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Revisiting wage, earnings, and hours profiles

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# Revisiting wage, earnings, and hours profiles\*

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## Abstract

We document empirical life cycle profiles of wages, earnings, and hours of work for pay from the Panel Study of Income Dynamics, following the same workers for up to four decades along the intensive margin of labor supply. For six of the eight cohorts we analyze the wage profile does not decline with age, while the earnings profile always does. The discrepancy is explained by a sharp drop of the hours profile beginning shortly after age 50, when many workers start a smooth transition into retirement by working progressively fewer hours. This pattern is not an artifact of staggered abrupt retirement, and is robust to attrition- and selection-correction (i.e., to taking into account that the composition of our sample, for a given cohort, changes over time). We explore the nontrivial restrictions on dynamic models of the aggregate economy that this evidence suggests, and we provide numerical profiles that can be readily used in quantitative macroeconomic analysis.

**JEL Classification Codes:** E24; J13; J22; J24; J26

**Keywords:** life cycle, wage profile, labor supply, intensive margin human capital, preretirement

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# 1 Introduction

This paper is an empirical investigation into life cycle profiles of wages (hourly compensation of labor), hours (work for pay supplied to the labor market), and earnings (the product of the two), from the vantage point of four-decades-long panel data. Theoretical and empirical investigation of such profiles has a long tradition in labor economics and macroeconomics, because of their importance in understanding a variety of phenomena such as labor supply, retirement, the allocation of time, incentive contracts, training and human capital, saving, and inequality. The Panel Study of Income Dynamics (PSID) now covers more than 40 years and so spans nearly the entire working life of the cohort that entered the labor market at the end of the 1960s, as well as substantial parts of the working lives of older and younger cohorts. We use these data to first estimate entire life cycle profiles that are straightforward to interpret and that can be readily used in quantitative macroeconomic analysis, and, second, to test the predictions of several variants of a benchmark life cycle model. We improve upon the existing literature, which we succinctly review in [Section 2](#) in order to put the paper in perspective, by taking a systematic approach to the analysis of life cycle profiles in longitudinal data. First, ours is a joint analysis of wages, hours, and earnings profiles of both men and women, and by education. Second, the entire life cycle is considered, not only the late working life, by exploiting the full longitudinal dimension of the PSID (1968-2009). Third, multiple cohorts are compared. Fourth, we investigate the restrictions that our observations place on quantitative aggregate models.

We find that wages typically do not fall (if they fall at all) until individuals are well into their 60's, in line with previous empirical research. However, hours fall substantially (and then, so do earnings) beginning shortly after age 50. Apparently, the drop in hours is generated by a smooth transition into retirement, in the form of less overtime work and passage from full- to part-time. Documenting these facts jointly is the first contribution of this paper. Although not documented in a systematic way, [Mincer \(1974\)](#) had inferred this pattern from census data decades ago. Analyzing these data, Mincer observed that the weekly wage rate was not declining at the end of working life while annual earnings were. He wrote: “There is no visible decline at these later ages in weekly earnings. Apparently, declines in weeks worked per year are the main factor in the decline of annual earnings during preretirement years.” (p. 70). This suggestion remained somewhat overlooked. The pre-retirement pattern we document conforms to the more general notion of retirement advocated by [Heckman \(1976\)](#): “Retirement can more generally be defined as a period with few hours of work supplied to the market.” (p. S15).

The pattern of non-declining wages and falling hours shortly after age 50 imposes nontrivial restrictions on quantitative aggregate models. In particular, such a pattern is inconsistent with a benchmark life cycle model with stationary uncertainty, complete markets, exogenous wages, and constant disutility of work along the life cycle. We discuss at the end of the paper the extent to which alternative departures from the benchmark model reconcile theory and data. In brief, the two departures that seem best able to reproduce the empirical pattern are endogenous wages from on-the-job training (leading to skills that do not depreciate until very late in life) and increasing marginal disutility of work (or increasing marginal utility of alternatives to work for pay) shortly after age 50—not necessarily because of changing preferences. This is the second contribution of this paper. We provide the numerical life cycle profiles that quantitative models should reproduce. This is our third contribution.

It is important to clarify what this paper is *not* about. First, the focus here is on the intensive

margin of labor supply. That is, when we construct the empirical hours profile and when we try to reproduce it in the model we consider hours *per worker*, not hours *per person*. The reason why we do not deal with the extensive margin here is that retirement choices have been studied exhaustively within a life cycle model. We know from this related research that technological features such as nonconvexities in the mapping between hours and labor services (e.g., Rogerson and Wallenius (2009), Erosa et al. (2011)) and institutional features such as social security rules (e.g., French (2005), Erosa et al. (2012)) allow a match of extensive margin behavior late in the life cycle.

Second, our goal is not to separate age, time, and cohort effects in life cycle profiles. We analyze jointly the wage and hours profile of different cohorts to provide evidence that researchers must take into account; namely, that workers in many cohorts substantially reduce labor supply along the intensive margin despite facing a non-declining wage profile. Similarly, we do not take a stand on why the wage profile that workers in many cohorts face does not decline. One possibility is that there are pure time or cohort effects at work. Another is that human capital depreciates only slowly. Yet another explanation is that incentive contracts are in place and the observed wage profile does not track the individual productivity profile closely.<sup>1</sup> This is certainly a very interesting question for future research.

The remainder of the paper is organized as follows. Section 2 connects the paper to the literature. Section 3 describes the data. Section 4 illustrates how these data restrict the theory. Section 5 concludes. In the Appendix we report tables containing the numerical wage, hours, and earnings profiles (raw and smoothed profiles) that can be readily used in quantitative analysis. These, of course, are also available in electronic format at our research pages.

## 2 Connection to the literature

From a historical viewpoint, among the theories developed to characterize life cycle profiles a prominent position is occupied by the human capital model, initiated by Ben-Porath (1967) and further developed by Ghez and Becker (1975), Blinder and Weiss (1976), Ryder et al. (1976), Heckman (1976), and Rosen (1976). Variants of this model have become a workhorse in dynamic macroeconomics and typically predict that wage, hours, and earnings profiles are “hump-shaped”. In this model the wage rate is the return on human capital, and grows as long as net investment increases the stock of skills. As the end of working life approaches, investment in human capital optimally falls below depreciation and the wage rate declines, tracing out a hump-shaped profile. The hours profile has the same shape because the substitution effect induces workers to work more when wages are higher. The earnings profile, then, is also hump shaped. The left portion of Figure 1, reproduced from Weiss (1986), illustrates the typical dynamics generated by the human capital model. This was meant to fit the data observed at the time it was developed, as summarized by Weiss (1986), p. 603:

“The major stylized facts which the theory attempts to explain are: a life cycle earnings profile which is increasing at early ages and is declining towards the end of the working

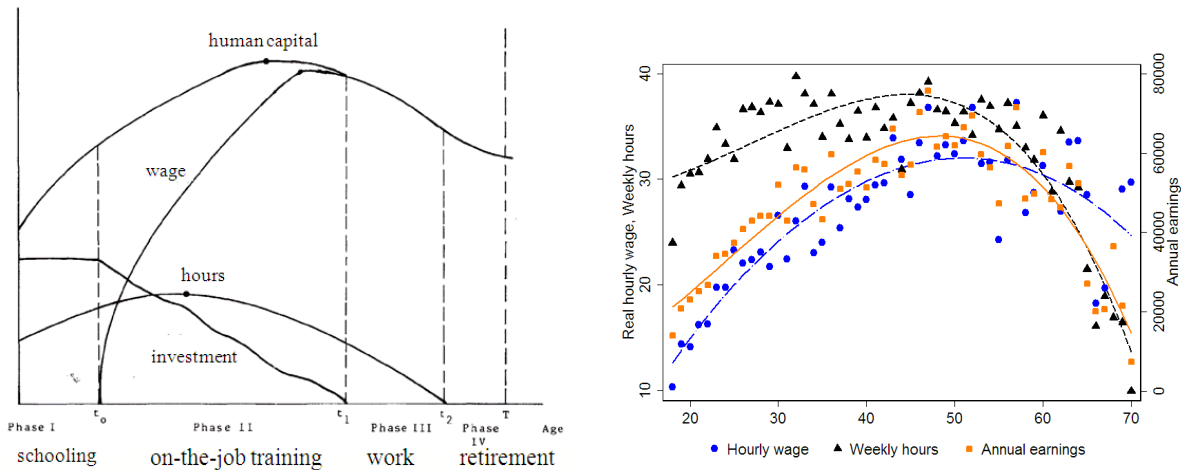
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<sup>1</sup>The works, among others, of Becker and Stigler (1974), Lazear (1979), Lazear (1981), Freeman (1977), Medoff and Abraham (1980), Medoff and Abraham (1981), MacDonald (1982), and Harris and Holstrom (1982) show that, at the individual level, wage growth is possible even in the absence of human capital (and productivity, more generally) growth. In this case the wage profile need not decline towards the end of the working life, even if individual productivity did. Gibbons and Waldman (1999) offer a thorough review of this literature.

period. A wage profile which tends to increase over the life cycle with a weak tendency for wage reduction towards the end of the working period. An hours of work life cycle profile which is increasing at early ages and declining at older ages, with the peak occurring earlier than in the earnings or wage profiles.”

When these empirical regularities were first isolated the main data sources were cross-sectional, so “the major stylized facts which the theory attempt[ed] to explain” were mostly derived from synthetic cohorts.<sup>2</sup> We produce and report in the right portion of Figure 1 the wage, hours, and earnings profiles that a researcher would have observed applying the synthetic cohort fiction to the 1970 cross-section of the PSID. They clearly resemble the theoretical profiles.

Figure 1: Theoretical and 1970 PSID synthetic cohort profiles



*Notes:* The figure on the left illustrates the theoretical life cycle profiles in the human capital model, and is reproduced from Weiss (1986). The figure on the right illustrates the empirical profiles constructed using the synthetic cohort method from the 1970 cross section of the PSID. The wage and earnings profiles result from adding 1% annual real wage growth to the raw cross sectional profiles, corresponding to the BLS estimate of productivity growth—this is roughly the average growth rate of labor productivity in the US since 1970. That is, the wage of an individual  $a$  years old in the cross section is multiplied by  $(1.01)^{a-18}$ , where 18 is the conventional age of the youngest worker in the 1970 cross section, thus “tilting” the wage and earnings profiles upward. The interpolating line is the best second-order fractional polynomial.

However, synthetic cohorts may produce a biased picture of the life cycle when productivity changes in time. Thornton et al. (1997) and Rubinstein and Weiss (2006) offer an illustration for annual and weekly earnings, respectively. When using repeated cross sections to form pseudo panels, many researchers have reached similar conclusions—i.e., wages decline in the second part of the working life and hours track them. For instance, Browning et al. (1985) apply this procedure to British household heads in the Family Expenditure Survey and find that wages peak around mid-working life and then decline, and similarly for hours. The increasing availability of longitudinal data has allowed a more direct look at actual portions of workers’ careers by following them over time. Johnson and Neumark (1996) use panel data from the National Longitudinal Survey of Older

<sup>2</sup>By synthetic cohort we mean the time series constructed from a cross-section at, say, time  $t$  using the  $a + j$  years olds at time  $t$  as a counterfactual for the  $a$  years olds at time  $t + j$ .

Men to infer the dynamics of male wages during the late portion of the working life, and do not find clear evidence of negative wage growth until workers are in their 60s. They do not consider the associated labor supply behavior, however. Recent research in macroeconomics based on micro panel data has focused on earnings profiles, finding that they are hump-shaped. Examples include [Huggett et al. \(2007\)](#), and [Heathcote et al. \(2008\)](#). The dynamics of earnings, however, results from both wages and *choices* of hours of work, and it is of interest to look separately at these two distinct (although not necessarily independent) processes.

A number of additional recent papers in macroeconomics are directly or incidentally concerned with life cycle profiles. [French \(2005\)](#) studies the effect of health and social security rules on hours and retirement behavior of men in the US. As a preliminary step in his structural investigation, French uses the annual portion of the PSID (1968-1997) to estimate wage and hours profiles. He finds that the wage profile is hump-shaped, although the most visible decline does not happen before age 62. The hours profile he estimates is also declining, with the trend changing a bit later than we estimate. French notes that “Most of the variation in the wage and labor supply profiles is from individuals aged 55-65 [...]. [The] decline in hours coincides closely with the decline in wages” (p. 412). Apparently, this contrasts with our results despite using much of the same data. However, the samples used are different (Male head of households 1968–1997 in French, all individuals 1968–2009 here), as well as the estimation methods. For the wage profile, French uses the prediction from a fixed-effects regression of wages—corrected for tied wage-hours effect—on a quartic function of age, conditioning on health status and family size, and pooling all cohorts; we report simple raw profiles by cohort. Relative to these differences, the dissimilarities between ours and French’s estimates seem unimportant.

[Kuruscu \(2006\)](#) estimates the return to on-the-job training using NLSY data. This data set does not yet allow the observation of wages of older workers, so he *assumes* that the wage profile is not declining late in the working life, based on limited evidence from cross-sectional data as well as the PSID. Correspondingly, he assumes that human capital does not depreciate in his model. Our analysis confirms the soundness of such an assumption. In Kuruscu’s model, however, labor is inelastically supplied, and this puts aside the question of what happens to hours.

