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Abstract

This paper explores how earnings variability is related to retirement wealth. Past research has demonstrated that the average American household on the verge of retirement would need to save substantially more, in order to preserve consumption flows in old age. While several socioeconomic factors have been examined that might explain such problems, prior studies have not assessed the role of earnings variability over the lifetime as a potential explanation for poor retirement prospects. Thus two workers having identical levels of *average* lifetime earnings might have had very different patterns of earnings *variability* over their lifetimes. Such differences could translate into quite different retirement wealth outcomes. This paper evaluates the effect of earnings variability on retirement wealth using information supplied by respondents to the Health and Retirement Study (HRS). This is a rich and nationally representative dataset on Americans on the verge of retirement, with responses linked to administrative records from the Social Security Administration. Our research illuminates the key links between lifetime earnings variability and retirement wealth.

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I. Introduction

Recent work has demonstrated the essential value of investing in large and extensive household surveys containing detailed questions on housing, pensions, social security, and other financial wealth, in order to fully understand the determinants of retirement wellbeing. One of the best such sources of information is the Health and Retirement Study (HRS), which we use in this paper to assess the factors that appear to drive retirement wealth and retirement needs. Previous research demonstrated that the median American household on the verge of retirement in 1993 held about 2/5 of its retirement wealth in the form of social security promises, about 1/5 from employer pension promises, and the remainder is held in housing and other financial assets. Prior studies also indicated that the typical older household had not prepared for retirement adequately, in that substantial additional retirement saving would be needed to smooth old-age consumption. Some factors associated with greater retirement wealth including having committed to "automatic saving" mechanisms including company pensions and having to pay off a mortgage. The present paper extends the literature by focusing on the nexus between household retirement wealth and the variability of workers' lifetime earnings. In particular, we use the HRS linked with administrative earning records data supplied by the Social Security Administration to evaluate the links between lifetime earnings variability and retirement preparedness.

Our research is relevant to policy analysis for several reasons. First, potential pension or social security reform proposals could have very different impacts on retiree wellbeing, depending on how specific reforms link workers' earnings profiles to their retirement benefits. For this reason, it is useful to evaluate how earnings variability (EV) differs across people of various income levels and socioeconomic characteristics. Second, it is of interest to determine how earnings variability translates into pension and social security values in the real world. Third, we explore whether retirement wealth is more powerfully associated with earnings variability *per se*, holding constant other demographic, social, and economic characteristics of workers and their families, or

whether retirement wellbeing is particularly vulnerable to earnings fluctuations at particular points in the work-life cycle.

In what follows, we first briefly review prior studies regarding retirement wealth profiles for older Americans and describe the nature and scope of retirement saving. We then discuss alternative measures of lifetime earnings variability and describe what the data show. Last, we demonstrate how these EV measures are related to retirement wealth measures, holding constant other socioeconomic, health status, and preference factors in a multivariate statistical analysis.

II. Prior Studies

In previous research, we have used the nationally representative Health and Retirement Study linked to administrative records on earnings to explore how patterns of retirement wellbeing are associated with differences in the length of worklife and pay levels.[1] The initial HRS cohort was first interviewed in 1992, when it was on the verge of retirement – age 51-61 (also, spouses of any age were also interviewed). Moore and Mitchell (1998) and Mitchell and Moore (2000) modeled and measured important saving shortfalls for this cohort. For instance, we found that the median older household would need to save 16% more annual income each year, if it were to maintain consumption levels after retirement at age 62. The targeted saving shortfall declined by half, to 8% of annual income, if the retirement age target were boosted to age 65.

Follow-on research by Mitchell, Moore and Phillips (MMP, 2000) evaluated several factors associated with retirement saving, and it demonstrated that several factors played a role. These included respondents' and spouses' educational attainment, lifetime earnings, marital and children status, and ethnicity. Overall, socioeconomic variables accounted for a substantial portion of the saving deficits for retirement. In addition, health and preference proxies also accounted for 20-25% of explained variance, and in particular, households having longer financial planning horizons were likely to be closer to saving targets. Various other factors, including depression, memory problems, and earlier-than-predicted mortality, did not appear to be strongly associated with saving shortfalls. Finally, the analysis indicated that understanding married couples'

[1] See for example, Levine et al., 2000a and b, 2002; Mitchell and Moore, 1998; Mitchell, Moore and Phillips, 2000; and Moore and Mitchell, 2000.

preparedness for retirement requires one to take into account both spouses' economic, health, and preferences. For married households, spousal effects accounted for about one-half of the explained variance in saving shortfall patterns.

Subsequent analysis by Levine, Mitchell and Phillips (LMP, 2000a and b, 2002) examined how married women's earnings contributed to HRS household wellbeing in retirement. We examined whether women were eligible for Social Security benefits on their own account, and among the eligible, how much higher women's wages would have had to have been for them to collect benefits based on their own work records, rather than their spouses'. That research showed that wives ineligible for benefits would have to work substantially more before becoming eligible, but among the eligible, just a modest increase in pay would enable them to receive higher benefits based on their own work records rather than as a spouse. These findings are of interest since they indicate that more market work by women would yield only small gains in Social Security benefit receipt for married women under current program rules, though their higher earnings would eventually enhance household retirement benefits.

One key issue left unexamined in prior research is whether the timing and variability of workers' lifetime earnings patterns are powerfully related to retirement asset accumulation. In the present project, therefore, we explore how aspects of lifetime earnings variability influence retirement wealth levels.[2] The outcomes of special interest include total retirement assets as well as the primary components of retirement wealth, including Social Security, pension, and other wealth.

III. Research Design and Methods:

The HRS, along with its companion employer pension and Social Security earnings and benefits records, afford a unique opportunity to analyze the influence of lifetime earnings variability on retirement and wealth. In addition to containing rich health and demographic information, the linked HRS datafile provides a comprehensive picture of workers' lifetime earnings patterns. These are obtained from Social Security Administration records of workers' taxable earnings from 1950 to 1991, provided with respondent consent. We use these lifetime earnings records to generate measures of

[2] Our future work will evaluate shortfall measures in greater depth.

lifetime earnings variability for sample respondents and spouses, and then link these to the MMP datafile to examine retirement wealth and saving shortfalls.

The variables used in analysis include measures of workers' earnings variability and lifetime retirement wealth. Here we describe the earnings variability measures we derive, since the retirement wealth measures we have developed are described in previous research (LMP2000a, 2002; see also Appendix I).

