

# Revisiting Wage, Earnings, and Hours Profiles\*

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**Abstract.** This paper documents empirical life cycle profiles of wages, earnings, and hours of male workers from the Panel Study of Income Dynamics. We find that the wage profile does not decline with age, while hours per worker drop sharply beginning shortly after age 50, when many employed individuals seem to start a smooth transition into retirement by working progressively fewer hours. This evidence is robust to (and actually reinforced by) selection-correction, and is not affected by attrition. The traditional hump-shape of the earnings profile documented elsewhere in the literature (and that we find as well) is therefore driven by labor supply. This pattern poses a challenge to the standard life cycle model. Among other possibilities, a model in which the value of leisure/disutility of work grows after age 50 can reconcile theory and data.

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

**Keywords:** wages, earnings, labor supply, life cycle, synthetic cohorts, human capital, preretirement, value of leisure.

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# 1 Introduction

This paper is an empirical investigation into wage (i.e. hourly compensation of labor), hours (i.e. hours of market work), and earnings (i.e. the product of wage and hours) profiles over the entire life cycle, from the vantage point of panel data. To date, no empirical study has simultaneously considered these three variables within the same framework using individual-level, longitudinal data covering the entire working life. In contrast, the theoretical literature is much more mature.

Consensus is well-established around two different theories. First, the human capital model. This framework is still the workhorse in macro-labor, and makes sharp predictions on the shape of wage, hours, and earnings profiles over the life cycle. A common view in the literature on human capital acquisition and its returns is that these profiles are all “hump-shaped.” The human capital model initiated by [Ben-Porath \(1967\)](#) and developed by [Ghez and Becker \(1975\)](#), [Blinder and Weiss \(1976\)](#), [Ryder, Stafford, and Stephan \(1976\)](#), [Heckman \(1976\)](#), and [Rosen \(1976\)](#) posits that the wage rate is the unit return on the individual stock of human capital. The wage rate initially grows because 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 that reflects the dynamics of individual productivity. Hours and earnings, then, are also hump shaped. This model was meant to explain the “stylized facts” known at the time, summarized by [Figure 1](#) and this quote, both taken from [Weiss \(1986\)](#):

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 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. (p. 603)

At the time these empirical regularities were discovered, the main data sources were either cross-sectional or short panels, so “the major stylized facts which the theory attempt[ed] to explain” derived from synthetic cohorts or repeated cross sections from administrative sources, such as social security data.<sup>1</sup> [Figure 2](#) illustrates life cycle profiles from a single cross-section of the Panel Study of Income Dynamics (PSID) using the synthetic cohort method. These profiles closely resemble the theoretical ones shown in [Figure 1](#).<sup>2</sup> This representation explains why the human capital model has been so successful. However, the bias that derives from the use of synthetic cohorts rather than longitudinal data can be substantial. [Thornton, Rodgers, and Brookshire \(1997\)](#) and [Rubinstein and Weiss \(2006\)](#) offer an illustration for annual and weekly earnings, respectively.

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<sup>1</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  $t + j$ .

<sup>2</sup>We choose 1970 to reconstruct what a researcher would have inferred in the early 1970s. The wage and earnings profiles in [Figure 2](#) result from “tilting” the raw cross sectional profiles to allow for 1% real wage growth every year. This is the average growth rate of labor productivity in the US between 1970 and 2006. In other words, the wage of an individual  $a$  years old in the cross section is multiplied by  $(1.01)^{a-23}$ , where 23 is the conventional age of the youngest worker in the cross section. The interpolated lines are the predicted values from a regression of the real wage on a second-order polynomial of age. This was the standard representation before [Murphy and Welch \(1990\)](#) suggested a fourth-order polynomial.

Figure 1: Theoretical Profiles, Weiss (1986)