[Imai and Keane \(2004\)](#) study a human capital model to reconcile small and large intertemporal elasticities of labor supply at the individual and aggregate level. The model is estimated using data from the NLSY, like [Kuruscu \(2006\)](#), and produces out-of-sample (i.e., after age 40) predictions that have the shape of the profiles in [Figure 1](#). As far as the shape of the wage profile is concerned, the difference between [Imai and Keane \(2004\)](#) and [Kuruscu \(2006\)](#) originates in different assumptions about whether human capital depreciates or not. Nonetheless, as we illustrate later, [Imai and Keane \(2004\)](#) and its developments offer a key intuition (investment in human capital increases substantially the opportunity cost of time early in the life cycle) to reconcile a non-declining wage profile and a declining hours profile. [Rogerson and Wallenius \(2009\)](#), like [Imai and Keane \(2004\)](#), are interested in understanding the discrepancy between micro and macro elasticities of labor supply. The main feature of their model is a nonconvexity (a flat initial portion of mapping between hours of work and labor services) that generates motives for entering and leaving the labor force at specific points in the life cycle. Their model takes the wage profile as exogenous and assumes it is hump-shaped. This implies that hours decline before retirement. In this model, the only way one can generate this decline in hours (and the other results) when wages do not decline is by assuming that the disutility of working increases at later stages in the life cycle. This is another possibility we explore at the end of this paper.

## 3 Data

### 3.1 Data sources and data selection criteria

After the full release of the 2009 wave at the end of 2011, the Panel Study of Income Dynamics (PSID) offers the unique opportunity to observe individual life cycle profiles of wages, hours, and earnings spanning 41 years. This amounts to virtually the entire working life of the cohorts who entered the labor market at the end of the 1960s. We use individual-level data containing demographic, socio-economic and labor market information from 1967 to 2008, for different cohorts.<sup>3</sup> We compute averages of hourly wages, hours, and earnings for a given cohort of interest and all available years to trace the life cycle profiles of individuals in that cohort. Wages and earnings are before-tax and are expressed in constant 2010 dollars using the CPI-Urban. In order to have a sufficient number of observations to compute meaningful averages, we define cohorts based on 5-year bins and use the central value of the bin to keep track of the age of the cohort. For instance, workers who were between 21 and 25 years old in 1967 we define as the “23 years old” cohort, those who were between 26 and 31 years old in 1967 are the “28 years old” cohort, etc.

We can use eight such cohorts from the PSID. The youngest is the 23 years old cohort, and the oldest is the 58 years old cohort. The former is the cohort we analyze more closely, because it is the only one for which we can observe the entire working life. Wage rates are directly observed for workers paid by the hour (about 1/3 of the total) and are estimated by the ratio between annual hours and annual earnings for those who are salaried. It is well known that this procedure leads to measurement error in hourly wages, but we notice that this problem is vastly mitigated by averaging across individuals in the cohort. However, since we do not average zeros (i.e., we focus on the intensive margin of labor supply), selection into employment is an issue. Another issue is attrition: since we only use workers who are present in the PSID since 1967, this is substantial over a period of 41 years. We will address self-selection and attrition later, but we anticipate here that these processes do not affect our results. In constructing our final sample we apply the following selection criteria. First, We restrict our analysis to households belonging to the SRC sample.<sup>4</sup> Second, self-employed individuals are excluded from the analysis both because their wage rate is more likely to be measured with error, and because the wage of a self-employed individual is a mix of labor and capital income. Third, we exclude individuals whose nominal wage rate in a given year is less than 50% the federal minimum wage in force that year. Fourth, in order to eliminate outliers we trim the distribution of wages, hours, and earnings at or above the top 1% and at or below the bottom 1% every year. This eliminates a handful of observations every year. Trimming at the top helps taking care of top-coded wage information, which we do not correct otherwise.

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<sup>3</sup>A year in our data set refers to the period a variable refers to, not the period in which the data were actually collected. For instance, the 1968 wave collected information referring to year 1967, the 1969 wave collected information referring to year 1968, and so on.

<sup>4</sup>The core sample of the PSID originates from two distinct samples: a cross-sectional national representative sample of about 3,000 households (the 1968 SRC sample) and a non-representative sample of about 2,000 low-income families located in metropolitan areas (the SEO sample). The SRC sample was representative of the U.S. population back in 1967, so there is no guarantee that it is representative during the following 41 years. However, this is the group that maximizes the representativeness of our sample across the four decades. Another way to make the PSID representative of the U.S. population is to apply individual sampling weights to the full core sample. Unfortunately, this cannot be done in a consistent way across all of the 41 waves. Fiorito and Zanella (2012) illustrate how representative the components of the PSID core sample are.

Table 1 reports summary statistics of relevant demographic and socio-economic characteristics for 8 different cohorts, over the entire 1967–2008 period.

Table 1: Summary statistics by cohort

Variable	Cohort (age in 1967)							
	23	28	33	38	43	48	53	58
Year born	1944	1939	1934	1929	1924	1919	1914	1909
Sample size in 1967	497	470	484	580	500	504	415	386
Age	39.6	44.2	49.2	53.9	58.0	61.7	65.7	69.1
	(11.2)	(11.2)	(11.2)	(11.0)	(10.7)	(10.1)	(9.3)	(8.5)
Male	0.49	0.45	0.43	0.48	0.48	0.42	0.42	0.42
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.49)	(0.49)	(0.49)
White	0.92	0.87	0.85	0.90	0.88	0.89	0.88	0.89
	(0.26)	(0.34)	(0.36)	(0.30)	(0.32)	(0.31)	(0.32)	(0.31)
Black	0.05	0.09	0.09	0.08	0.08	0.08	0.09	0.09
	(0.21)	(0.28)	(0.29)	(0.26)	(0.27)	(0.26)	(0.29)	(0.28)
Disability	0.13	0.15	0.20	0.21	0.29	0.31	0.38	0.42
	(0.34)	(0.35)	(0.40)	(0.40)	(0.45)	(0.46)	(0.49)	(0.49)
Married	0.81	0.82	0.81	0.83	0.79	0.72	0.67	0.59
	(0.39)	(0.38)	(0.39)	(0.38)	(0.41)	(0.45)	(0.47)	(0.49)
Widowed	0.02	0.04	0.06	0.09	0.13	0.21	0.26	0.32
	(0.13)	(0.19)	(0.24)	(0.29)	(0.34)	(0.41)	(0.44)	(0.47)
Divorced	0.11	0.10	0.09	0.06	0.05	0.04	0.04	0.03
	(0.31)	(0.30)	(0.28)	(0.23)	(0.23)	(0.20)	(0.19)	(0.17)
Separated	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
	(0.15)	(0.14)	(0.14)	(0.10)	(0.09)	(0.09)	(0.10)	(0.08)
Children	1.15	1.15	0.99	0.70	0.42	0.28	0.14	0.10
	(1.25)	(1.43)	(1.48)	(1.23)	(0.97)	(0.82)	(0.56)	(0.49)
College or more	0.25	0.20	0.19	0.19	0.14	0.14	0.07	0.11
	(0.43)	(0.40)	(0.39)	(0.39)	(0.35)	(0.34)	(0.26)	(0.32)
High School	0.43	0.37	0.43	0.43	0.41	0.38	0.35	0.27
	(0.50)	(0.48)	(0.49)	(0.49)	(0.49)	(0.49)	(0.48)	(0.45)
Less than High School	0.14	0.23	0.26	0.26	0.36	0.35	0.50	0.51
	(0.34)	(0.42)	(0.44)	(0.44)	(0.48)	(0.48)	(0.50)	(0.50)
Total family income	84.01	87.04	85.16	84.00	69.58	62.74	50.61	47.20
	(71.32)	(90.35)	(79.75)	(84.29)	(54.07)	(53.06)	(50.60)	(73.08)

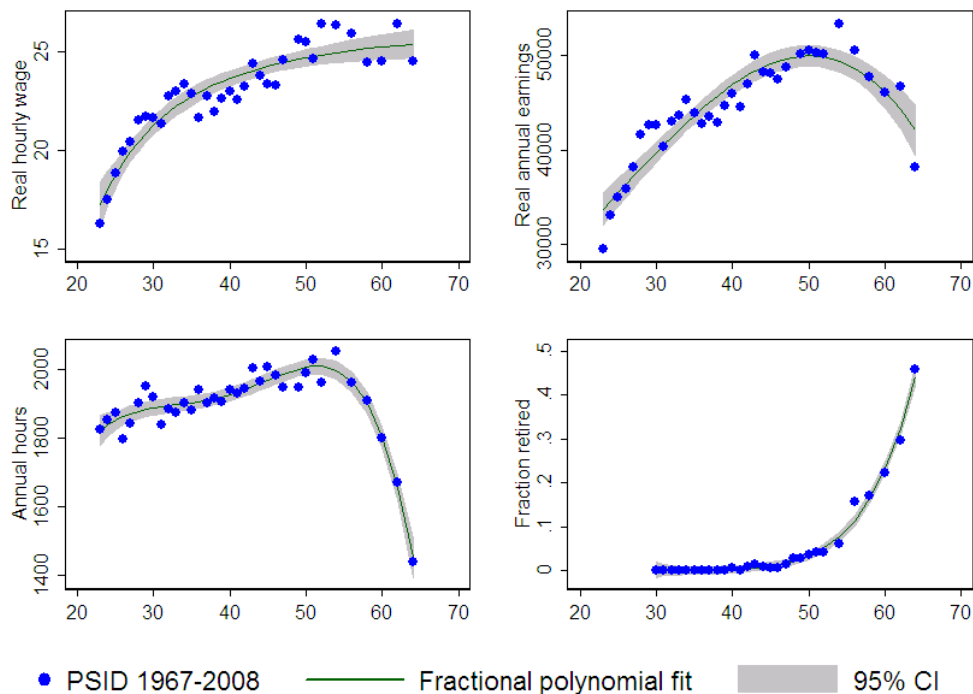
*Notes:* The table contains means and (in parentheses) standard deviations. A cohort is labelled by age in 1967, and results from pooling into a five-year bin individuals belonging to five adjacent one-year bins. For example, cohort 23 is composed of individuals who were between 21 and 25 years old in 1967. “Disability” is the share of individuals who report having a condition that limits the amount of type of work they can do. “Children” is the number of individuals below age 18 living in one’s household. “Total family income” is the sum of all individual gross incomes (from all sources, including losses) in one’s family, and is expressed in thousands of 2010 U.S. dollars.



### 3.2 Empirical profiles

We begin with an illustration of raw life cycle profiles in the PSID for the entire “23 years old” cohort, the only one for which we observe the entire working life: individuals in this cohort were between 21 and 25 years old at the first observation in 1967 and between 62 and 66 years old at the last available observation in 2008. Figure 2 illustrates the wage, earnings, and hours profiles of this cohort, as well as the share reporting “retired” as labor market status each year. The interpolating line is the best second-order fractional polynomial, except for hours where a fourth-order polynomial is used. The wage profile is increasing throughout the working life, and does not show any tendency to decline. Wage growth is sustained until about age 40, modest between 40 and 50, and virtually zero thereafter. The earnings profile, instead, has the familiar hump-shape: earnings reach a maximum around age 50 and then decline visibly. The hours profile shows that hours increase slowly until age 50 and then fall sharply, thus driving earnings down. Starting at this same age, more and more individuals in the cohort begin classifying themselves as retired.

Figure 2: Life cycle profiles: cohort 23



*Notes:* The figure reports wage, hours, earnings, and retirement profiles of individuals who were between 21 and 25 years old in 1967 (cohort 23). The interpolating line is the best second-order fractional polynomial, except for hours where a fourth-order polynomial is used.

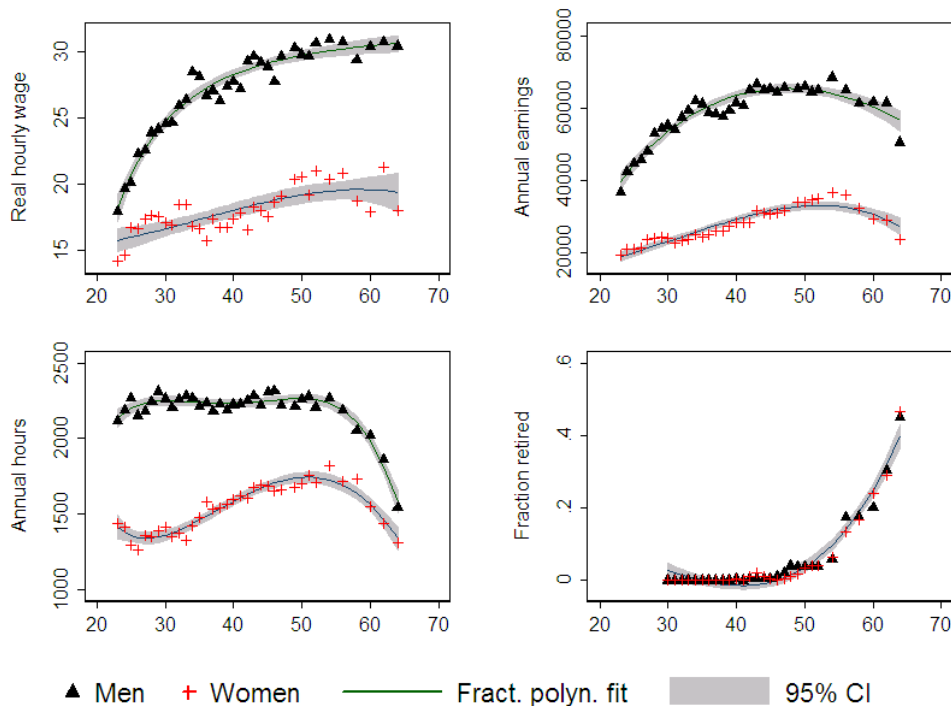
It is useful to decompose these profiles by gender and education. Figure 3 shows the gender decomposition. Wages, both in levels and growth rates, are lower for women, as are earnings. But while the latter are hump-shaped, wages do not show a clear tendency to decline for either men or women. The hours profile of men is flat from shortly after the beginning of the working life

until shortly after age 50, when it falls sharply. Women, instead, reduce hours until about age 30 and then increase them steadily until shortly after wage 50. At that point hours fall at a rate comparable to that of men. The hours profile of women clearly reflects the importance of part-time jobs in this group, as well as fertility choices. The figure also shows that there are no relevant gender differences in retirement rates in this cohort.