The earnings level measures we create using linked administrative records for HRS respondents appear in Panel I of Table 1. These earnings records are available from 1950 to 1991 for all respondents who consented to the research match, and for whom records could be found. As is described in Mitchell, Olson, and Steinmeier (2000), a match was feasible for approximately 75% of the respondents.[3] In our sample, lifetime average real annual earnings amounted to about $15,000 as of 1992, and Average Indexed Monthly Earnings (AIME) computed using Social Security formulas totaled $1,300 per month (all dollar figures are given in 1992 terms).

→ *Table 1 here*

Under the agreement with the HRS project, Social Security Administration provided annual earnings records for this cohort of respondents. For 1950 to 1991, earnings up to the Social Security tax ceiling are available. From 1981 to 1991, what is known as "W-2" earnings are reported, which includes amounts earned above the tax ceiling. In this paper, we use the higher of the two values for years we have both reports. Figure 1 indicates how often annual earnings attained the tax cap, with the average for women standing at 2% between ages 20 and 50, as well as for each decade of life (i.e. 20-29, 30-39, and 40-49). More men tended to earn at the taxable cap, with the proportion at

[3] Because of the confidential nature of the administrative data, researchers may access them only under restricted conditions; see www.umich.edu/~hrswww for details. These files were obtained for a majority of HRS respondents, namely those providing permission to link their survey data with administrative records supplied by the Social Security Administration and also with pension plan descriptions provided by respondents' employers. In a few cases Social Security benefits could not be calculated so the respondent had to be omitted from the analysis. One reason for missing Social Security benefits was that respondents gave permission for the University of Michigan to request their Social Security records, but no match was obtained because their records did not match SSA identification information. Also some age-eligible respondents declined to sign the release form permitting their Social Security data to be matched with the HRS (a handful of the very wealthy, some Blacks, and some Hispanics did not provide consent). Omission of nonmatch cases might bias results if those who had a matched file differ from those lacking a match; however our own exploratory analysis as well as analysis by others suggests little evidence that results are biased.

the cap attaining 27% in their twenties, 49% in their thirties, and 30% in their forties. Future research will explore alternative statistical techniques to handle censoring of this sort, though we note here that earnings are less likely to be capped during the latter portion of workers' careers (see Appendix II for further discussion of the statistical issues raised here).

→*Figure 1 here*

One approach to measuring lifetime earnings variability uses the coefficient of variation, or the standard deviation of a worker's earnings divided by his average earnings. For this paper we use taxable or W-2 earnings and compute COEFVAR for the entire period between the worker's 20^{th} and 50^{th} birthdays; this we call lifetime COEFVAR. In addition we also compute the coefficient of variation over each decade of the worker's life, or when he was in his 20's, 30's, and 40's, respectively (COEFVAR20, 30 and 40). These three decadal EV measures help explore whether earnings variability fluctuates over the lifetime or whether it changes in some systematic way.

To use only COEFVAR, however, would imply that earnings variability matters symmetrically: that is, that an earnings drop or an increase of the same size would have the same effect on key outcomes of interest. We test whether the symmetry hypothesis is inappropriate by also devising an asymmetric EV measure which focuses only on *earnings declines*. We call this the "expected hit" to earnings (EXPIT), which allows us to determine whether earnings drops have a more negative effect on retirement wellbeing than do fluctuations *per se*. Lifetime EXPHIT captures the expected size of a real wage loss in the event that it occurs over the worker's lifetime, computed by multiplying the probability that he or she experienced a real wage loss by the size of the loss. In this sense it is a shortfall measure akin to those used in insurance and risk analysis. Decadal measures EXPHIT20, 30, and 40, are also derived, measuring, respectively, the conditional expected earnings drops when the worker was in his or her 20's, 30's, and 40's.

Panels II and III of Table 1 provide descriptive statistics on these EV measures. Focusing first on the symmetric EV metric, it is interesting that lifetime COEFVAR has an average value of greater than 1. However the coefficient of variation tends to be large for younger workers and one-third smaller during the decade of the 40's. Thus

COEFVAR falls at older ages. Turning to the asymmetric measure, the expected size of the earnings loss conditional on an earnings drop (EXPHIT) averaged about 16% of lifetime earnings overall. Here, in contrast to the other measure, the results do not vary much by decade of life. Thus the earnings loss conditional on an earnings drop (EXPHIT) exhibits no clear age pattern.

Panel IV of Table 1 offers a correlation matrix of the key EV measures used in the paper, and it indicates substantial correlation both by decade and over the lifetime. As a set, however, the EXPHIT measures are less correlated among themselves than are the symmetric COEFVAR measures. Panel V demonstrates that both the COEFVAR and the EXPHIT measure also differ by lifetime earnings levels, as proxied by the quintile of the employee's Average Indexed Monthly Earnings (AIME).[4] In the case of the symmetric measure, COEFVAR, it is clear that earnings volatility follows a pattern: people in lower lifetime earnings quintiles have the highest lifetime earnings variability. The pattern remains but is attenuated for the asymmetric measure. In the analysis of retirement wealth, below, we explore separately how both lifetime EV and age-specific EV influences outcomes.

Further information on EV patterns is provided in Table 2. Here we report multivariate regression estimates using least squares, relating the lifetime and decadal EV measures to a vector of socioeconomic factors. Controls include a measure of the worker's lifetime earnings (AIME), the respondent's sex, education, race/ethnic status, and marital status. In addition a health variable is included to assess whether the respondent had problems with activities of daily living; this is clearly a noisy measure of lifetime health problems, but it still can provide insight into functional limitations.

→ *Table 2 here*

Table 2 results confirm our earlier observation that workers with higher lifetime earnings levels are also those with lower earnings variability. However this is now a stronger finding, since the conclusion is statistically significant after holding other factors constant. The inverse relationship holds for both lifetime EV measures, as well as the decadal EV measures. It is interesting, however, that the negative relationship becomes more pronounced with age in the case of the symmetric measure, COEFVAR, but not for

[4] This is a metric developed according to Social Security rules.

the asymmetric measure, EXPHIT. Evidently, the two EV concepts behave differently over the worklife.

Table 2 also indicates that several demographic factors are significantly associated with EV patterns, even after controlling on lifetime earnings (via AIME). Both EV measures are higher for Blacks than Whites, though not systematically for Hispanics. Surprisingly, respondents with greater educational attainment are *more* likely to have higher measures of COEFVAR, but for EXPHIT the relationship is weaker. Neither EV lifetime measure is strongly associated with the respondent's sex, but by decade of age more differences by sex emerge. For example, women are more likely to experience higher earnings variability during their 20's and less during their 40's. Being divorced is associated with lower earnings variability early in life, but it appears there is a positive relationship with EXPHIT and divorce later in life. The health limitation variable is positively associated with both EV measures during the decade of the 40's, with no significant effects during the decade of the 20's. Finally, we note that the regression models indicate that the included right-hand-side variables account for about 40% of the variation in EV measures. In the next section, we control on these variables in models linking EV measures retirement wealth and shortfalls.

