the first example, the house value was adjusted by adding the appropriate number of zeros. In cases such as the second example, the median value between the surrounding years was imputed, so in the second example the house value for 2002 would be $\frac{450{,}000+350{,}000}{2} = \$400,000$. In cases where a value was reported but did not appear to have an apparent fix, the household was dropped. In the case where a house value of zero was reported in any wave, the household was also dropped. The households identifying numbers that were adjusted are available upon request.

Household Income

Household income comes from the RAND HRS file and is a sum of all the self-reported income to the household, which includes: individual earnings, capital income, pension income, annuity income, social security, other government transfers, and other household income.

Non-Housing Wealth

Non-Housing Wealth come from the RAND HRS file and is the sum of the self-reported values of real estate excluding the primary residence, vehicles, businesses, IRA accounts, stock value, checking accounts, checkable deposits, bonds, and other savings minus household debt.

Spending on Do-It-Yourself Materials

Spending on Do-It-Yourself Materials is a CAMS variable. Households that reported values over \$40,000 in a given year were dropped as many of these appeared to be errors in the survey response and were not reflective of the households typical spending patterns.

Spending on Professional Services

Spending on Professional Services is a CAMS variable. Households that reported values over $40,000 in a given year were dropped as many of these appeared to be errors in the survey response and were not reflective of the households typical spending patterns.

Time Spent on Home Improvement

Time Spent on Home Improvement is a CAMS variable.

Age

Age comes from the RAND HRS file. The household variable for age is determined by the age of the male in married households and the age of the individual in single households.

Marital Status

Marital Status comes from the RAND HRS file. This is a dummy variable takes a value of 1 if they report they are married and a value of 0 for any other marital status.

Gender

Gender comes from the RAND HRS file.

Good Mobility

Mobility comes from the RAND HRS file and is constructed from the variables RwMOBILA and SwMOBILA. The mobility index is a scale of 0-5. If the average for the household is less than 2 then the household is considered to have good mobility and this variable takes a value of 1, otherwise it takes a value of 0.

Good Cognition

Cognition comes from the Rand HRS file and is constructed from the variables RwCOGTOT and SwCOGTOT. The cognition score is from 0-35. If the average for the household is greater than 17 then the household is considered to have good cognition and this variable take a value of 1, otherwise it takes a value of 0.

Good Health

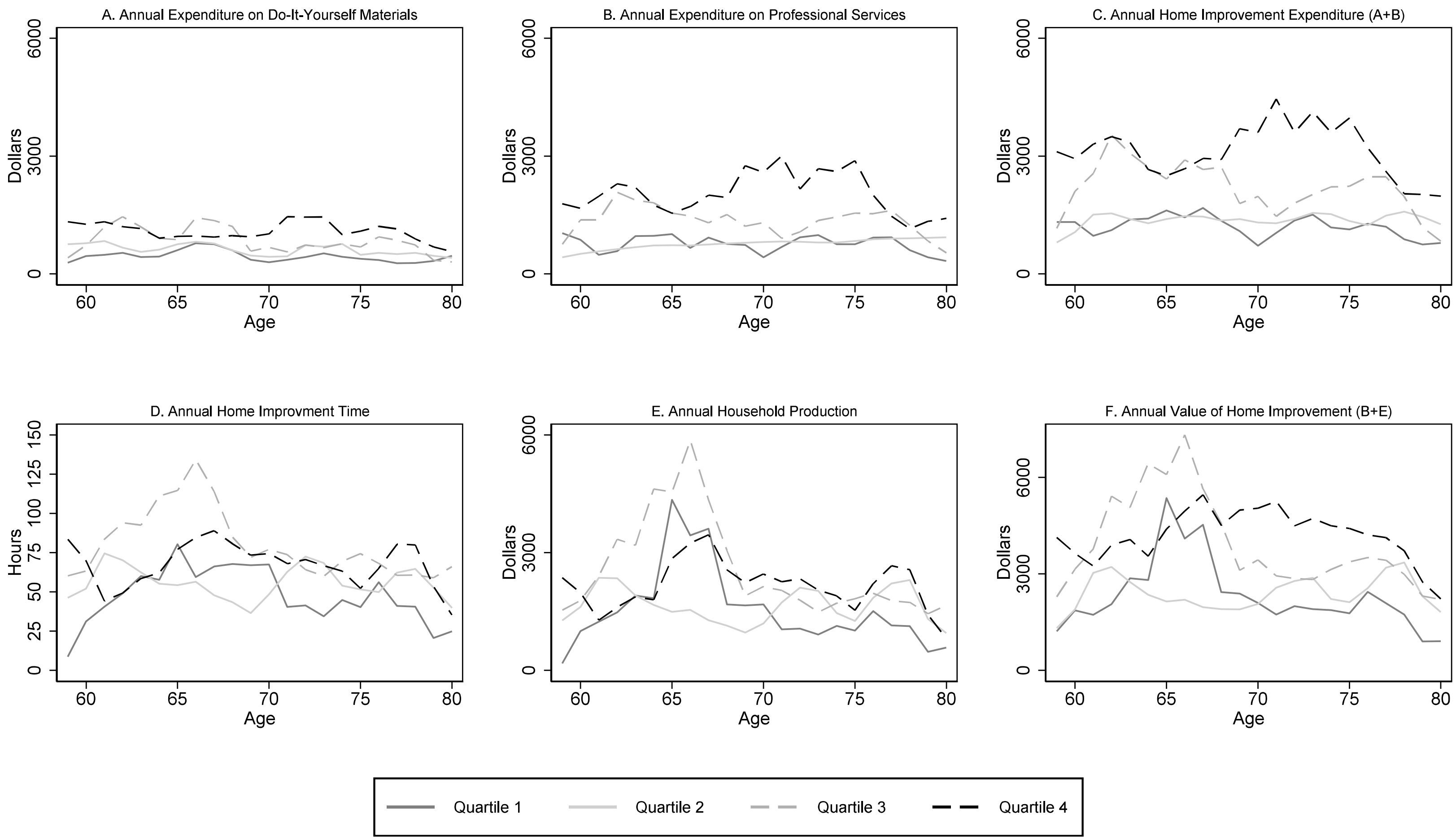
Health comes from the Rand HRS file and is constructed from the variables RwSHLT and SwSHLT on self reported health. The health score is from 1-5. If the average for the household is greater than 3 then the household is considered to have good good health and this variable take a value of 1, otherwise it takes a value of 0.