Figure 4 shows the decomposition by education level. We consider two groups: college graduates and workers with a high school degree or less. The wage profiles of the two groups grow at a comparable rate until about age 30. Thereafter, the profile of the less educated is virtually flat and the profile of college graduates keeps growing at a sustained rate until age 50. At that point there is some negative wage growth. Both earnings profiles decline after age 50, when hours fall sharply at a similar rate. The hours profile of college graduates, however, is above the profile of non graduates (the difference is about 200 hours), except during a worker’s 20s, when college graduates are allocating most of their time to education and training and so work less. Finally, the picture suggests that the less educated tend to retire earlier.

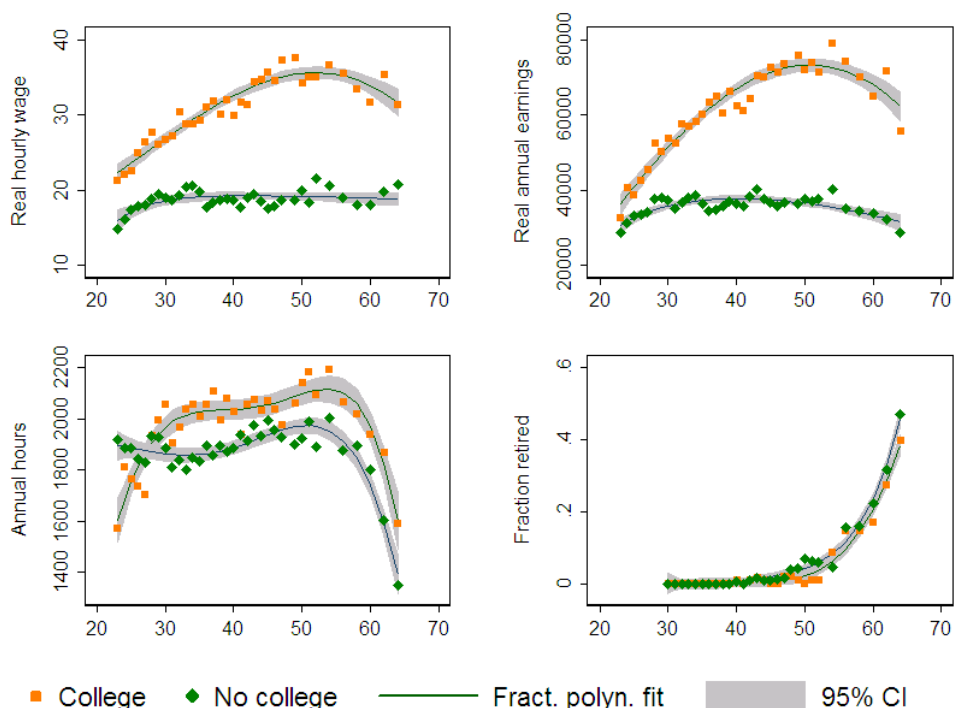
Table 2 summarizes the percentage changes of raw wage, earnings, and hours between ages 23 and 51, and between ages 51 and 64 in this cohort, for the whole sample and by gender and education.

Figure 3: Life cycle profiles: cohort 23, by gender



Notes: The figure reports wage, hours, earnings, and retirement profiles by gender of individuals who were between 21 and 25 years old in 1967 (cohort 23). The interpolating line is the best second-order fractional polynomial, except for hours where a fourth-order polynomial is used.

Figure 4: Life cycle profiles: cohort 23, by education



*Notes:* The figure reports wage, hours, earnings, and retirement profiles by level of education (college degree and high school degree or less, respectively) of individuals who were between 21 and 25 years old in 1967 (cohort 23). The interpolating line is the best second-order fractional polynomial, except for hours where a fourth-order polynomial is used.

Table 2: Cumulative variations in the raw data, cohort 23

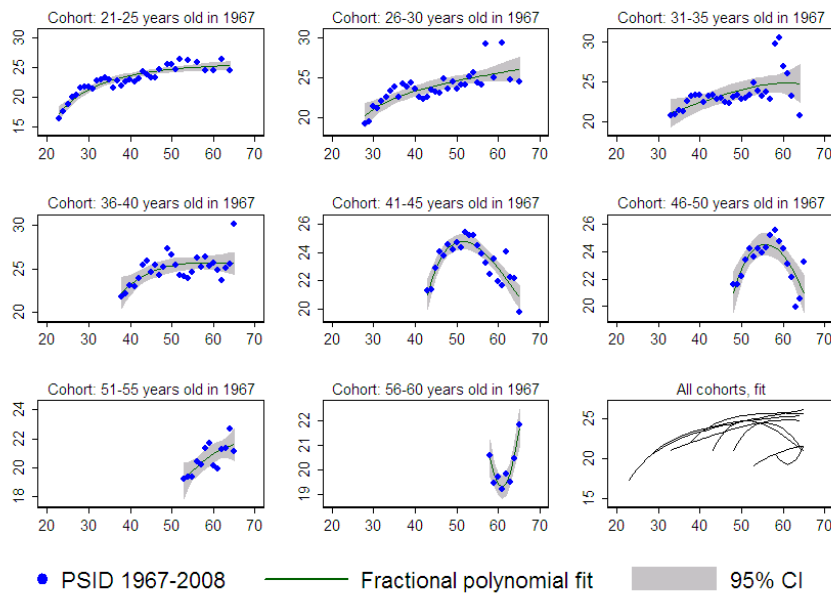
	% wage change		% earnings change		% hours change	
	23–51	51–64	23–51	51–64	23–51	51–64
All	51.3	-0.6	70.6	-24.0	11.2	-29.1
Males	65.5	2.5	75.0	-21.7	4.0	-32.4
Females	35.5	-6.2	78.8	-31.7	21.9	-25.2
College	59.3	-10.8	81.4	-24.8	20.6	-27.2
No college	24.1	13.1	28.8	-22.4	3.7	-32.1

*Notes:* The table reports the percentage change in hourly wages, earnings, and hours of market work for individuals who were between 21 and 25 years old in 1967 (cohort 23), for the whole sample as well as by gender and education. The variations are between age 23 and 51, and between age 51 and 64, and refer to the raw PSID data plotted in Figure 2, Figure 3, and Figure 4.

So far we have considered a single cohort, the youngest one for which the entire life cycle can be observed in the PSID. While we can guess that the shape of the wage profile is invariant across

cohorts in the early stages of the life cycle, the shape at the end is a more sensitive issue. One could think that the cohort we have analyzed benefited from positive aggregate shocks in the final years of the career (i.e., between 2000 and 2008). Absent such shocks the wage profile would have exhibited the traditional hump-shape. We can look at older cohorts to make sure the pattern we have isolated is not driven by shocks that affect particularly the 23 years old cohort. Figure 5, Figure 6, and Figure 7 illustrate the wage, earnings and hours profiles, respectively, of the eight cohorts summarized in Table 1.<sup>5</sup> These pictures reproduce the pattern observed in Figure 2, with only two exceptions as far as the wage profile is concerned: “cohort 43” and “cohort 48”, i.e. workers that were between 41 and 45, and between 46 and 50 years old, respectively, in 1967. The wage decline for *both* these cohorts begins around 1980, when the two groups are between 54 and 58, and 59 and 63 years old, respectively, and continues afterward until they reach age 63-67 (i.e., age 65 in the picture). Obviously, there may exist cohort specific shocks, for example effects from large recessions near retirement age, that might affect some cohorts more than others. It is possible that these older workers may have been more adversely affected by the 1980-1982 recessions. The last panel of each picture overlaps the profiles of the 9 cohorts. While the hours profiles are almost perfectly overlapped, with some increase in hours for the two of the youngest cohorts<sup>6</sup>, the wage and earnings profiles shift upward for younger cohorts. This, of course, reflects productivity growth.

Figure 5: Wage profile, all cohorts

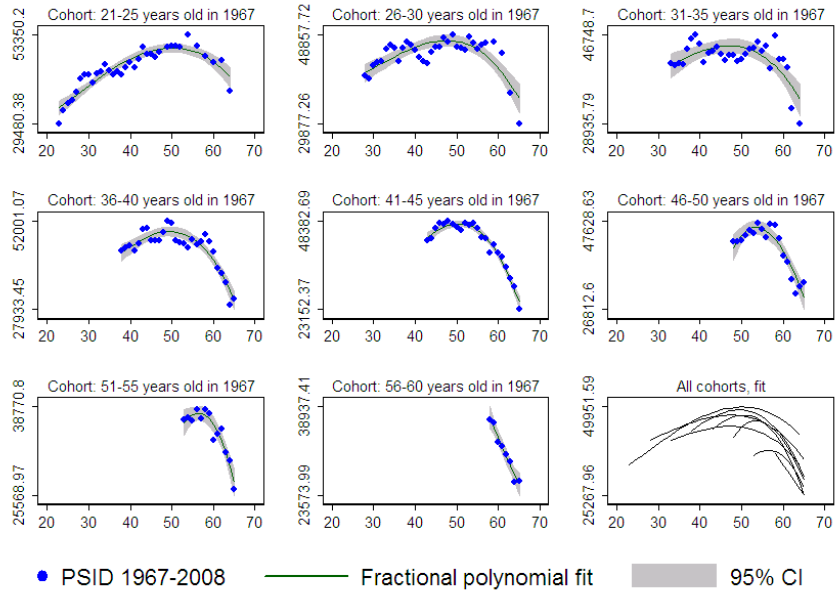


*Notes:* The figure reports the wage profiles of all the cohorts who were in the labor market in 1967. The interpolating line is the best second-order fractional polynomial.

<sup>5</sup>These profiles are truncated at age 65 (i.e., when individuals in the cohort are between 63 and 67 years old): in our data set the group of workers in a specific cohort after that age is too small to provide reliable estimates.

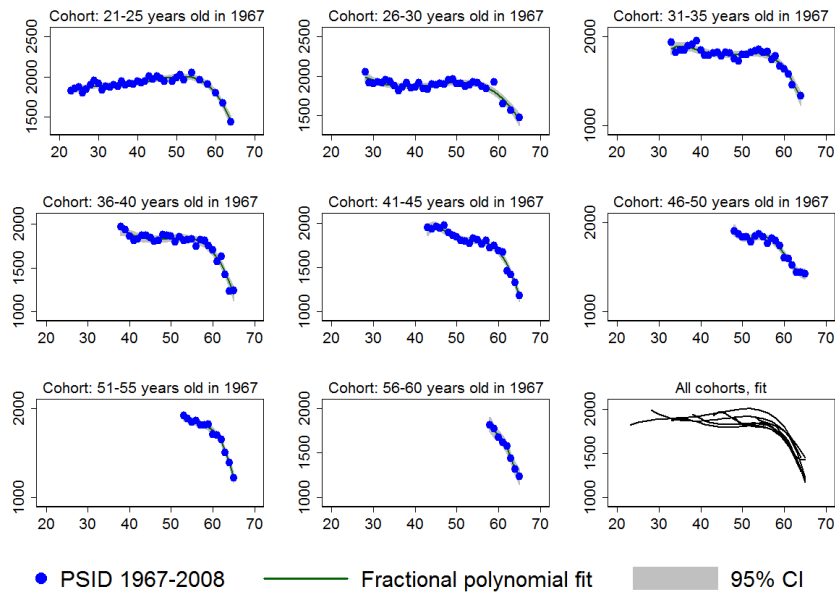
<sup>6</sup>This is consistent with the evidence reported in papers that analyze time use trends across different cohorts. See, for instance, figures 21 and 22 in Attanasio et al. (2012)

Figure 6: Earnings profile, all cohorts



*Notes:* The figure reports the earnings profiles of all the cohorts who were in the labor market in 1967. The interpolating line is the best second-order fractional polynomial.