IV. Earnings Variability and Retirement Wealth

Before turning to the multivariate analysis linking retirement wealth to the EV metrics, a few comments are in order about anticipated results. First, we hypothesize that earnings variability will behave differently, depending on the type of retirement wealth under consideration. As an example, Social Security rules use a redistributive average lifetime earnings formula, and thus provide higher replacement rates to lifetime low-earners. By contrast, private pension formulas are less redistributive, because they are more likely to embody a final earnings-replacement philosophy. Consequently, it is reasonable to expect that pension wealth levels would be far more sensitive to earnings variability than Social Security wealth, particularly for nonmarried individuals. The case for married couples is less clear since a nonworking spouse is entitled to Social Security benefits based on his or her working spouse's lifetime earnings; this may make the household's total Social Security wealth potentially more vulnerable to one earner's pay fluctuations than a single person. Hence we have:

Hypothesis 1: Pension and financial wealth levels will be more sensitive to earnings variability than Social Security wealth.

Second, we hypothesize that any given earnings fluctuation would have a larger effect on nonmarried workers' wealth than on married household wealth levels. This is because lifetime pay fluctations would be expected to have a direct impact on retirement wealth for single individuals. By contrast, married households have opportunities for risk-sharing which could mitigate this link. For example, the wife might boost her labor market work when her husband experiences a negative earnings shock (this is the long-discussed "added worker" effect in the labor economics literature). [5] There is even the possibility that, through assortative mating, individuals would seek marital partners who have human capital risk characteristics orthogonal to their own, so as to more effectively manage risk within marriage. In any event, smaller sensitivity of retirement wealth to EV measures might be expected for married couples than for single individuals. Hence we have:

Hypothesis 2: *Retirement wealth for nonmarried workers will be more sensitive to EV measures than for married households.*

Third, we hypothesize that financial wealth may be the most sensitive form of wealth to pay variability, of all the types of wealth we examine. This is because, as mentioned above, Social Security and pensions tend to be formulaically related to earnings. By contrast, the process of building up financial wealth has more of a discretionary character, requiring the individual to save rather than spend liquid income. Recent studies on how hard workers find it to exhibit self-control when it comes to saving (Madrian and Shea, 2001) therefore would imply that automatic savings mechanisms are better able to build up retirement assets than less automatic means. We would also anticipate that changes in other wealth could be most easily offset by changing financial assets, which again implies that this type of wealth would be treated as a buffer stock sort of holding. In both cases, we have:

[5] A caveat to this anticipated difference by marital status, of course, is that people who report themselves as nonmarried on the verge of retirement may well have been married earlier in life, which would mitigate observed marital status differences in the EV coefficients. The models also control for marital history (ever married and ever divorced) as well as for the number of children, for both married and currently nonmarried respondents.

Hypothesis 3: *Financial wealth will be more sensitive to pay fluctuations than other forms of wealth.*

In what follows, we evaluate the empirical data for evidence on these three hypotheses.

Findings for EV Measures

The goal is to evaluate whether lifetime earnings variability appears to be linked in important ways to retirement wealth, after controlling on socioeconomic, health, and preference factors including for respondents. That is, we use multivariate analysis to explore whether fluctuations in earnings over the life cycle is associated with greater or lesser levels of total retirement wealth, as well as pension, Social Security, and financial wealth.

Summary statistics for the key wealth measures appear in Table 3. We calculate that median total household wealth for an age-62 HRS respondent was approximately $400,000 (all dollar values are in $1992).[6] Since wealth has a highly skewed distribution, the mean is around $644,000. Total retirement wealth according to our formulation is made up of four components: employer pensions, Social Security, net housing wealth, and other financial wealth (stocks, bonds, etc). Median values of these components in our sample amounted to about $150,000 for Social Security wealth, around $70,000 in pension wealth, about $50,000 in housing equity, and $36,000 in financial wealth.

→ *Table 3 here*

To evaluate how retirement wealth is associated with earnings variability among the older population, we next report results where we regress the key EV variables of interest on retirement wealth measures. These appear in Tables 4-7, which summarize, in turn, the EV coefficients from multivariate linear models linking (the natural log of) Social Security, pension, financial, and total wealth. In addition we hold constant a vector of control factors. We estimate separate equations for nonmarried and married households, first presenting the results for singles, and then for married couples. The vector of control variables is drawn from our previous work (MMP 2000), and includes lifetime earnings levels (AIME), education, race/ethnic status, health controls, and preference proxies. These have been explored in previous work and controlling on them

[6] In keeping with past practice, we report the median 10% of the distribution.

permits the assessment of a "pure" effect of adding the EV measures to the analysis. [7] The equations for married respondents include the relevant characteristics of their spouses, including spousal EV measures.

Table 4 summarizes results for the Social Security wealth regressions. Of all the wealth sources we examine, we posit that Social Security would be the least affected by variation in earnings since it uses a lifetime average earnings measure to calculate benefits. It is interesting, therefore, that both lifetime EV measures are relatively large and negative in the Social Security wealth regressions, and the coefficients are statistically significant in the single person regressions. This indicates that workers' earnings fluctuations actually have a detrimental impact on Social Security benefits, as anticipated by nonmarried workers. This result could be due to the fact that pay variability can reflect respondents' insured status for Social Security benefits: that is, people who spend portions of their worklives without a job (or in uncovered jobs) are less likely to be eligible for a benefit in their own right (Levine, Mitchell and Phillips, 2000). This explanation is supported by the fact that earnings variability early in life is not associated with single persons' later Social Security wealth, whereas fluctuations in the decade of their 40's has a very strong negative effect.

→ *Table 4 here*

Turning to the married household results, it appears that a very different pattern prevails for Social Security wealth. Both EV lifetime measures are positive when statistically significant, and they tend to be small. Further, the decadal measures show the effect is strongest early in life. As a consequence, these results indicate that after controlling on lifetime earnings, more EV is associated with higher Social Security wealth for couples, in contrast to the single person results. A possible explanation for this is that when earnings fall, benefits are relatively high due to the redistributive benefits formula; conversely, when earnings rise, household benefit increases are magnified since nonworking spouses can receive benefits that are a multiple of the worker's retiree benefit. This explanation seems plausible since the COEFVAR measure, which includes upside variability, is more often positive and significant than the asymmetric measure,

[7] Appendix Table 1 offers descriptive statistics on all variables used in the empirical analysis.