Labor Hours

Labor hours is a self-reported value that can be found in the CAMS file.

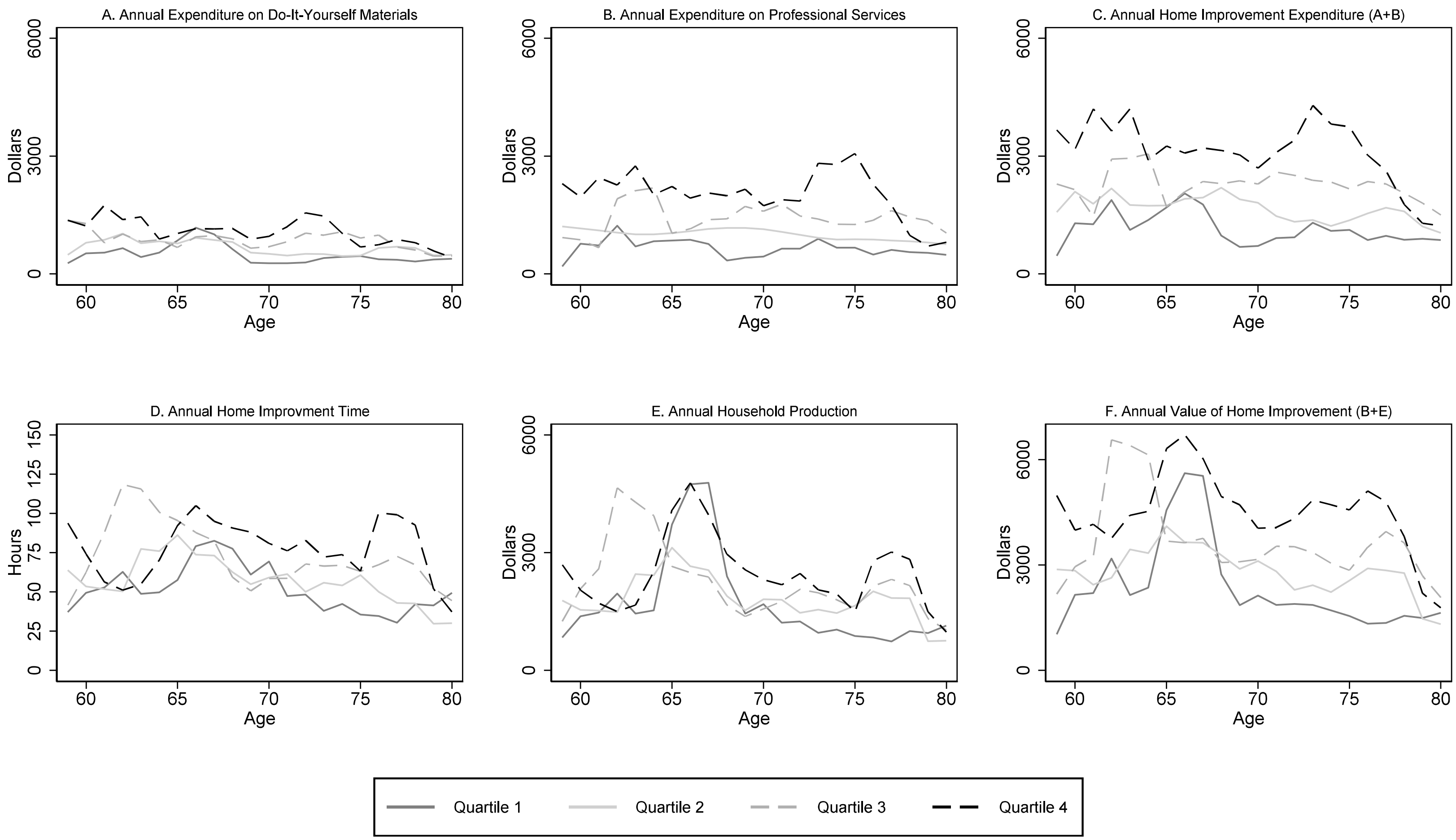
Appendix B: Additional Tables and Figures