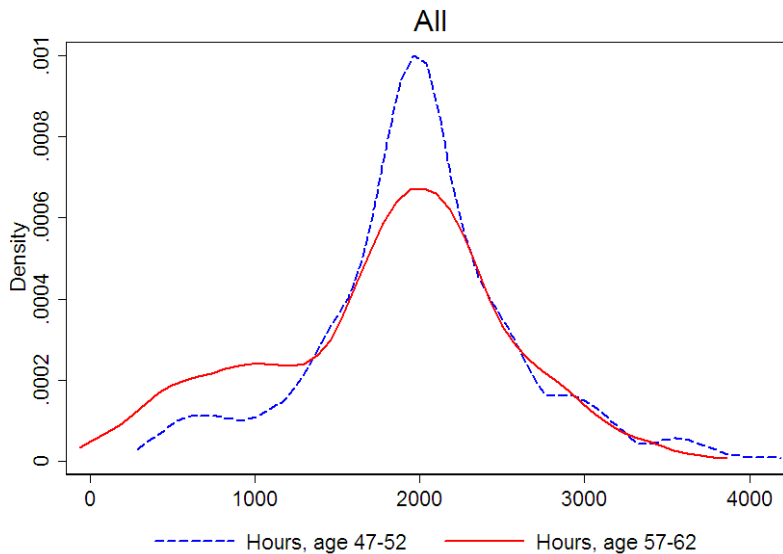
Figure 7: Hours profile, all cohorts



*Notes:* The figure reports the hours profiles of all the cohorts who were in the labor market in 1967. The interpolating line is the best fourth-order fractional polynomial.

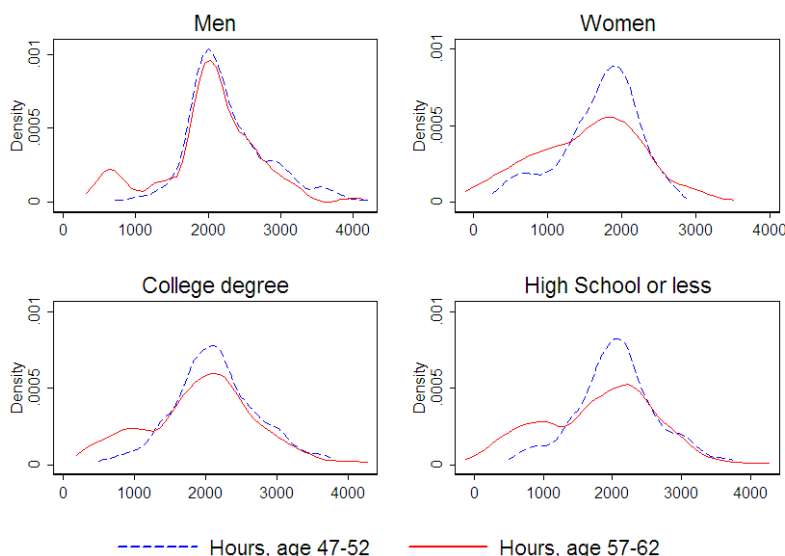
We next investigate how workers reduce hours along the life cycle, a process we refer to as “pre-retirement”. The main margins of adjustment are likely two: switching from full-time to part-time and reducing overtime hours. Figure 8 shows that this is exactly what happens for the 23-years old cohort. The figure shows kernel density estimates of the distribution of hours when the cohort is between 47 and 52 year old (that is, at the peak of hours) and ten years later, when the cohort is between 57 and 62 year old. The figure shows that the distribution at the early stage is concentrated around the full-time level of hours, and has fat tails, indicating that a non-negligible portion of workers are employed part-time or do overtime work. However, ten years later there is an important decrease of density at full-time, the right tail is thinner, and the distribution looks bimodal—there is a second peak around part-time hours. Therefore, ignoring for a moment selection into employment (an issue we tackle below), this picture suggests that many senior workers switch to part-time mode and reduce overtime work. This pattern is confirmed if we decompose the distribution by gender and education, as illustrated in Figure 9. Given the possibly relevant role of moves from full- to part-time during the pre-retirement years, the existence of a negative part-time premium on hourly wages documented by Aaronson and French (2004) suggests that pre-retirement adjustments may lead to underestimating productivity growth late in the working life. This reinforces the pattern we are documenting.

Figure 8: Distribution of hours



*Notes:* The figure shows the kernel density estimate (Epanechnikov kernel) of hours worked on the market by individuals who were between 21 and 25 years old in 1967 at two different points in time: when they are between 47 and 52 years old and ten years later, when they are between 57 and 62 years old.

Figure 9: Distribution of hours, by gender and education



*Notes:* The figure shows, by gender and education, the kernel density estimate (Epanechnikov kernel) of hours worked on the market by individuals who were between 21 and 25 years old in 1967 at two different points in time: when they are between 47 and 52 years old and ten years later, when they are between 57 and 62 years old.

To sum up the finding documented in this section, the empirical regularity that emerges from our analysis can be summarized as follows. The life cycle earnings profile is increasing at early ages and is declining after age 50. The wage profile, however, increases over the life cycle with no clear tendency to decline before age 65 (with the exception of 2 cohorts out of 8). Women and college graduates are a possible exception, with some negative wage growth after age 60. Therefore, earnings fall because of a reduction in hours of market work, along the intensive margin. Such a reduction is sizeable (about 1/3, on average) and constitutes a smooth transition into retirement via reduction of overtime work and switch to a part-time work mode.

A concern is that this pattern may be an artifact of staggered abrupt retirement, selection out of employment, and attrition. We next address these threats to the picture we are rendering.

### 3.3 Is this pattern an artifact?

So far we have ignored three important processes that may give the appearance of a smoothly declining hours profile and a non-declining wage profile. First, the smooth decline of the aggregate hours profile could result from staggered abrupt retirement. This means the following. Suppose that one group moves from full time work to zero hours at age 57, another group at 58, another at 59, and so on. This would induce a continuous declining aggregate hours profile in spite of discontinuous underlying individual profiles.

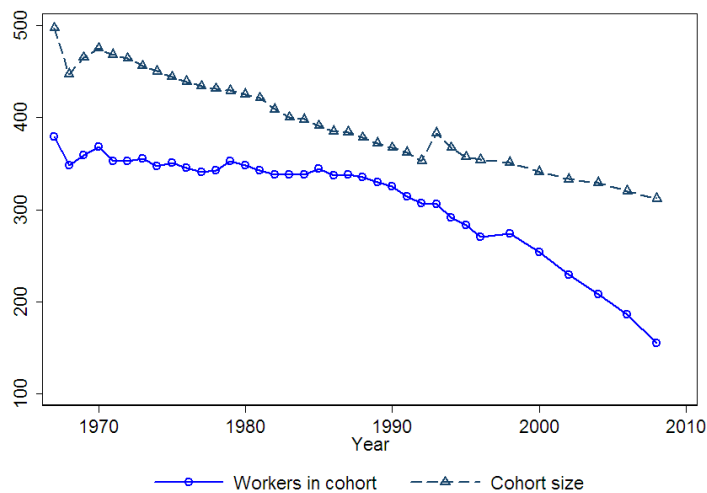
Second, our sample changes over time because of selection into and out of employment. The selection problem in this context is easy to see: as [Figure 2](#) illustrates, around age 50 workers begin self-selecting into retirement. This process is very likely non-random with respect to wages,

earnings, and hours, which implies the shape of life cycle profiles in the selected sample may be biased relative to the population profiles of interest. The direction of the bias is unclear, though. Consider the wage profile and suppose that low-wage workers retire first, or that a negative wage shock induces workers to retire. Then our sample would change in a way that leads to overestimating wage growth late in the working life: we would render a non-declining selected profile while the true underlying profile is actually declining. However, if it's the more productive, high-wage individuals who retire earlier then the uncorrected wage profile would underestimate wage growth at the end of the working life.

Third, our sample changes over time because of attrition. Focusing on specific cohorts in a panel that included about 3,000 households (the SRC sample) at its outset in 1967 means working with relatively few individuals. We follow the same individuals in time, and attrition is substantial over a 40-year horizon. Figure 10 illustrates this fact for the 23 years old cohort. This picture shows that in 1967 this cohort comprised about 500 individuals, of which 370 were employed. The decline of cohort size in time illustrates that attrition is, in fact, substantial.<sup>7</sup> Notice that after the mid 1990s the attrition rate is reduced, while the number of workers declines faster due to retirement. At the last data point, in 2008, individuals in the cohort are between 62 and 66 years old and we have only about 120 observations for which wages and hours are observed.

Is the empirical regularity we have isolated an artifact of these three processes? The answer is no. In what follows we carefully motivate this answer. Readers uninterested in the details may skip the remainder of this section, and jump directly to section 4, where we illustrate how the empirical pattern we have documented restricts the benchmark life cycle model.

Figure 10: Sample size and employment: 23 years old cohort



*Notes:* The figure shows the number of individuals in the cohort of those who were between 21 and 25 years old in 1967 who are present in the panel every year and, among these, the number who are employed. All figures refer to the sample before the application of the sample selection criteria described in Section 3.

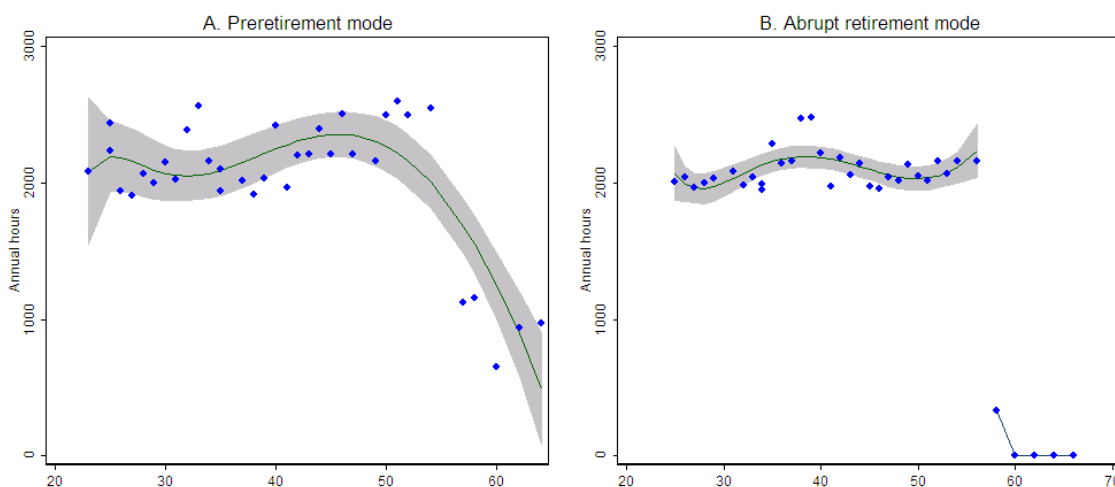
<sup>7</sup>The increase in sample size in 1992 is due to the reappearance of “recontacts”, individuals who were present in 1967, had left the sample, and were brought back into the survey that year.



### 3.3.1 Pre-retirement vs. abrupt retirement

Rogerson and Wallenius (2011) claim on the basis of PSID data that “abrupt retirement” (i.e., moving from, say, full-time hours to zero hours) is by far the most important retirement mode (more than 70% of workers) in the U.S. This, apparently, contrasts with the preretirement pattern we have documented above. To understand the difference between these two retirement modes, consider Figure 11. This pictures reproduces the *individual* profiles of two workers in the 23-years old cohort. Panel A refers to a worker (a man) who is retiring along a preretirement pattern. He works at a full-time level (i.e., about 2000 hours per year) until age 55, and then switches to a part-time level (i.e., about 1000 hours), with a declining trend thereafter. Panel B, instead, refers to a worker (another man) who moves abruptly from full-time work to zero hours at age 58, through an intermediate step of 330 hours—presumably during the first two months of the retirement year. There are 77 individuals in the 23-year old cohort for whom we can inspect individual hours profile like the two we have just illustrated (i.e., 77 individuals in the cohort who work every year from 1967 until 1997 and who may move to zero hours afterwards.). Of these 77 profiles, 26 look like case A in Figure 11, 28 look like case B, 15 are non-declining, and 9 are hard to interpret. This suggests that preretirement is more important a mode than the analysis in Rogerson and Wallenius (2011) suggests, although abrupt retirement is important too. The contrast with Rogerson and Wallenius (2011) is in fact only apparent, because they restrict the sample to individuals who worked at least 1750 hours after age 56. This selection procedure removes workers who are already on a preretirement path like the worker in panel A of Figure 11.