EXPHIT. In general, the findings confirm hypothesis 2, that retirement wealth for nonmarried workers is more sensitive to EV measures than for married households

Turning to the results for pension wealth, Table 5 confirms hypothesis 1, which was that pension wealth is more sensitive to EV measures than is Social Security wealth. Among nonmarried individuals, both lifetime EV measures are large in magnitude, negative, and statistically significant. Most of the negative effect for the symmetric COEFVAR measure is concentrated later in life, during the decade of the 40's,and EXPHIT also grows more negative with age. This may be because HRS respondents with pensions tend to have defined benefit coverage, where benefit levels depend closely on earnings close to retirement. As a result, the pension wealth values prove particularly sensitive to earnings fluctuations in later years.

→ *Table 5 here*

Results for pension wealth in married households also tend to be negative for both spouses when significant, and the results for EXPHIT more statistically important at older ages. However, the couples' results are also much smaller in magnitude as compared to nonmarried results, again supporting hypothesis 2 in that retirement wealth for married workers is less sensitive to earnings fluctuations than for nonmarried households.

Findings for financial wealth appear in Table 6. Results for unmarried respondents reveal a much less clear picture, with the lifetime COEFVAR measure positively associated with financial wealth, primarily attributable to a strong impact for the decade of the 30's. By contrast, the EXPHIT coefficient is not significant, due to conflicting effects early and later in life. Taken together, the results from COEFVAR and EXPHIT paint a mixed picture for nonmarried persons, where financial wealth levels are higher for those with symmetric earnings variation in midlife, but lower for those with large earnings drops in midlife. Among married couples, financial wealth is generally positively and strongly associated with earnings fluctuations, for both EV measures examined. The effect is particularly strong for younger workers in their 20's. It will also be recalled that financial wealth may be more sensitive to pay fluctuations than other forms of wealth (hypothesis 3); these results are only partly supportive of this view. This is because the estimated coefficients in the financial wealth equations on COEFVAR and

EXPHIT are often smaller in absolute value and less statistically significant, than they are in the pension wealth and Social Security wealth equations. Consequently it does not appear that financial wealth acts as a buffer asset, in times of earnings variability.

→ *Table 6 here*

Table 7 summarizes how EV measures are associated with total retirement wealth, which is the sum of the components just examined plus housing equity. The findings for nonmarried persons reveal different effects of the symmetric versus the asymmetric EV measures, with COEFVAR coming in positive and EXPHIT coming in negative for the lifetime measure. The source of difference appears to be the differential effect of earnings fluctuations occurring in the middle decade of age, the 30's, since greater symmetric variability seems to raise total wealth but negative hits lower it. For married households, the dominant pattern is similar, with COEFVAR raising total wealth, but asymmetric losses reducing it, particularly late in life. It is interesting that higher earnings fluctuations for spouses raise total wealth, which perhaps speaks to some substitution between couples' work effort when pay levels fluctuate.

→ *Table 7 here*

Findings for Other Factors

Rather than reviewing all the results for other independent variables, we simply summarize here the other results reported in more detail in tables available on request. In general, the results are sensible and conform to those reported in our earlier work. Not surprisingly, single as well as married workers with higher AIMEs also tend to have accumulated larger pension, Social Security, and financial assets, as well as total retirement wealth. Higher educational attainment is generally associated with higher retirement wealth levels. Larger families tend to have less wealth than smaller ones, perhaps reflecting constraints on saving. Hispanic sample members tend to have rather low wealth, but there is no significant relationship for Black respondents in equations that control for earnings variation.

The health and preference controls also appear to be linked to retirement wealth in predictable ways. Those having difficulty with ADLs, who are pessimistic about surviving to age 75, smokers, and those who have low cognitive scores, tend to have less wealth than their counterparts. Moderate drinking is associated with relatively higher

wealth than not drinking at all. The models also control for a number of "preference proxy" variables, including a measure of risk aversion that uses responses from a battery of questions on gambles to determine a respondent's taste for risk. Here we find that risk averse respondents tend to hold more wealth than do their risk taker counterparts. We also find, consistent with prior work, that those stating they have relatively long planning horizons hold more retirement wealth than do respondents with shorter horizons. Finally, we included a variable identifying which respondents contacted the Social Security Administration to learn about their benefit amounts. Probably not surprisingly, those who did contact SSA had less wealth than those who did not, overall.

V. Conclusions

This research has two goals: first, to see how earnings variability (EV) differs in the population according to income levels and socioeconomic characteristics; and second, to examine how pay variability over the lifetime is associated with retirement wealth. Using HRS data matched with administrative records on lifetime earnings provided by the Social Security Administration, we find some very interesting results. One finding is that workers with lower earnings variability also have higher lifetime earnings levels. This conclusion remains robust in a multivariate setting, after controlling on lifetime income levels and socio-demographic factors. In addition, the inverse relationship becomes more pronounced with age in the case of the symmetric EV measure, COEFVAR, but not for the asymmetric measure, EXPHIT. Evidently, the two EV concepts behave differently over the worklife.

The second phase of the analysis uses a multivariate model to relate our constructed EV measures to retirement wealth. Our results indicate several conclusions, holding other things constant:

1. Retirement wealth is more sensitive to EV measures for nonmarried individuals than for married households.
2. Social Security wealth is inversely related to earnings variability for nonmarried persons and especially during the later workyears. It is positively related to EV for married persons.
3. Pension wealth is particularly sensitive to earnings fluctuations in later years, and pension wealth is more sensitive to EV measures than is Social Security wealth.

Results for married workers indicate less pension wealth response to earnings fluctuations, than for nonmarried households.

4. Financial wealth levels are higher for nonmarried workers having *symmetric* earnings variation in midlife, but they are *lower* for those with large earnings drops in midlife. Among married couples, financial wealth is generally positively and strongly associated with earnings fluctuations.
5. Financial wealth appears to be less susceptible to earnings variability than does pension and Social Security wealth. We conclude that financial wealth does not appear to act as a buffer asset in times of earnings variability.
6. Total retirement wealth is the sum of all components. Among nonmarried individuals, the symmetric and asymmetric lifetime EV measures had different effects: COEFVAR is positive and EXPHIT negative. This is mainly due to differential effects of earnings fluctuations during the 30's. Among married households, the pattern is similar, with COEFVAR associated with higher total wealth, but EXPHIT reducing it, particularly late in life. In the case of couples, earnings fluctuations for spouses raise household total wealth, indicating a degree of substitution between couples' work effort when earnings fluctuate.

In sum, earnings variability over the worklife appears to have interesting and powerful effects on retirement wealth. The EV results for nonmarried persons are potentially the cleanest to interpret, since risk-sharing within married couples may offer means to offset the direct link between earnings fluctuations and retirement wealth. We also conclude that symmetric and asymmetric measures of variability often give different answers, and we would propose that both are of interest for future research. In general, earnings fluctuations over the lifetime do appear to erode retirement wealth, though some forms of retirement wealth are more closely associated with earnings variability than others, holding constant other demographic, social, and economic characteristics of workers and their families.