Figure B1: Age Profile of Home Improvement by Income Quartile



Notes: Notes: This figure shows the age-profile of annual expenditure on professional services, do-it-yourself materials, total maintenance expenditure, time spent on home improvement, annual value of home production, and annual value of home improvement by income quartile. Age is restricted to between 59–80 as there are few observations at each age level between ages 55–58 ($N < 10$) and 81–84 ($N < 20$).

Figure B2: Age Profile of Home Improvement by House Value Quartile



Notes: This figure shows the age-profile of annual expenditure on professional services, do-it-yourself materials, total maintenance expenditure, time spent on home improvement, annual value of home production, and annual value of home improvement by house value quartile. Age is restricted to between 59–80 as there are few observations at each age level between ages 55–58 ($N < 10$) and 81–84 ($N < 20$).

Table B1: Regression Results for Estimating Home Production

Expenditure on Professional Services	1.146
	(1.57)
Expenditure on DIY Materials	-0.530
	(4.50)
Time Spent on Maintenance	24.93
	(48.99)
DIY x Time	0.01
	(0.01)
Trend	-1336.2
	(1405.40)
Observations	731
R^2	0.016

Notes: Regression output from equation 3 used to predict home production. Standard errors are clustered at the households level. Controls include a household fixed-effect.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Appendix C: Expanded Sample Tables and Figures

Table C1: Descriptive Statistics – Expanded Sample

	All		**Married**		**Single**		**Single Men**		**Single Women**	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Demographics										
Age	71.76	7.20	71.37	7.15	71.76	7.37	70.58	7.05	72.17	7.43
Male	0.44	0.50	0.49	.050	0.26	0.44	1.00	0.00		
Female	0.56	0.50	0.51	0.50	0.74	0.44			1.00	0.00
Married	0.78	0.42								
Urban	0.77	0.42	0.79	0.41	0.75	0.43	0.78	0.41	0.74	0.44
Good Mobility	0.89	0.32	0.90	0.30	0.84	0.37	0.88	0.33	0.82	0.38
Good Cognition	0.93	0.26	0.94	0.24	0.90	0.30	0.88	0.32	0.90	0.30
Good Health	0.80	.40	0.80	0.40	0.80	0.40	0.82	0.39	0.80	0.40
Wealth Measures										
House Value	$213,125	184,986	$222,348	187,640	$179,832	171,055	$209,421	214,637	$169,881	152,506
Income	$68,558	86,284	$75,340	84,896	$44,781	86,932	$61,821	120,564	$38,900	70,898
Non-Housing Wealth	$370,162	760,065	$404,094	819,825	$251,197	478,279	$40,435	551,684	$220,396	446,378
Home Improvement Expenditure										
Do-It-Yourself Materials	$797	1,905	$878	1,985	$515	1,559	$494	1,042	$522	1,701
Professional Services	$1,277	2,231	$1,343	3,302	$1,044	2,956	$494	1,042	$522	1,701
Total (DIY + Prof Services)	$2,074	4,009	$2,221	1,559	$3,612	1,538	$3,594	1,566	$3,620	3,114
Time Spent on Home Improvement										
Men	59.64	131.92	61.55	135.41	39.07	82.23	40.46	86.28	30.69	61.67
Women	25.33	77.07	26.97	80.01	18.24	62.37	11.03	23.39	18.53	63.45
Total	68.23	154.95	80.36	169.38	21.82	60.80	35.69	84.51	18.19	52.34
House Value Appreciation										
Compound Annual Growth Rate	-0.005	0.15	-0.004	0.15	-0.011	0.17	-0.017	0.19	-0.009	0.17
Log Differences	-0.034	0.30	-0.028	0.29	-0.053	0.36	-0.074	0.41	-0.046	0.34
Observations	5,637		4,386		1,251		321		930	