Figure 11: Retirement modes: abrupt retirement vs. preretirement path

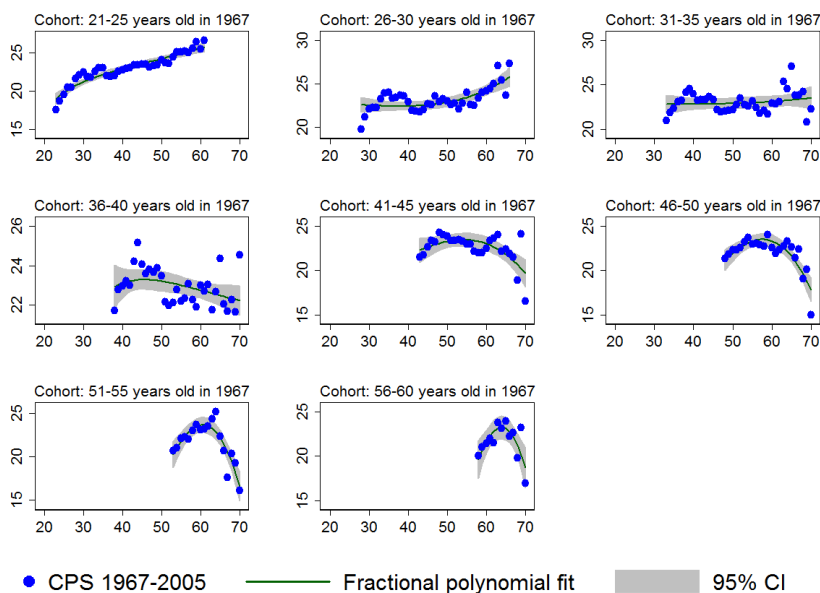


*Notes:* The figure shows two individual profiles of workers who were between 21 and 25 years old in 1967. Worker in panel A moves into retirement through a preretirement stage at part-time hours. Worker in panel B moves into retirement by switching abruptly to zero hours. The interpolating line is the best fourth-order fractional polynomial.

### 3.3.2 Attrition

To show that attrition does not affect the pattern, we first provide two informal checks based on a comparison with the Current Population Survey (CPS) and with the no-attrition group in the PSID, respectively, and then we perform formal tests. The first informal check consists of constructing equivalent life cycle profiles for the same cohorts from the Outgoing Rotation Groups of the CPS. Attrition is not an issue in the CPS: finding a similar pattern would suggest it is not issue in the PSID either, as far as the shape of life cycle profiles is concerned.<sup>8</sup> To perform such a check we use the CPS data set constructed by [Heathcote et al. \(2010\)](#). These data result from applying selection criteria similar to those we applied to the PSID, and cover the 1967–2005 period. Because sample size is now much larger we can expand (relative to [Figure 5](#), [Figure 6](#), and [Figure 7](#)) the upper limit of the age interval to 70 years without having to worry about unreliable estimates. [Figure 12](#) illustrates the resulting wage profile. This picture confirms the patter found in the PSID, at least for the 3 younger cohort (cohorts 23, 28, and 33). The wage profiles of the 5 older cohorts look hump-shaped, although it is clear from this picture that even in these cases wage growth does not turn negative until about age 65, even for the two cohorts (cohorts 43 and 48) for whom the wage profile declines in the late 50s in the PSID. [Figure 13](#), and [Figure 14](#) illustrate the earnings and hours profiles. Except for the 23 year old cohort (which we observe only until age 61 in this CPS data set) the CPS also replicates the shape of earnings and hours profiles in the PSID.<sup>9</sup>

Figure 12: Wage profile in the CPS, all cohorts



<sup>8</sup>Using CPS data also provides a useful check with respect to small sample size in the PSID.

<sup>9</sup>There is an issue about the *level* of hours, which turn out to be slightly higher in the CPS than in the PSID—between about 30 and 120 hours. This difference may reflect the different wording of the survey questions (hours *usually* worked per week in the CPS versus hours *actually* worked per week in the PSID).

Figure 13: Earnings profile in the CPS, all cohorts

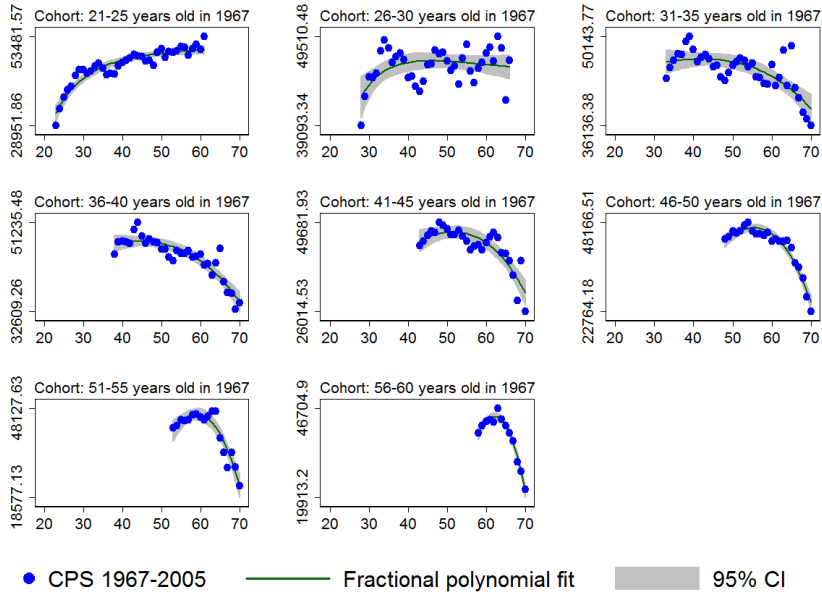
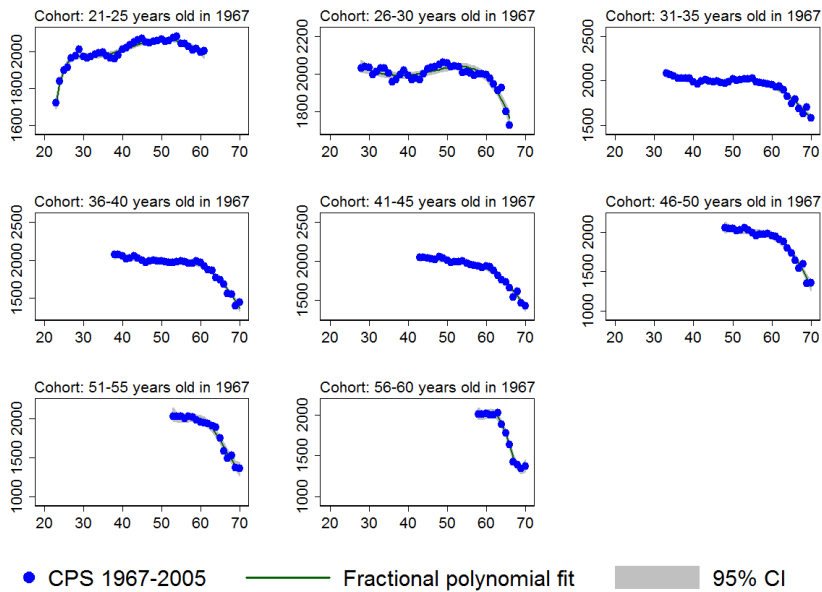


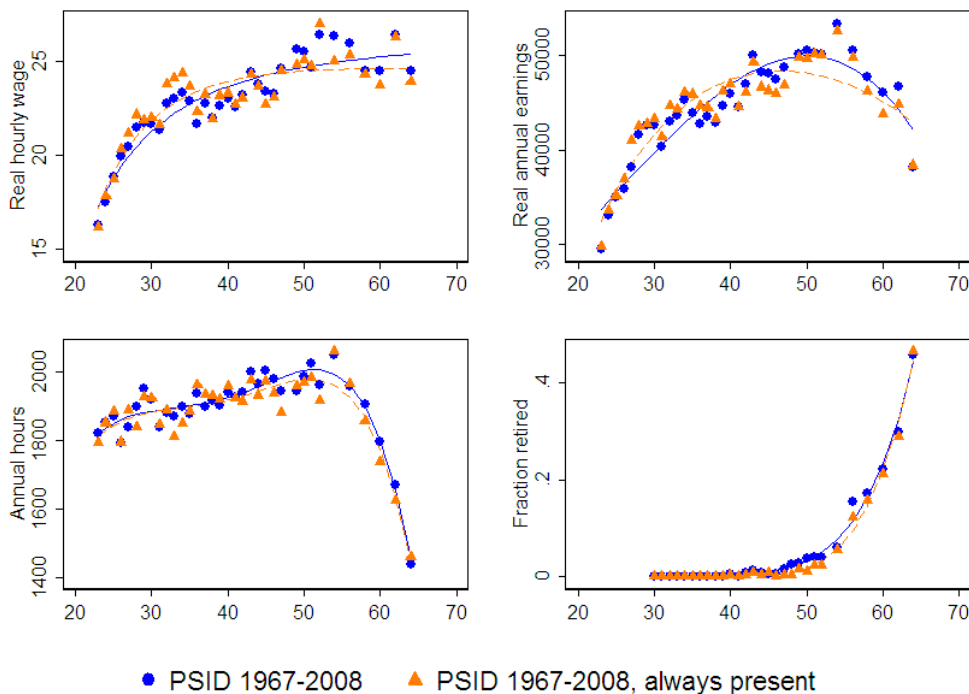
Figure 14: Hours profile in the CPS, all cohorts



Notes: Figure 12, Figure 13, and Figure 14 are the CPS analog of Figure 5, Figure 6, and Figure 7. They illustrate the hours, earnings, and hours profiles of all the cohorts who were in the labor market in 1967, from the March CPS. The interpolating line is the best second-order fractional polynomial, except for hours where a fourth-order polynomial is used.

The second informal check consists of comparing the profiles of the full, but selected sample (because of attrition), with the profiles of the group of individuals in the cohort who are present in the survey every year from 1967 to 2008. We refer to these individuals as the “always present”. These are about 270 such individuals in the cohort. If the profiles of these two groups are different, then we have evidence that attrition is selective with respect to the three variables of interest. If instead they do not differ, then we have evidence that, with respect to these variables, individuals leave the survey at random. This comparison is illustrated in Figure 15. This picture suggests that attrition is random with respect to wages, earnings and hours.

Figure 15: Life cycle profiles: cohort 23, full sample vs. no-attrition group



*Notes:* The figure reports wage, hours, earnings, and retirement profiles of individuals who were between 21 and 25 years old in 1967 (cohort 23), for the full sample and for the sample of individuals who are present in the survey every year from 1967 to 2008 (i.e., the no-attrition group). The interpolating line is the best second-order fractional polynomial, except for hours and the fraction retired where a fourth-order polynomial is used.

Finally, we test for the presence of attrition bias formally using a parametric, Heckman-type two-step procedure. We follow Wooldridge (2010), chapter 19.9.3, who suggests first-differencing the data and working with the usual pair of equations, one for outcome and one for selection:

$$\Delta y_{it} = \Delta \mathbf{x}_{it} \boldsymbol{\beta} + \Delta \varepsilon_{it}, \quad (1)$$

$$s_{it} = \mathbb{I}[\mathbf{q}_{it} \boldsymbol{\gamma} + e_{it} > 0], \quad (2)$$

where  $y_{it}$  is the variable of interest (wage rate, earnings, or hours),  $\mathbf{x}_{it}$  is a vector of time-varying

covariates,  $\mathbb{I}[\cdot]$  is the indicator function,  $s_{it}$  is the selection indicator, keeping track of whether individual  $i$  is present ( $s_{it} = 1$ ) in the survey or not ( $s_{it} = 0$ ),  $\mathbf{q}_{it}$  is a vector containing variables that may correlate with the attrition process and that are observable for at least one period after attrition, and  $e_{it}$  is an unobservable term with a standardized normal distribution.<sup>10</sup>

The test is based on three assumptions. First, attrition is an absorbing state, i.e.  $s_{it+j} = 0$  for all  $j > 0$  when  $s_{it} = 0$ . This is straightforward to impose on the data. Second, the conditional mean of  $\Delta\epsilon_{it}$  is linear:  $\mathbb{E}[\Delta\epsilon_{it}|e_{it}, s_{it}] = \rho_t e_{it}$ . Third, both  $\Delta\epsilon_{it}$  and  $e_{it}$  are independent of  $\mathbf{q}_{it}$ . Then it follows from these assumptions that

$$\mathbb{E}[\Delta y_{it} | \Delta \mathbf{x}_{it}, \mathbf{q}_{it}, s_{it-1} = 1] = \Delta \mathbf{x}_{it} \boldsymbol{\beta} + \rho_t \lambda(\mathbf{q}_{it} \boldsymbol{\gamma}), \quad (3)$$

where  $\lambda(\cdot)$  is the inverse Mills ratio. The latter can be estimated for each period via pooled Probit and interacted with time dummies to allow for a time-varying  $\rho$  in Eq. (3). This equation is then estimated via pooled two-stage least squares (clustering standard errors at the individual level and allowing for heteroskedasticity), using a subset of  $\mathbf{q}_{it}$  as instrument for  $\Delta \mathbf{x}_{it}$ .<sup>11</sup> Then, the null hypothesis of no attrition bias is equivalent to the joint hypothesis that  $\rho_t = 0$  in each period, which is straightforward to test. Since Eq. (3) is in first-difference, we base the test on the annual portion of the PSID (1967-1996).<sup>12</sup> We cannot reject the null for either wages (P-value: 0.15), earnings (P-value: 0.14), or hours (P-value: 0.24).<sup>13</sup>

Based on this informal and formal evidence we conclude that attrition, although non-negligible, is unlikely to have serious consequences for inferring the shape of life cycle profiles in our data. This conclusion is consistent with what is known about attrition in the PSID at large, at least until the end of the 1990s: [Fitzgerald et al. \(1998\)](#) and [Lillard and Panis \(1998\)](#) conclude that despite being selective, attrition has not undermined the representativeness of the PSID and that ignoring it when estimating the dynamics of variables of interest has probably only mild consequences.