Appendix I: Data Construction

Earnings Measures

The data on earnings levels used to compute earnings variability measures are derived from the Social Security earnings histories provided under restricted access conditions. For the period 1950 to 1991, Social Security taxable earnings are available reflecting annual earnings up to the Social Security taxable earnings ceiling. In addition, for the period 1981 to 1991, additional information from the same source is available containing the so-called W-2 earnings. These are annual earnings reported on the W-2 payroll forms provided by employers to the federal government. These two earnings figures may differ for the same worker if his earnings exceeded the taxable earnings ceiling in a given year. Inasmuch as the initial HRS cohort was in its 40's during the 1980s, having the W-2 data is quite valuable in avoiding the chances of censored earnings data. The earnings streams we use therefore rely on the higher of the W-2 versus the Social Security taxable earnings. While we recognize that some workers' taxable earnings were capped prior to 1981, we do not formally model this phenomenon in this paper (in the analysis sample used in this paper, workers' earnings were at the cap an average of once or twice by decade of age. Alternative methods of handling such censoring are taken up in Appendix II.

Retirement Wealth and Shortfall Measures

For the empirical analysis, we derived current retirement wealth for all age-eligible respondents in the HRS datafile surveyed in 1992, along with real (in $1992) values of retirement wealth expected if the head retired at 62 and also at 65.[8]

This required us to compute expected present values of contingent future income (pensions, social security) combined with current and future values of financial assets and housing wealth. Mean total household wealth, which includes net financial wealth, net housing equity, pension wealth, and Social Security wealth, stood at around half a million dollars, with the median household having approximately $325,000 in total retirement wealth.

To project retirement wealth at age 62 and 65, we forecasted financial wealth by projecting four types of household assets, with future growth rates depending on their past trajectories: 1) net financial wealth which includes such assets as savings, investments, business assets, and non-residential real estate less outstanding debt not related to housing, 2) net housing wealth - the current market value of residential housing less outstanding mortgage debt, 3) pension wealth, or the present value of retirement benefits, and 4) present value of social security. The forecasting methodology for financial wealth uses the techniques developed in MM (2000). For instance, housing wealth is projected using HRS responses on the purchase price of each participant's house, year of purchase, and mortgage payment amount and frequency. Interest rates are drawn from the average interest rate for households in the American Housing Survey with the same year of purchase. Given these interest rates, we then determine amortization schedules for mortgages and project reduction in housing debt over time. This in turn implies an increase in net housing wealth. Pension wealth is projected to retirement based on the plan provisions of employer provided Summary Plan

[8] This discussion follows MMP (2000).

Descriptions and HRS data on salary and tenure of service where appropriate. Individuals are assumed to remain with their current employer until the retirement age and invest their pensions, if they have authority to do so, and returns assumed on defined contribution pensions are consistent with historical averages. Mortality follows actuarial tables obtained from the Social Security Administration. Social security wealth is derived from the earning and benefits file (EPBF) as described in MOS (2000).

To derive saving shortfalls, we then projected retirement wealth forward to age 62 and 65 for each HRS household and computed how much additional saving beyond existing assets and pension plans would be needed to smooth that family's consumption patterns as of that retirement date.[9] To determine adequacy of saving we use the replacement rate, an annual income amount sufficient to smooth consumption before and after retirement, allowing for changes in tax status and the change from saving to spending in retirement. Each household's replacement rate is solved for, in conjunction with the determination of its saving rate, so as to determine how much income it would need in retirement to attain pre-retirement consumption levels from retirement at that given age.[10] For example, if the determined rate was 0.80 for a household with an income of $50,000 per year pre-retirement, the suggested annual income level in retirement is $40,000 for that household given differences in taxes and saving. More generally, assets needed at retirement are the result of taking into account i) household income at retirement, ii) the appropriate replacement rate for that income level, and iii) a joint and survivor annuity factor allowing for the age composition of the household (either individual or married couples).

The rate of saving necessary to meet these levels is solved for simultaneously with the household's replacement rate. Given a replacement rate, the shortfall between a household's projected value of assets and its projected need determines its prescribed saving rate. This rate represents a prescription of what the older household would need to save as a percent of income each year until retirement to achieve that projected need. If the resultant projected saving rate was too small (large) to meet projected need, the replacement rate was lowered (raised) until replacement and saving rates balance.

[9] Age 62.5 is the modal retirement age currently, where retirement is defined as the age at which people apply for Social Security benefits.

[10] This iterative approach to solving for the household's saving shortfall is described in MM (2000).

Appendix II. Alternative Ways of Handling Capped Earnings from Administrative Records

This appendix describes an approach to take in measuring wage variability while allowing for the censoring of our wage data. Due to the extent of censoring for men at younger ages, but also because of the effect of exits from the labor force at older ages, this procedure has to date not provided reliable estimates of individual wage variance. For this reason, we do not report those results in the body of the paper. We include a discussion of this method in the present appendix because it should be possible to use this approach with HRS data that will become available in the future.

We assumed the following model for wages:

$$\log(Y_{i,t}^{*}) = X_{i,t}\beta + \nu_{i,t}$$

where

$Y_{i,t}^{*}$ is true uncensored (real) wages,

$X_{i,t}$ is a vector of individual demographic and other data,

β is a vector of coefficients,

$\nu_{i,t} = \nu_{i,t-1} + \varepsilon_{i,t}$, $\varepsilon_{i,t} \sim N(0, \sigma_{\varepsilon_i}^{2})$ is the wage shock, and

i is an index for different individuals, while t denotes time.

This wage error structure assumes that all wage shocks persist to the end of working life. Empirical estimates of wage shock processes that allow for the presence of both temporary and persistent wage shocks (see, for example, Campbell *et al.* (2000); Heaton and Lucas (2000), Carroll and Samwick (1997)), have demonstrated the significance of persistent wage shocks, often with a unit root. In this appendix we present the analysis with only these persistent shocks, as persistent wage shocks will have a much greater effect on retirement wealth outcomes than temporary wage shocks, and because the omission of non-persistent wage shocks has no effect on the reliability of the results for reasons that will become clear. The method can easily be adjusted to account for the presence of temporary wage shocks.

For the demographic variables $X_{i,t}$, we used dummy variables for sex, race, educational attainment and year of birth. We also allowed for a third-order polynomial profile of mean wages by age, including the variables age, age^2, and age^3. In principle, interaction terms between all of these variables could also be included.