The expanded sample includes households until they move, get divorced, or suffer the death of a spouse and single households that have more than one person in addition to the original sample of households that never move and are either continuously married or single.

Table C2: Valuation of Home Production – Expanded Sample

	(1)		(2)		(3)	
	Married	**Single**	**Married**	**Single**	**Married**	**Single**
Household Production	\$2,916	\$1,167	\$2,480	\$1,207	\$2,509	\$844
	(4798)	(2688)	(4146)	(2374)	(7363)	(7241)
Value of Time	\$25.00		\$19.54		\$29.05	\$27.81
					(10.83)	(10.08)
Total Investment	\$4,289	\$2,172	\$3,851	\$2,032	\$4,276	\$1,958
	(6213)	(4225)	(5555)	(3993)	(8530)	(7155)
Observations	2,447	1,127	2,447	1,127	2,442	1,116

Notes: This table shows the value of home production, value of time, and total investment calculated using the following three methods outlined in section 3.3. Numbers in parenthesis are the standard deviation. The expanded sample includes households until they move, get divorced, or suffer the death of a spouse and single households that have more than one person in addition to the original sample of households that never move and are either continuously married or single.

a) According to *Home Advisor's True Cost Guide*, https://www.homeadvisor.com/cost/handyman/#closing-article (6/23/2020), they average cost of a handyman is \$77 per hour. In (1) we assume people are about $\frac{1}{3}$ as productive as a professional regardless of age or gender. Therefore, we assign the value of time to be \$25 per hour.

b) In (2) we use the CPS hourly average for full-time workers in 2009, which is \$19.54 per hour

c) In (3) we estimate the value of home production, H, from equation 4. We calculate Value of Time = home production / hours spent on maintenance for each household.

Table C3: Annual Households Improvement Expenditure by Age and Household Type – Expanded Sample

	Panel A: Married			Panel B: Single Women		
	55-64	**65-74**	**75-84**	**55-64**	**65-74**	**75-84**
Household Expenditure						
Professional	$1,900	$1,407	$982	$772	$1,275	$1,010
Services	(4598)	(3362)	(2173)	(2116)	(3613)	(2920)
Do-It-Yourself	$1,029	$950	$722	$590	$587	$388
Materials	(1744)	(2175)	(1857)	(1401)	(2002)	(1151)
Total Improvement	$2,928	$2,356	$1,705	$1,362	$1,862	$1,399
Expenditure	(5354)	(4202)	(3407)	(2649)	(4566)	(3261)
(Prof Services + DIY)						
Hours Spent on Home Improvement						
Men	61	70	51			
	(120)	(153)	(115)			
Women	28	31	22	20	22	14
	(75)	(91)	(64)	(48)	(79)	(40)
Value of Household Production						
Men	$3,077	$3,597	$2,394			
	(6899)	(9194)	(6379)			
Women	$2,849	$3,424	$2,247	$902	$1,067	$473
	(6448)	(8682)	(6161)	(2237)	(9045)	(1365)
Total Value of	$4,814	$4,837	$3,282	$1,674	$2,336	$1,492
Home Improvement	(8519)	(9518)	(6637)	(3142)	(10406)	(3268)
Observations	752	2,224	1,235	155	484	288

Notes: Age is the age of the man in a married household and the age of the individual in a single household. Home production is the estimated value, H, from equation 4 (method 3 from Table 2). The expanded sample includes households until they move, get divorced, or suffer the death of a spouse and single households that have more than one person in addition to the original sample of households that never move and are either continuously married or single.