### 3.3.3 Self-selection

We finally address selection. We first provide an informal check based on a comparison with the group of continuously employed individuals in the PSID, and then we produce a selection-corrected wage profile. In both cases (except when comparing the PSID with the CPS) we focus on the 23-years old cohort.

The first informal check is conceptually equivalent to the second informal check on attrition bias illustrated in [Figure 15](#). That is, we compare the profiles of the full, but selected sample (because

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<sup>10</sup>We include in  $\mathbf{x}_{it}$  the following variables: age, whether married, number of children living in the household, whether college degree or more, non-labor income, whether lives with an employed partner, whether unemployed, whether disabled, and whether relocated during the year. As for  $\mathbf{q}_{it}$ , we include in this vector the first lag of  $\mathbf{x}$  (i.e.,  $\mathbf{x}_{it-1}$ ) as well as six permanent characteristics: whether ever obtained a college degree, maximum number of children ever lived in the household, whether white, whether ever been unemployed, whether ever reported a disability, whether ever relocated.

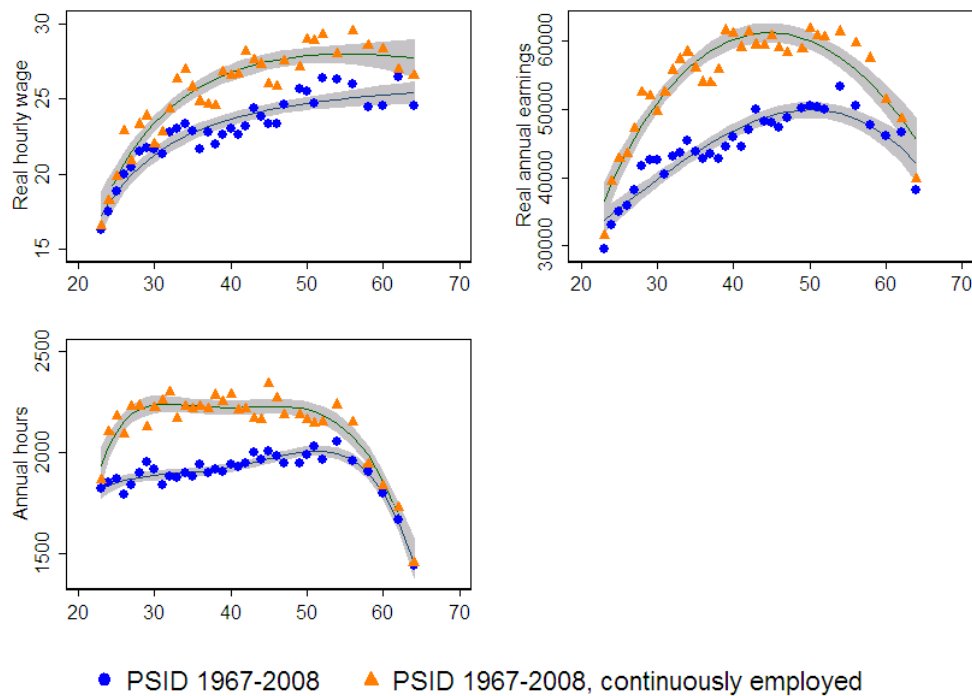
<sup>11</sup>We use  $\mathbf{x}_{it-1}$  as instruments. The rationale for using lags of levels to instrument first differences is illustrated in [Arellano \(1989\)](#)

<sup>12</sup>The survey became biennial after the 1996 wave.

<sup>13</sup>The following, much simpler test confirms this result: estimate in levels using the fixed-effects estimator and including  $s_{it+1}$  as an additional right-hand variable; then test the null hypothesis that the coefficient on  $s_{it+1}$  is zero. The intuition is that if the attrition process is random with respect to wages, earnings, and hours, then the attrition indicator in the next period should not help predicting any of these variables.

of self-selection into employment), with the profiles of the group of individuals in the cohort who are employed every year from 1967 to 2008. These are referred to as the “continuously employed”, and their number in the 23-years old cohort is just 38. Despite such tiny sample size, if the shape of the wage, earnings, and hours profiles of these two groups are the same, then we have evidence that the pattern we have isolated is not an artifact of self-selection out of employment towards the end of the life cycle. The profiles of the full sample of continuously employed individuals are reported in Figure 16. This picture shows that the profiles in the full sample and in the subsample of continuously employed individuals have the same shape.<sup>14</sup>

Figure 16: Life cycle profiles: cohort 23, full sample vs. continuously employed



*Notes:* The figure reports wage, hours, earnings, and retirement profiles of individuals who were between 21 and 25 years old in 1967 (cohort 23), for the full sample and for the sample of those who are employed every year from 1967 to 2008 (i.e., the continuously employed). The interpolating line is the best second-order fractional polynomial, except for hours where a fourth-order polynomial is used.

We can correct at least the wage profiles using the procedure for selection-correction in panel data developed by Wooldridge (1995).<sup>15</sup> This is an extension of standard two-stage methods valid for cross sectional data such as “Tobit” and “Heckit”. Specifically, we predict wages of individuals

<sup>14</sup>The levels are of course different, and reflect the different labor market attachment in the two groups. Those more attached—i.e., those who do not experience unemployment nor leave the labor force for more than 11 months—have higher wages and work more hours.

<sup>15</sup>Correcting the hours profile (and so the earnings profile as well) is harder with the procedure we use below: one cannot maintain that the unobservable determinants of hours are uncorrelated with the unobservable determinants of the decision to supply a positive amount of hours.

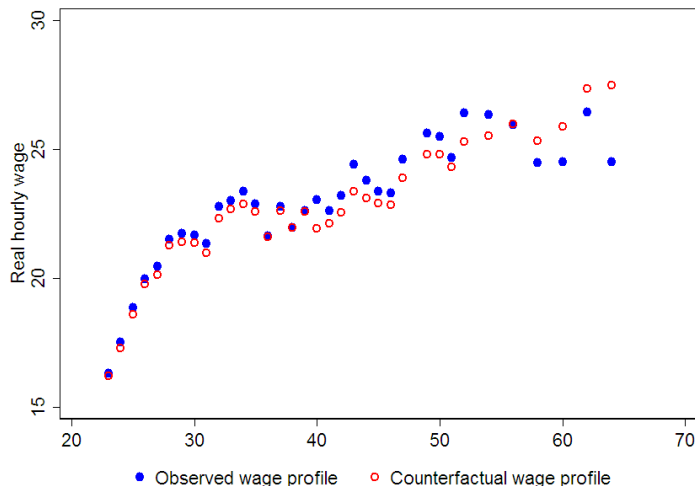
who are not employed in a given year—but for whom we observe covariates in that year as well as in other periods—using the coefficients of wage regressions consistently estimated. Consistency is achieved as follows. As in the case of the attrition test illustrated above, the model consists of a pair of equations, one for outcome (the wage rate) and one for selection into employment—the latter now takes the Tobit form because selection is determined by a corner solution in the labor supply problem.

$$w_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + \theta_i + \varepsilon_{it}, \quad (4)$$

$$h_{it} = \max(0, \mathbf{X}_i\boldsymbol{\gamma} + v_{it}), \quad (5)$$

where  $w_{it}$  is the wage rate,  $h_{it}$  hours,  $\mathbf{x}_{it}$  time-varying covariates,  $\mathbf{X}_i$  contains vectors  $\mathbf{x}_{it}$  at all leads and lags (in practice, feasibility requires us to replace these with the corresponding longitudinal averages), and  $v_{it}$  is normally distributed and independent of  $\mathbf{X}_i$ . It is understood that  $w_{it}$  is observed if and only if  $h_{it} > 0$ . Under the mean conditional independence assumption  $\mathbb{E}[\varepsilon_{it}|\mathbf{X}_i, \theta_i, h_{it} > 0] = 0$   $\boldsymbol{\beta}$  can be consistently estimated via pooled OLS after including in Eq. (4) the Tobit residuals from Eq. (5) estimated for each period as additional regressors. Using this procedure, we obtain a counterfactual wage profile—i.e., the profile we would have observed had those workers who retired remained employed. The observed and counterfactual wage profiles for the 23-years old cohort are reported in Figure 17.

Figure 17: Selection-corrected wage profile



*Notes:* The figure reports the observed average wage profile of individuals who were between 21 and 25 years old in 1967 (cohort 23), and the corresponding profile after prediction of missing wages through a selection-correction procedure.

This figure shows that the non-declining wage profile we have documented is not an artifact of selection. During the early part of the working life there seems to be “negative selection” out of employment. That is, the counterfactual wage profile is below the observed one, suggesting that individuals who do not work would earn a lower hourly wage relative to those who work.

However, towards the end of the working life there is “positive selection” into retirement: it’s workers with higher wages who leave employment first. This evidence is consistent with the findings of [Casanova \(2010\)](#), who studies the wage process of older workers using panel data from the Health and Retirement Study. She also finds evidence of positive selection into retirement. This evidence is instead inconsistent with [French \(2005\)](#), who finds that selection-corrected wages are 7% and 11% lower at age 62 and 65, respectively, relative to the uncorrected ones. However, French uses a very different correction procedure, based on assuming that selection bias in the PSID is the same as in his model, and comparing the wages of workers and non-workers in the model. In any case, as we show next, even negative wage growth in the order of 10% at the end of the working life can hardly be replicated in a benchmark life cycle model unless the intensive margin elasticity of labor supply is calibrated to an implausibly large value.

## 4 A benchmark life cycle model

We now perform a very simple quantitative exercise aimed at understanding how accurately a basic life cycle model explains the empirical regularities we have documented so far. The model is intentionally simple, and, not surprisingly, in its basic version unable to replicate the pattern of falling hours when calibrated with reasonable parameters and the empirical wage profile. We explore which variants of the benchmark model, among those more frequently considered in the macroeconomic literature, are able to reconcile facts and theory. Far from being an exhaustive summary of the literature, this section is intended to be an agenda for empirical research in labor economics and macroeconomics inspired by the data we have described.

In this quantitative exercise we stick to the fiction of a representative worker who makes intensive margin choices only. We do not attempt to replicate the important heterogeneity along gender and education we documented above, nor extensive margin decisions. The reason is that the model we want to use is too simple to capture such heterogeneity or retirement behavior in any meaningful way. Furthermore, the analysis is built on a single cohort, so time and age are indistinguishable in what follows. The representative worker enters the labor market at time 0 and dies at time  $T$ . For the moment, assume there is no uncertainty. The problem is to choose sequences of consumption,  $\{c_t\}$ , labor supply,  $\{h_t\}$ , and assets,  $\{a_{t+1}\}$ , given an exogenous wage profile, a sequence of real interest rates,  $\{r_t\}$ , and initial and terminal assets, to maximize utility over the life cycle:

$$\begin{aligned} \max_{\{c_t, h_t, a_{t+1}\}} \quad & \sum_{t=0}^T \beta^t \left[ v(c_t) - \gamma \frac{h_t^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}} \right] \\ \text{s.t.} \quad & c_t + a_{t+1} \leq a_t(1+r_t) + w_t h_t \\ & h_t \leq \bar{h} \\ & a_0 = a \\ & a_{T+1} = 0 \end{aligned}$$

where  $\beta$  is the discount factor,  $v(\cdot)$  a quasi-concave increasing function,  $\gamma$  the disutility of labor relative to consumption (or, equivalently, the “value of leisure”),  $\varepsilon$  the intertemporal elasticity of substitution of labor, and  $\bar{h}$  the time endowment. From the first-order conditions, the dynamics of



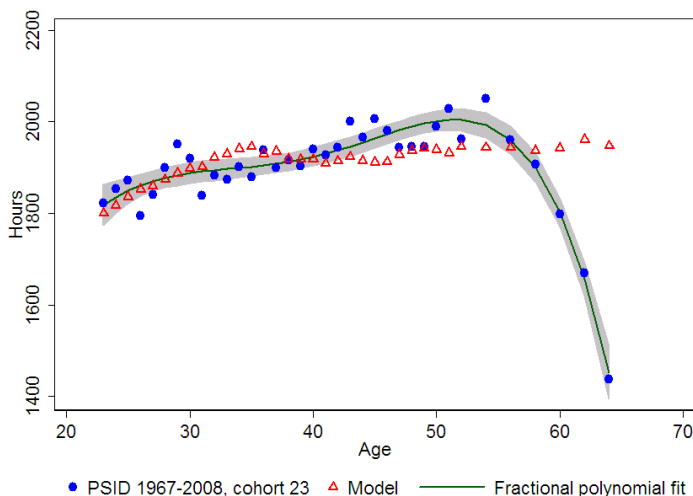
hours in this model, for  $t < T$ , is given by:

$$\frac{h_{t+1}}{h_t} = \left[ \frac{1}{\beta(1+r_{t+1})} \frac{w_{t+1}}{w_t} \right]^\varepsilon. \quad (6)$$

The term  $1/\beta(1+r_{t+1})$  is the ratio between the multipliers on the budget constraint in two adjacent periods and captures the income effect: the worker is moving along a known wage profile and is accumulating assets optimally. The term  $w_{t+1}/w_t$ , on the other hand, captures the substitution effect. If the income effect is not too strong (i.e.  $\beta(1+r_{t+1}) \leq 1$ ) then hours rise if wages do, or fall if wages fall.