If we let $y_{i,t}^{*} = \log(Y_{i,t}^{*})$ [11], and $y_{i,t} = \log(Y_{i,t})$, where the star denotes that the variable is the true uncensored variable, we observe the censored variable:

[11] The censoring problem at 0 was handled by adding a small amount to each wage amount before taking logs.

$y_{i,t} = \min(X_{i,t}\beta + \nu_{i,t}, c_t)$, where c_t is the Social Security wage cap in year *t*.

We wished to obtain an estimate for the wage shock variance $\sigma_{e_i}^2$ for each individual.

A pseudo-likelihood function can be constructed for the entire sample. Ideally it would be maximized to estimate the values of β and $\sigma_{e_i}^2$ jointly. Implementing this approach proved computationally intractable, involving maximizing more than 6000 variables.

A second tactic would take a two-step approach, first estimating the values of β, and then estimating individual wage shock variances. This allows the shock variance to be estimated separately for each individual, changing the estimation problem from one 6000-parameter problem to 6000 one-parameter problems. This is similar to the approach adopted by Campbell *et al.* (2000).

The values of β are fairly easy to estimate if we are prepared to make a convenient assumption about the variance-covariance matrix and if too many data points are not censored. It is straightforward to assume that the errors are uncorrelated and homoschedastic, since this permits the use of censored regression programs in standard econometric packages. Since censoring is quite severe for men at younger ages (see Figure 2), the censored regression yielded what appeared to be unreasonable values of mean censored wages. This problem would have grown more severe with different assumptions about the error term variance-covariance matrix.

For completeness, we describe our implementation of the rest of the procedure. Owing to the unreliable estimates of mean wages, we cannot place much credence in individual wage variability estimates resulting from this procedure; hence we do not report the results here. There were some also some other problems with the estimates that were the result of zero wages that will be described later.

We used these estimated values of β to obtain conditional means,

$$\hat{M}_{i,t} = E[\log(Y_{i,t}) \mid X_{i,t}],$$

and used these conditional means to calculate estimated values of the censored errors $\nu_{i,t}$:

$$\hat{\nu}_{i,t} = \log(Y_{i,t}) - \hat{M}_{i,t}.$$

We knew whether each individual value of $\hat{\nu}_{i,t}$ was censored or not. We wanted to estimate the variance of innovations in the true, uncensored values of $\nu_{i,t}$, (call these $\nu_{i,t}^*$). These we estimated by first differencing successive values of $\hat{\nu}_{i,t}$:

$$\dot{\hat{n}}_{i,t} \equiv \hat{e}_{i,t} = \hat{n}_{i,t} - \hat{n}_{i,t-1}.$$

The fact that successive values are differenced implies that $\hat{e}_{i,t}$ could be uncensored, censored above or below, or censored both above and below, depending on which of the two values of $\hat{n}_{i,t}$ were censored above. We used these four cases to construct a pseudo-likelihood function for each individual, and maximized this likelihood to obtain an estimate of individual *i*'s error variance $s^2_{e_i}$.

The estimates obtained from this process proved unreliable, even on the assumption that the censored regression produced reasonable estimates of age-wage profiles. This was because the variance estimates were very sensitive to labor force participation effects – especially to exits from the labor force at the end of the life cycle. We found that our wage variability estimates were often little more than proxies for labor force entry and exit. Without observing whether these changes in labor force participation were voluntary or not, it is difficult to account for them in estimates of wage variance of this type in a consistent and meaningful way.

We anticipate that the proposed future linkage of new W-2 (i.e. uncensored) wage data with HRS records will attenuate the censoring effect and allow this technique to produce more reliable estimates. Also, additional regression information might allow us to impute whether changes in labor force participation are voluntary, which will help to mitigate the effects of labor force exits on our estimates.

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Figure 1. Percent of Respondents with Zero Earnings by Age and Sex

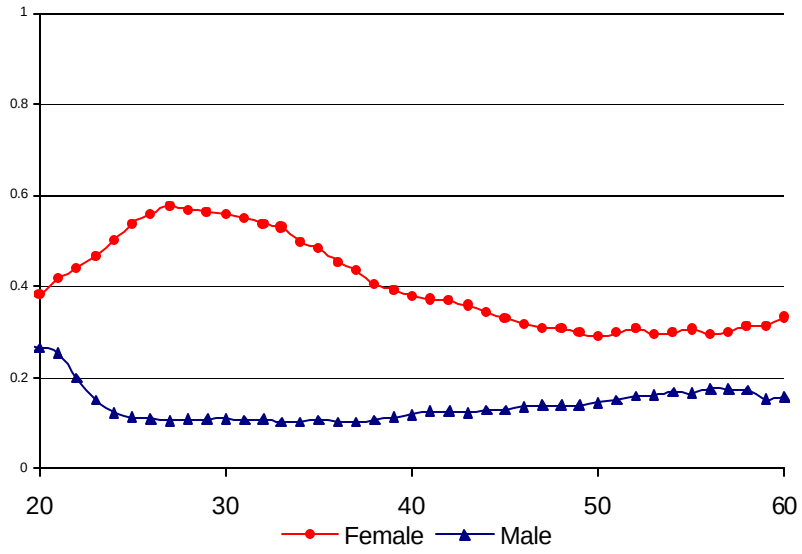

Figure 2. Percent of Respondents with Capped Earnings by Age and Sex

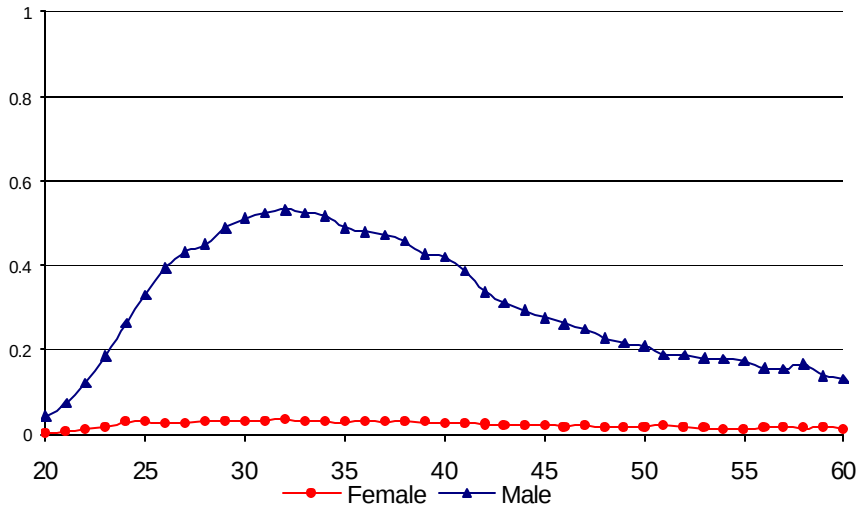

Table 1. Earnings Levels and Variability Measures for HRS Respondents
(Weighted data)