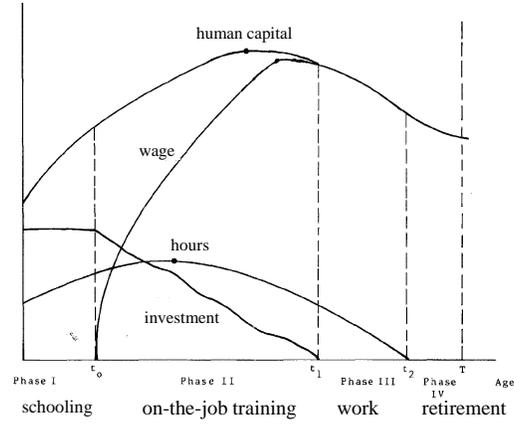
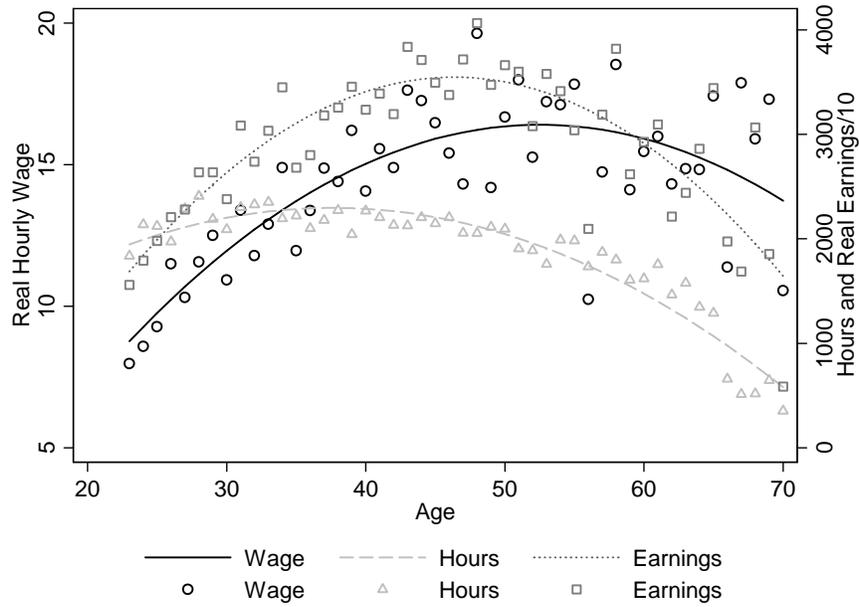


Figure 2: Empirical Profiles, 1970 Synthetic Cohort from the PSID

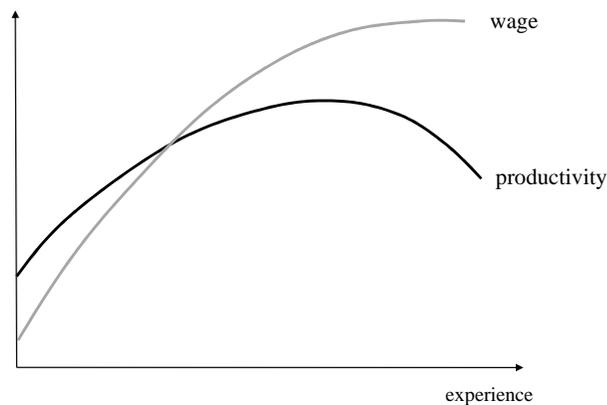


Second, there is a strand of literature that incorporates the theory of incentives. This framework is more popular in microeconomics than in macro-labor, and provides important insights on the shape of the wage profile. The works, among others, of [Becker and Stigler \(1974\)](#), [Lazear \(1979, 1981\)](#), [Freeman \(1977\)](#), [Medoff and Abraham \(1980\)](#), [Medoff and Abraham \(1981\)](#), [MacDonald \(1982\)](#), and [Harris and Holstrom \(1982\)](#) show that wage growth is possible even in the absence of human capital (and productivity, more generally) growth. These papers suggest that the wage profile need not decline towards the end of the working life. [Gibbons and Waldman \(1999\)](#) offer a thorough review of this literature, which they summarize as follows:

Although the exact size of the returns to seniority is still being debated, the emerging consensus seems to be that firm-specific seniority has a significant positive effect on wage growth (p. 2397).

Consider, as an example, the Lazear model. [Figure 3](#) is a simplified illustration. In order to prevent shirking over the worker's career, wages must be below productivity when seniority is low, and above productivity when seniority is high. Furthermore, wage growth must be positive until retirement, as the incentive to shirk increases closer to retirement. A similar prediction comes from models that emphasize instead learning about workers' ability and insurance as the force preventing wages from falling. This prediction is not necessarily contrary to the corresponding predictions of the human capital model, for at least two reasons. First, the human capital model produces a non-declining wage profile when skills do not experience net depreciation. Second, the prediction of these models for wage growth is conditional on remaining tied to the same employer. This literature, however, is agnostic about labor supply.

Figure 3: Theoretical Wage Profile, Lazear (1979, 1981)