Therefore, Eq. (6) can be used to predict the hours profile of the 23 years old cohort in the PSID. We set  $\beta = 0.98$ , and  $\varepsilon = 0.12$ . This is the point estimate of *intensive* margin responses in the SRC subsample of the PSID produced by Fiorito and Zanella (2012). Finally, we estimate the series of  $r_t$  as the difference between the annualized 6-Month Treasury Bill interest rate and the CPI-U (all urban consumers, all items) inflation rate from 1967 to 2008. We set  $h_0$  to 1800 hours per year and simulate hours forward based on the actual PSID wage profile.

Figure 18: Actual and simulated hours profile



The result of this simulation is shown in Figure 18. The model reproduces reasonably well the empirical wage profile until age 50 and very badly afterwards, because of the inability to generate the sharp fall in hours observed after this age.<sup>16</sup> Given a non-declining wage profile, the tracking between hours and wages prevents the model from generating such a fall. Some departure from this benchmark model is needed to match the data. We consider four possible departures: (1) uncertainty about future wages; (2) borrowing constraints; (3) human capital investment via on-the-job training; (4) time-varying disutility of labor. In all these cases hours can potentially fall even if wages do not. However, the empirical implications of such departures are not always plausible. We do not consider the incentives embedded in the Social Security system. While it is well known that these affect labor supply, they primarily affect the extensive margin. And when

<sup>16</sup>Gomme et al. (2004) also find that a standard life cycle model does not perform well when trying to explain the hours of older workers.

they do affect the intensive margin<sup>17</sup> they do not do so until age 62—i.e., about 10 years after the wage profile starts declining.

## 4.1 Uncertainty

As illustrated by Low (2005), if one introduces wage uncertainty in the benchmark model, then it is possible to have declining hours in spite of an increasing wage profile. That is, it is possible to observe high labor supply early in life when wages are low, and low labor supply later in life when wages are high. Uncertainty breaks the close tracking between hours and wages. The intuition is straightforward: when the wage rate is uncertain, workers are subject to a precautionary effect and delay leisure until the late stages of the life cycle. The point can be illustrated analytically as follows. Without uncertainty, the growth rate of hours, from Eq. (6), is approximately equal to:

$$\Delta \ln h_{t+1} = -\varepsilon \ln \beta(1 + r_{t+1}) + \varepsilon \Delta \ln w_{t+1}, \quad (7)$$

where  $\Delta \ln h_{t+1} = \ln h_{t+1} - \ln h_t$ , and similarly for  $\Delta \ln w_{t+1}$ . If the wage rate is uncertain, then the first-order conditions do not boil down to anything like Eq. (6). Instead, they boil down to:

$$\frac{h_t^{\frac{1}{\varepsilon}}}{w_t} = \beta(1 + r_t) \mathbb{E}_t \left[ \frac{h_{t+1}^{\frac{1}{\varepsilon}}}{w_{t+1}} \right]. \quad (8)$$

Taking a second-order expansion of  $\frac{h_{t+1}^{\frac{1}{\varepsilon}}}{w_{t+1}}$  around  $h_t, w_t$  and rearranging, we obtain the analog of Eq. (7) under uncertainty:

$$\mathbb{E}_t[\Delta \ln h_{t+1}] = -\varepsilon \ln \beta(1 + r_{t+1}) + \varepsilon \mathbb{E}_t[\Delta \ln w_{t+1}] - \frac{1 - \varepsilon}{2\varepsilon} \mathbb{E}_t[\Delta \ln h_{t+1}^2] - \varepsilon \mathbb{E}_t[\Delta \ln w_{t+1}^2]. \quad (9)$$

The variance of the wage rate and the consequent variance of hours (i.e., the last two terms) counterbalance the effect of positive wage growth on the hours profile. If the variance increases late in the life cycle, then hours may fall even if the wage rate does not. However, this variant of the benchmark model does not perform well quantitatively in our sample. To illustrate, we solve Eq. (9) for  $\mathbb{E}_t[\Delta \ln h_{t+1}^2]$  after replacing the left-hand side with  $\Delta \ln h_{t+1}$  and recover the implied series of the variance of the growth rate of hours under the same calibrated parameters.<sup>18</sup> Given the variance of wages, such variance in the series for hours growth allows the model to perfectly replicate the PSID trend. This series is illustrated in Figure 19. Two things are noteworthy in this picture. First, the model actually requires *negative* variance of the growth rate of hours over most of the early part of the life cycle—which of course cannot be. The reason is that the benchmark model without uncertainty reproduces the trend in hours reasonably well until age 50. With uncertainty, the variance of the wage profile reduces hours growth. Therefore, one would need negative variance of hours to keep hours growing at the rate they would grow without uncertainty. Second, while the variance is roughly constant over this part of the life cycle, it needs to grow sharply after

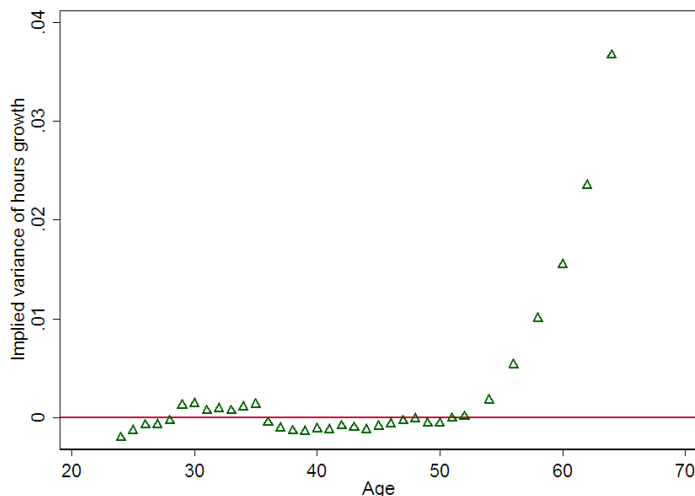
<sup>17</sup>Johnson and Neumark (1996) suggest that Social Security may lead some workers to choose jobs or tasks associated with low wages

<sup>18</sup>Via the formula  $\mathbb{V}_t[\Delta \ln h_{t+1}] = \mathbb{E}_t[\Delta \ln h_{t+1}^2] - \mathbb{E}_t[\Delta \ln h_{t+1}]^2$ .

age 50 to induce the observed fall in hours.

The benchmark model with uncertainty, therefore, raises two questions when attempting to replicate the empirical hours profile given a non-declining wage profile. First, why do hours exhibit some positive growth until age 50? Second, why does the variance of hours or the variance of wages, or both, increase sharply after this age? Notice that this conclusion does not depend on the assumption of intratemporal separability between consumption and leisure. Such an assumption, as [Low \(2005\)](#) makes clear, has consequences for the shape of the consumption profile, which is not the focus of this paper.

Figure 19: Implied variance of the hours growth rate



## 4.2 Borrowing constraints

[Erosa et al. \(2011\)](#) are able to replicate the fall in hours worked in the PSID by calibrating a model with both uncertainty and a borrowing constraint. The constraint takes the form of a zero lower bound on assets. Workers engage in precautionary savings and work more when young (more than in [Low \(2005\)](#), where there is no borrowing constraint) even if their future wage rate will be higher. Later in the life cycle, the stock of assets is so large that even small negative wage shocks induce workers to retire. Since the time period in their model is a third of a year, retirement generates a decline in hours on a one-year basis. Notice that this explanation relies on an active extensive margin. In particular, the argument implies that a declining hours profile of workers is an artifact of staggered abrupt retirement, in the sense discussed at the end of [section 3.2](#). However, we have documented there that this is not the case in the PSID: pre-retirement transitions to fewer hours are an important phenomenon.

It is nonetheless of interest to understand whether a borrowing constraint improves the empirical performance of the benchmark model along the intensive margin of labor supply. To isolate the role of such a constraint, we assume that there is no uncertainty. Adding inequality  $a_{t+1} \geq 0$  to the constraint set and denoting by  $\mu_t$  the associated multiplier, the Euler equation becomes:

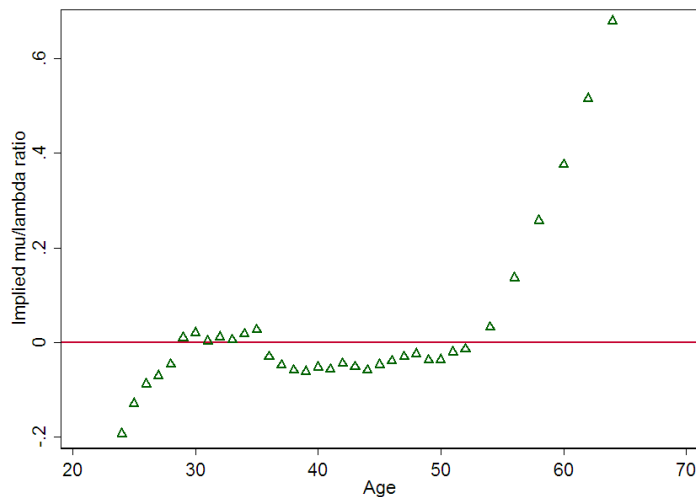
$$\lambda_t = \beta(1 + r_{t+1})\lambda_{t+1} + \mu_t, \tag{10}$$

meaning that when the borrowing constraint is binding ( $\mu_t > 0$ ) a worker cannot smooth consumption, so  $\lambda_t > \beta(1+r_{t+1})\lambda_{t+1}$  and consumption at time  $t$  is lower than it would have been otherwise. The dynamics of hours is now given by:

$$\frac{h_{t+1}}{h_t} = \left[ \frac{1 - \frac{\mu_t}{\lambda_t}}{\beta(1+r_{t+1})} \frac{w_{t+1}}{w_t} \right]^\varepsilon. \quad (11)$$

That is, hours grow at a slower (possibly negative) rate when the borrowing constraint is binding, and at the same rate as in the basic model when it is not. This may sound counterintuitive: we expect an individual for whom the borrowing constraint is active—i.e., for whom the marginal utility of consumption is higher than in the unconstrained case and so an extra hour of work more valuable—to work more. However, this is a statement about growth rates, not levels. A borrowing-constrained worker does, in fact, work more hours in the model when the constraint is binding compared to when it's not. As a consequence, the hours growth rate is defined relative to a higher level and so is lower. From Eq. (11) we can back-out the series of  $\frac{\mu_t}{\lambda_t}$  that allows the model to reproduce the data. This is illustrated in Figure 20. Not surprisingly, we incur in the same difficulty as in the previous case of uncertainty. Here it is the  $\mu_t/\lambda_t$  ratio that is required to be negative during most of the early part of the life cycle—which of course cannot be either. Furthermore, to explain the hours decline along the intensive margin through this channel we would need a binding borrowing constraint after age 55. This contradicts the empirical fact that after that age workers dissave and do not borrow. The model of Erosa et al. (2011), in fact, reproduces the fall in hours per worker worse than the fall in hours per person.

Figure 20: Implied  $\frac{\mu_t}{\lambda_t}$



### 4.3 On-the-job training

A falling hours profile can be generated out of a non-declining wage profile in the benchmark model if wages depend on past labor supply. This is what happens in the presence of accumulation of human capital via on-the-job training: in this case it is by working that an individual obtains

wage growth over the life cycle. Such a mechanism breaks the tracking between hours and wages because it is no longer true that young workers want to work less than older workers in response to their initially low wages. However, the extent of the fall in hours late in the working life depends on how fast the effect of current hours of work on future wages (that is, the return to on-the-job training) declines. To illustrate, assume that the current wage rate depends on past labor supply:

$$w_t = w_t(\mathbf{h}^{t-1}), \quad \text{where} \quad \mathbf{h}^{t-1} = \{h\}_{j=0}^{t-1}.$$

As illustrated by [Keane \(2011\)](#), the consequence is that the opportunity cost of time increases. The increase is equal to the present value of the cumulative effect of current labor supply on all future wage rates. To see this, notice that now the first-order condition for hours is no longer  $h_t^{\frac{1}{\varepsilon}} = v'(c_t)w_t$ , but:

$$h_t^{\frac{1}{\varepsilon}} = v'(c_t)w_t + \sum_{j=t+1}^T \beta^{j-t} v'(c_j) h_j \frac{\partial w_j}{\partial h_t}, \quad (12)$$

where the second term on the right-hand side is the present value of the lifetime increase in earnings caused by an extra hour of work at time  $t$ . [Eq. \(6\)](#) becomes:

$$\frac{h_{t+1}}{h_t} = \left[ \frac{1}{\beta(1+r_{t+1})} \frac{\tilde{w}_{t+1}}{\tilde{w}_t} \right]^{\varepsilon}, \quad (13)$$

where

$$\tilde{w}_t = w_t + \sum_{j=t+1}^T \frac{1}{\prod_{k=t+1}^j (1+r_k)} h_j \frac{\partial w_j}{\partial h_t}. \quad (14)$$

It is clear from these expressions that hours decline, even if the current wage rate does not, if the full opportunity cost of time  $\tilde{w}_t$  declines fast enough. We can infer from the data the growth rate of  $\tilde{w}_t$  that makes this variant of the model consistent with the empirical hours trend. The series is illustrated in [Figure 21](#). Given that the wage profile is essentially flat after age 50, this variant of the benchmark model implies that in order to reproduce the data, the marginal return from on-the-job training (i.e.,  $\tilde{w}_t - w_t$ ) should decline by about 7% per year from age 52 to age 64. This number matches remarkably well the estimate of the decline in the rate of return provided by [Kuruscu \(2006\)](#). In that paper, the cumulative decline in the marginal return from on-the-job training between 30 and 45 years of experience (age 53 and 68 in our paper) is about 6% per year (see [Figure 5](#) in [Kuruscu \(2006\)](#)).