	Mean	*Stdev*
I. Earnings Levels		
AIME	$1,321	$970
Average Earnings	$15,324	$12,116
II. Lifetime Earnings Variability Measures		
COEFVAR	1.060	0.863
EXPHIT	0.160	0.175
III. Earnings Variability Measures by Decade of Life		
COEFVAR20	1.030	0.768
COEFVAR30	0.796	0.837
COEFVAR40	0.642	0.713
EXPHIT20	0.171	0.356
EXPHIT30	0.131	0.248
EXPHIT40	0.177	0.279

IV. Correlation Between Variability Measures

	COEFVAR	COEFVAR20	COEFVAR30	COEFVAR40	EXPHIT	EXPHIT20	EXPHIT30	EXPHIT40
COEFVAR	1.000							
COEFVAR20	0.629	1.000						
COEFVAR30	0.761	0.422	1.000					
COEFVAR40	0.722	0.212	0.455	1.000				
EXPHIT	0.727	0.372	0.525	0.697	1.000			
EXPHIT20	0.591	0.214	0.546	0.525	0.675	1.000		
EXPHIT30	0.444	0.239	0.273	0.558	0.702	0.243	1.000	
EXPHIT40	0.497	0.332	0.307	0.426	0.743	0.233	0.333	1.000

V. Distribution of EV Measures by Lifetime Earnings Quintile

AIME quintile	COEFVAR	EXPHIT
1	2.35	0.38
2	1.22	0.19
3	0.80	0.12
4	0.54	0.08
5	0.50	0.04

Variable Definitions:

Average Earnings: Average annual real earnings over the lifetime (in 1992$)
AIME: Average indexed monthly earnings over the lifetime in $92)
COEFVAR St. dev. of earnings/own lifetime avg earnings
COEFVAR# By decade of life: St. dev. of earnings/own lifetime avg earnings
EXPHIT (Prob. wage loss * size of loss}/Av lifetime earnings
EXPHIT# By decade of life: (Prob. wage loss * size of loss}/Av lifetime earnings

Source: Authors' calculations using the Health and Retirement Study.

Table 2. Factors Associated with Lifetime and Decadal Earnings Variability
(Weighted data)

	COEFVAR		COEFVAR20		COEFVAR30		COEFVAR40	
	Coef.	*Std. Err*	*Coef.*	*Std. Err*	*Coef.*	*Std. Err*	*Coef.*	*Std. Err*
RAIME1000	-0.603 **	0.011	-0.347 **	0.011	-0.593 **	0.012	-0.511 **	0.010
Rfemale	0.030	0.022	0.344 **	0.022	0.175 **	0.021	-0.195 **	0.020
Rage	0.031 **	0.003	0.024 **	0.003	0.019 **	0.003	0.030 **	0.002
RBlack	0.110 **	0.027	-0.016	0.028	0.127 **	0.026	0.165 **	0.025
RHispanic	0.033	0.038	-0.041	0.042	0.005	0.038	0.037	0.035
RLTHS	0.016	0.024	0.092 **	0.024	-0.134 **	0.023	-0.032	0.022
RBAplus	0.149 **	0.019	0.167 **	0.018	0.153 **	0.018	0.087 **	0.017
Revdivorce	-0.147 **	0.018	-0.083 **	0.018	-0.070 **	0.017	-0.026	0.016
Revwidow	-0.096 **	0.032	-0.036	0.033	-0.103 **	0.032	-0.002	0.029
RADLany	0.022	0.036	-0.018	0.036	-0.077 **	0.035	0.067 **	0.033
cons	0.020	0.149	-0.019	0.149	0.414 **	0.146	-0.376 **	0.136
Adj. R-square	0.461		0.365		0.504		0.364	
Nobs	5939		5419		5310		5640	

	EXPHIT		EXPHIT20		EXPHIT30		EXPHIT40	
	Coef.	*Std. Err*	*Coef.*	*Std. Err*	*Coef.*	*Std. Err*	*Coef.*	*Std. Err*
RAIME1000	-0.111 **	0.003	-0.139 **	0.006	-0.083 **	0.004	-0.111 **	0.005
Rfemale	-0.006	0.005	0.057 **	0.011	-0.012	0.008	-0.052 **	0.009
Rage	0.002 **	0.001	0.007 **	0.001	0.000	0.001	-0.001	0.001
RBlack	0.038 **	0.006	0.098 **	0.014	-0.001	0.010	0.021 *	0.011
RHispanic	-0.015 *	0.008	-0.061 **	0.019	-0.011	0.014	0.029 *	0.016
RLTHS	0.019 **	0.005	-0.049 **	0.012	0.051 **	0.009	0.052 **	0.010
RBAplus	-0.003	0.004	-0.011	0.009	-0.016 **	0.007	0.013 *	0.008
Revdivorce	-0.004	0.004	-0.053 **	0.009	0.028 **	0.007	0.016 **	0.007
Revwidow	-0.006	0.007	-0.041 **	0.016	0.018	0.012	0.003	0.013
RADLany	0.040 **	0.008	0.046 **	0.018	0.050 **	0.013	0.027 *	0.015
cons	0.152 **	0.033	-0.122	0.075	0.238 **	0.055	0.363 **	0.062
Adj. R-square	0.370		0.193		0.120		0.121	
Nobs	5939		5907		5919		5924	

Note: ** significant at 1%; * significant at 5%
Variable definitions:

COEFVAR	Coefficient of variation age 20-50	RBlack	Respondent Black (=1)
COEFVAR#	Coefficient of variation for specific decade	RHispanic	Respondent Hispanic (=1)
EXPHIT	Exp. Hit to earnings over lifetime, age 20-50	RLTHS	Respondent has < High School
EXPHIT#	Exp. Hit to earnings over lifetime for specific deca	RBAplus	Respondent has >= college
RAIME1000	Respondent lifetime AIME/1000 ($)	Revdivorce	Respondent divorced
Rfemale	Respondent female (=1)	Revwidow	Respondent widowed
Rage	Respondent age in 1992 (yrs)	RADLany	Respondent has at least some ADL impairment

Source: Authors' calculations using the Health and Retirement Study.

Table 3. Total Retirement Wealth and Components for HRS Respondents (1992$)
(Weighted data)

	Median 10%	*Mean*	*Stdev*
Total Wealth	$395,977	$644,368	$781,722
Pension Wealth	$70,459	$193,143	$285,164
Social Security Wealth	$150,249	$148,063	$55,081
Financial Wealth	$35,594	$222,588	$667,941
Net Housing Wealth	$50,393	$80,574	$94,299

Note: Retirement wealth measures contingent on age-62 retirement and expressed in 1992 $.

Variable definitions:

Total Wealth	Total real household wealth ($92) = Pension+Social Security+ Financial + Net Housing wealth.
Pension Wealth	Total real household pension wealth ($92) from all pensions.
Social Security Wealth	Total real household Social Security wealth ($92)
Financial Wealth	Total real household financial wealth ($92)
Net Housing Wealth	Total real household nonfinancial wealth ($92)

Source: Authors' calculations using the Health and Retirement Study following Mitchell and Moore (2000).

Table 4. The Effect of Earnings Variation on (ln) Social Security Wealth
(Weighted data)

	Variable Name	Nonmarried Households	
		COEFVAR	EXPHIT
1	Earnings Variance	-0.063**	-0.477***
	Lifetime	(0.026)	(0.143)
2	Earnings Variance	-0.017	-0.057
	ages 20-29	(0.013)	(0.062)
3	Earnings Variance	0.001	-0.161***
	ages 30-39	(0.015)	(0.057)
4	Earnings Variance	-0.114***	-0.258**
	ages 40-49	(0.025)	(0.115)

	Variable Name	Married Households			
		COEFVAR		EXPHIT	
		Respondent	Spouse	Respondent	Spouse
5	Earnings Variance	0.038***	0.015**	0.110***	0.014
	Lifetime	(0.006)	(0.007)	(0.028)	(0.011)
6	Earnings Variance	0.018***	0.013**	0.061***	0.009
	ages 20-29	(0.006)	(0.006)	(0.009)	(0.006)
7	Earnings Variance	0.016**	0.015**	0.023	-0.022
	ages 30-39	(0.007)	(0.006)	(0.017)	(0.020)
8	Earnings Variance	0.001	-0.025***	0.024	-0.004
	ages 40-49	(0.008)	(0.007)	(0.016)	(0.015)

Note: Complete regression results appear in Appendix Table 2.
Models 1 and 5 include only one measure of EV as indicated. Remaining models include all three decadal EV measures in same equation.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors' calculations using the Health and Retirement Study

Table 5. The Effect of Earnings Variation on (ln) Pension Wealth
(Weighted data)

	Variable Name	Nonmarried Households	
		COEFVAR	EXPHIT
1	Earnings Variance Lifetime	-0.947***	-9.959***
		(0.266)	(1.437)
2	Earnings Variance ages 20-29	0.072	-2.834***
		(0.281)	(0.476)
3	Earnings Variance ages 30-39	0.283	-3.130***
		(0.318)	(0.642)
4	Earnings Variance ages 40-49	-1.614***	-3.497**
		(0.403)	(1.377)

	Variable Name	Married Households			
		COEFVAR		EXPHIT	
		Respondent	Spouse	Respondent	Spouse
5	Earnings Variance Lifetime	-0.345**	-0.291*	-5.854***	-1.411***
		(0.155)	(0.150)	(0.709)	(0.384)
6	Earnings Variance ages 20-29	-0.021	0.192	-1.231***	-0.239***
		(0.198)	(0.180)	(0.307)	(0.089)
7	Earnings Variance ages 30-39	0.605***	0.058	-2.209***	-1.528***
		(0.174)	(0.184)	(0.497)	(0.438)
8	Earnings Variance ages 40-49	-0.709***	-0.403*	-2.332***	-1.992***
		(0.209)	(0.221)	(0.377)	(0.374)

Note: Complete regression results appear in Appendix Table 2.
Models 1 and 5 include only one measure of EV as indicated. Remaining models include all three decadal EV measures in same equation.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors' calculations using the Health and Retirement Study

Table 6. The Effect of Earnings Variation on (ln) Financial Wealth
(Weighted data)

	Variable Name	Nonmarried Households	
		COEFVAR	EXPHIT
1	Earnings Variance	0.732***	0.377
	Lifetime	(0.171)	(0.875)
2	Earnings Variance	0.091	0.807**
	ages 20-29	(0.163)	(0.314)
3	Earnings Variance	0.521***	-1.458**
	ages 30-39	(0.166)	(0.616)
4	Earnings Variance	-0.096	0.481
	ages 40-49	(0.253)	(0.456)

	Variable Name	Married Households			
		COEFVAR		EXPHIT	
		Respondent	Spouse	Respondent	Spouse
5	Earnings Variance	0.241***	0.227***	0.604**	0.401***
	Lifetime	(0.054)	(0.053)	(0.248)	(0.094)
6	Earnings Variance	0.224***	0.172**	0.251***	0.125***
	ages 20-29	(0.077)	(0.069)	(0.094)	(0.031)
7	Earnings Variance	0.137*	0.041	0.055	-0.03
	ages 30-39	(0.072)	(0.075)	(0.186)	(0.165)
8	Earnings Variance	0.191**	0.329***	0.073	0.146
	ages 40-49	(0.095)	(0.088)	(0.153)	(0.165)

Note: Complete regression results appear in Appendix Table 2.
Models 1 and 5 include only one measure of EV as indicated. Remaining models include all three decadal EV measures in same equation.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors' calculations using the Health and Retirement Study

Table 7. The Effect of Earnings Variation on (ln) Total Retirement Wealth
(Weighted data)

	Variable Name	Nonmarried Households	
		COEFVAR	EXPHIT
	Earnings Variance	0.160***	-0.642*
1	Lifetime	(0.054)	(0.337)
	Earnings Variance	0.015	0.109
2	ages 20-29	(0.037)	(0.142)
	Earnings Variance	0.196***	-0.514***
3	ages 30-39	(0.046)	(0.142)
	Earnings Variance	-0.120**	-0.371
4	ages 40-49	(0.056)	(0.245)

	Variable Name	Married Households			
		COEFVAR		EXPHIT	
		Respondent	Spouse	Respondent	Spouse
5	Earnings Variance	0.104***	0.115***	-0.083	0.058**
	Lifetime	(0.018)	(0.018)	(0.086)	(0.029)
6	Earnings Variance	0.077***	0.064***	0.029	0.030**
	ages 20-29	(0.025)	(0.023)	(0.032)	(0.014)
7	Earnings Variance	0.134***	0.064***	-0.114*	-0.084
	ages 30-39	(0.024)	(0.025)	(0.058)	(0.058)
8	Earnings Variance	0.031	0.066**	-0.101**	-0.093**
	ages 40-49	(0.027)	(0.029)	(0.047)	(0.046)

Note: Complete regression results appear in Appendix Table 2.
Models 1 and 5 include only one measure of EV as indicated. Remaining models include all three decadal EV measures in same equation.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Source: Authors' calculations using the Health and Retirement Study