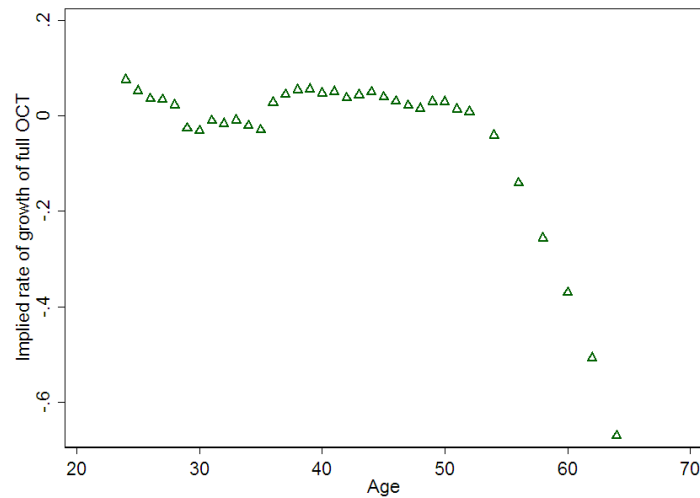
#### 4.4 Increasing disutility of work/utility of leisure

Finally, predicted hours may fall in the benchmark model if we allow the disutility of labor/value of leisure to increase after age 50. If  $\gamma$  is not constant, then [Eq. \(6\)](#) becomes:

$$\frac{h_{t+1}}{h_t} = \left[ \frac{1}{\beta(1+r_{t+1})} \frac{w_{t+1}}{w_t} \frac{\gamma_t}{\gamma_{t+1}} \right]^{\varepsilon}. \quad (15)$$

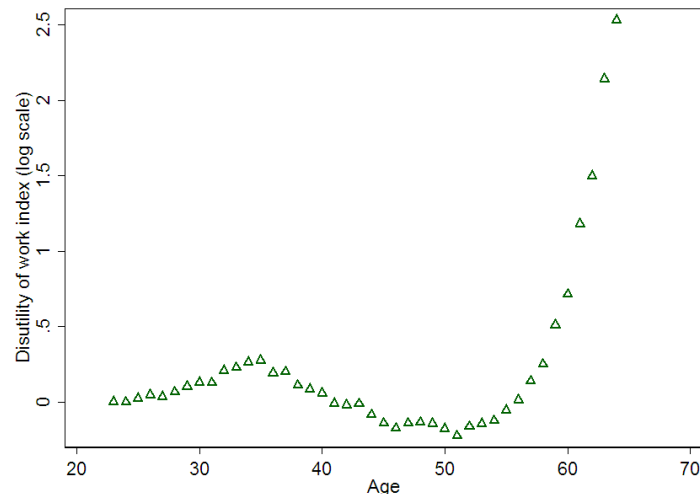
Clearly, if  $\gamma_t$  increases sufficiently fast after age 50 then hours fall. Like before, we can ask how this parameter should evolve in this model to reproduce the trend of the observed hours profile

Figure 21: Implied growth rate of full opportunity cost of time



(i.e., back out the implied  $\gamma_t$  profile). The result is illustrated in Figure 22, using the log scale. This picture reveals an interesting pattern.  $\gamma_t$  increases until the mid 30s (by about 30% at the local maximum at age 35), then declines throughout one’s 40s (by more than 60%, relative to the peak at 35, at the minimum, at age 51), and then picks-up very quickly. That is, the disutility of working or the value of alternatives to market work (or both) increases during the early years in the labor market, declines during the second half of prime age, and then increases fast. For junior workers, this may reflect adaptation and careers; for prime-age workers, work habits; for seniors, instead, factors such as health deterioration, stress, or a desire to work less and devote time to other activities may play an important role.

Figure 22:  $\gamma_t$  index



Health, however, explains little of the discrepancy between the actual and simulated profiles. Table 3 reports the results from a fixed-effects regression of hours on a quartic polynomial in age and the “disabled” dummy described in section 3. The regression reveals that deteriorating

health (as captured by this variable) induces a decline of only about 100 hours—less than 20% of the discrepancy between the data and the model at age 64 in cohort 23. Although this particular longitudinal measure of disability in the PSID may be a poor proxy for health conditions, the data suggest that an increase in the marginal disutility of labor via health deterioration alone is unlikely to explain the fall in hours after age 50. This is consistent with French (2005), who concludes that “health status alone must have a small causal role in the decline in the number of hours worked by workers near retirement.” (p. 410)

Table 3: Effect of disability on hours of workers

	1	2
	hours	hours
<i>disabled</i>	-98.215*	-102.133*
	(23.765)	(6.428)
<i>age</i>	384.056*	-13.774
	(104.357)	(10.680)
<i>age</i> <sup>2</sup>	-1,509.235*	141.247*
	(391.433)	(38.101)
<i>age</i> <sup>3</sup>	265.293*	-21.001*
	(63.125)	(5.748)
<i>age</i> <sup>4</sup>	-17.282*	0.361
	(3.702)	(0.311)
<i>Const.</i>	-1,773.50	1,570.944*
	(1,006.962)	(106.465)
Cohort	23 years old	all
Observations	9,427	143,156
Individuals	510	15,016

*Notes:* The table contains the results from a regression of hours on a fourth-degree polynomial in age and variable *disabled*. This is a dummy variable that takes value 1 if a person responded “yes” to the question “Do you have any physical or nervous condition that limits the type of work or the amount of work that you can do?”, and 0 otherwise. Only individuals reporting strictly positive hours and included in the regression. Standard errors in parenthesis. An asterisk denotes significance at the 1% confidence level or better

Another possibility is that the value of alternatives to market work increases during the pre-retirement years. For instance, in a companion paper to this one (Rupert and Zanella (2010)) we show that, with unchanging preferences over the life cycle, grandparenting goes a long way towards reconciling falling hours and non-declining wages. The reason is that the appearance of grandchildren increases the value of “leisure” during the preretirement years. It is interesting to note that in Figure 22 the value of alternatives to market work increases in those stages of the life cycle when there are young children in the household or the family. This endogenous process is observationally equivalent, in the benchmark model, to an exogenous increase in  $\gamma$  late in the life cycle. This example indicates how the evidence documented in this paper restricts quantitative macroeconomic models. Except for the dependence of  $\gamma$  on age and the wage schedule, this variant of the model is the discrete-time version of Rogerson and Wallenius (2009). They assume that the

wage profile is hump-shaped. Their results can be obtained with a concave, non-declining wage profile and a J-shaped profile for the value of leisure similar to the one in [Figure 22](#). Our results indicate that the latter is likely a better assumption.

## 5 Conclusions

We have documented that life-cycle wage profiles derived from the Panel Study of Income Dynamics show no tendency to decline until late into one’s 60’s. In contrast, hours begin to fall after age 50, as do earnings. These results challenge a common assumption in macroeconomic models, that the wage profile is hump-shaped and that it is its decline late in the working life that induces a reduction of labor supply along the intensive margin. A benchmark life cycle model is unable to replicate this pattern. The model and the data can be reconciled by departing from such benchmark. The mere presence of uncertainty and borrowing constraints seem unable, by themselves, to do so. However, we have shown that the life cycle model is able to replicate the empirical pattern under two circumstances, in particular. First, the benefits of accumulating human capital via on-the-job training are an important component of the opportunity cost of time and decline relatively fast after age 50—in line with previous empirical research. Second, the value of alternatives to work for pay increase fast after that same age. Research about this channel is more scant. While deteriorating health plays a role, it seems unlikely that it plays a decisive role. The possible desire by part of older workers to allocate more time to activities different from work for pay—perhaps because new “goods” become available—seems a promising direction for future research.

## 6 Appendix

In this appendix we report tables containing the numerical life cycle profiles illustrated in the paper. The initial value is normalized to 1 for cohort 23. For older cohorts, the initial value is normalized to the corresponding value, at that same age, of cohort 23.

We report both the raw profile and the profile smoothed using a fractional polynomial fit (degree 2 for wages and earnings, degree 4 for hours).



Table 4: Wage profiles

Age	Cohort 23		Cohort 28		Cohort 33		Cohort 38	
	Raw	Smooth	Raw	Smooth	Raw	Smooth	Raw	Smooth
23	1.000	<b>1.000</b>						
24	1.074	<b>1.109</b>						
25	1.157	<b>1.153</b>						
26	1.225	<b>1.191</b>						
27	1.254	<b>1.225</b>						
28	1.319	<b>1.255</b>	1.319	<b>1.255</b>				
29	1.333	<b>1.282</b>	1.329	<b>1.279</b>				
30	1.329	<b>1.306</b>	1.364	<b>1.300</b>				
31	1.310	<b>1.327</b>	1.381	<b>1.320</b>				
32	1.397	<b>1.347</b>	1.392	<b>1.337</b>				
33	1.411	<b>1.365</b>	1.423	<b>1.354</b>	1.411	<b>1.365</b>		
34	1.433	<b>1.381</b>	1.442	<b>1.369</b>	1.422	<b>1.376</b>		
35	1.404	<b>1.395</b>	1.438	<b>1.383</b>	1.458	<b>1.388</b>		
36	1.328	<b>1.408</b>	1.402	<b>1.396</b>	1.477	<b>1.400</b>		
37	1.397	<b>1.421</b>	1.466	<b>1.408</b>	1.488	<b>1.411</b>		
38	1.348	<b>1.432</b>	1.472	<b>1.420</b>	1.522	<b>1.423</b>	1.348	<b>1.432</b>
39	1.387	<b>1.442</b>	1.486	<b>1.430</b>	1.542	<b>1.435</b>	1.358	<b>1.464</b>
40	1.412	<b>1.452</b>	1.460	<b>1.440</b>	1.537	<b>1.447</b>	1.393	<b>1.493</b>
41	1.386	<b>1.460</b>	1.388	<b>1.450</b>	1.500	<b>1.459</b>	1.411	<b>1.518</b>
42	1.424	<b>1.468</b>	1.375	<b>1.459</b>	1.568	<b>1.470</b>	1.422	<b>1.539</b>
43	1.497	<b>1.476</b>	1.363	<b>1.468</b>	1.575	<b>1.481</b>	1.453	<b>1.558</b>
44	1.459	<b>1.483</b>	1.384	<b>1.476</b>	1.589	<b>1.492</b>	1.473	<b>1.574</b>
45	1.434	<b>1.489</b>	1.382	<b>1.484</b>	1.561	<b>1.503</b>	1.469	<b>1.588</b>
46	1.429	<b>1.495</b>	1.396	<b>1.491</b>	1.485	<b>1.514</b>	1.432	<b>1.600</b>
47	1.509	<b>1.501</b>	1.439	<b>1.499</b>	1.471	<b>1.524</b>	1.497	<b>1.611</b>
48	1.540	<b>1.506</b>	1.454	<b>1.506</b>	1.458	<b>1.534</b>	1.504	<b>1.620</b>
49	1.571	<b>1.511</b>	1.445	<b>1.513</b>	1.480	<b>1.543</b>	1.518	<b>1.627</b>
50	1.563	<b>1.516</b>	1.432	<b>1.519</b>	1.478	<b>1.552</b>	1.491	<b>1.634</b>
51	1.513	<b>1.520</b>	1.435	<b>1.526</b>	1.493	<b>1.561</b>	1.418	<b>1.639</b>
52	1.619	<b>1.524</b>	1.442	<b>1.532</b>	1.540	<b>1.569</b>	1.405	<b>1.644</b>
53			1.788	<b>1.538</b>	1.555	<b>1.576</b>	1.392	<b>1.647</b>
54	1.614	<b>1.531</b>	1.560	<b>1.545</b>	1.546	<b>1.583</b>	1.414	<b>1.650</b>
55			1.504	<b>1.551</b>	1.532	<b>1.589</b>	1.411	<b>1.653</b>
56	1.592	<b>1.538</b>	1.465	<b>1.557</b>	1.535	<b>1.594</b>	1.426	<b>1.654</b>
57			1.504	<b>1.563</b>	1.542	<b>1.599</b>	1.471	<b>1.655</b>
58	1.501	<b>1.544</b>			1.912	<b>1.603</b>	1.486	<b>1.656</b>
59			1.535	<b>1.574</b>	1.669	<b>1.605</b>	1.477	<b>1.657</b>
60	1.503	<b>1.549</b>			1.609	<b>1.607</b>	1.463	<b>1.657</b>
61			1.579	<b>1.586</b>	1.567	<b>1.608</b>	1.466	<b>1.656</b>
62	1.621	<b>1.554</b>			1.608	<b>1.608</b>	1.473	<b>1.656</b>
63			1.564	<b>1.598</b>			1.826	<b>1.655</b>
64	1.503	<b>1.558</b>			1.642	<b>1.604</b>	1.594	<b>1.654</b>
65			1.563	<b>1.610</b>			1.537	<b>1.652</b>

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