Our analysis exploits a unique feature of the PSID (1968-2007). This dataset now covers 40 years and so spans the entire working life of many in the cohort who entered the labor market in 1967, when the survey was initiated. It also includes the final portion of the working life of older cohorts whose careers started before 1967. This feature allows us to construct actual life cycle profiles by averaging individuals—we emphasize that these are always the *same* individuals—at each point in time and contrast them with both the empirical regularities found in cross-sectional data and the theoretical predictions of different models. We find that the wage rate does not exhibit any clear tendency to fall at the end of the working life (at least not until well into one’s 60’s). On the other hand, hours per worker drop sharply beginning shortly after age 50. Therefore, the observed decline in earnings after this age is completely driven by the decline in hours worked. This presents a significant challenge for the standard life cycle model with a constant value of leisure, regardless of the reason why the wage rate is not declining. The novelty of our contribution is not the evaluation of different models of wage growth, which requires a more sophisticated analysis based on higher moments. [Rubinstein and Weiss \(2006\)](#) offer a thorough survey of contributions to this area, including a review of alternative models of wage growth. Rather, our contribution is the joint documentation of the dynamics of wages, hours, and earnings over actual life cycles. The apparent puzzle we bring to light—hours fall sharply while the wage does not decline—indicates that some departure from the benchmark model is needed (we show later in the paper that wealth effects cannot explain this pattern). One possibility is to allow the value of leisure to increase during the pre-retirement years. In a companion paper to this one [Rupert and Zanella \(2010\)](#), for instance, we show that (with unchanging preferences over the life cycle) grandparenting goes a long way towards reconciling these empirical regularities. Our findings are robust to (and are actually reinforced by) selection-correction in the panel, and are not affected by attrition. To overcome the difficulties generated by a small sample size and to provide a further check on the effects of attrition we compute the same profiles for the same cohort using the March supplement of the Current Population Survey, CPS (1978-2009) which roughly reproduces the pattern we observe in the PSID.

We are not the first to observe that some measure of the wage rate does not decline at the end of working life while annual earnings do. For instance, [Mincer \(1974\)](#), who had noticed this pattern studying weekly earnings in census data, suggested the following:

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 has remained somewhat overlooked, as the prevailing approach is to attribute the decline in hours late in the life cycle to a hump-shaped wage profile. This approach is common outside the labor literature as well. For instance, [Bullard and Feigenbaum \(2007\)](#) show that one can obtain a hump-shaped consumption profile calibrating a model in which consumption and leisure are substitutes with a hump-shaped hourly wage profile, derived from a synthetic cohort from the 2002 March CPS. More recently, [Casanova \(2010\)](#) analyzed data from the Health and Retirement Study and found that after correcting for selection into retirement there is no evidence that wages of senior (i.e. after age 50) workers decline. She has richer data than we do in terms of gender, health, and type of pension scheme, as well as a larger sample size at older ages. However, she analyzes

the wage profile in isolation and does look at hours—her main point is correcting wage profiles for selection into retirement—while we are interested in understanding the relationship between wages and hours over the life cycle. The remainder of the paper is organized as follows. Section 2 briefly reviews the literature related to our work. Section 3 describes the dataset and documents empirical life cycle profiles. Section 4 discusses the underlying model. Section 5 concludes.

## 2 Related literature

A number of other papers are directly or incidentally concerned with life cycle profiles. [Kuruscu \(2006\)](#) estimates the return to on-the-job training, of the type emphasized in human capital theory, using NLSY data (a dataset that does not yet allow the observation of wages of older workers) and *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. Our results, based on following a cohort for 40 years, confirm that his assumption holds for men: wage growth is negligible after about 20 years of experience but does not become negative. In his model, however, labor is inelastically supplied (i.e. leisure has no value), and depreciation of human capital is zero. The second assumption naturally generates a non-declining wage rate, but the first assumption puts aside the question of what happens to hours. We notice that one of Kuruscu’s results (“workers who experience wage growth in later years of their working life are the ones whose learning technology generates large benefits from training”, p. 843) is consistent with the conditional profiles we report below—both the profiles of skilled and unskilled workers grow fast in the early years, then the unskilled profile stops growing after 15-20 years, while the skilled profile grows for an additional 10-15 years. In Kuruscu’s framework this means that college graduates operate a learning technology that generates a higher return to on-the-job training.

[French \(2005\)](#) uses PSID data to study retirement behavior and the dynamics of hours. He focuses on the role of health and social security rules. French emphasizes old workers’ movement along the extensive margin (retirement), while we focus on their choices along the intensive margin (hours) conditional on working. He estimates wage profiles and corrects for selection nonparametrically, relying on calibration. French shows that the (uncorrected) wage profile is markedly hump-shaped, with the decline beginning at age 50. However, he pools cohorts that are 18 years apart and so the estimated wage profile may be affected, to some extent, by synthetic cohort bias.

[Manovskii and Kambourov \(2005\)](#) look at empirical wage and earnings profiles in their study of the role of occupational mobility (which is supposed to destroy occupation-specific human capital) in the reduction of wage growth of successive cohorts, as well as increased earnings inequality, in the US from the 1960s onward. They use PSID data up to 1996, because there is no information on job mobility thereafter. As a consequence, they fit wage profiles only until workers are in their early 40s. Using a polynomial of third degree in age (figures 9 and 10 in their paper) they show that the wage profile is flattening and that there seems to be some negative growth for low-skilled workers. These pictures are consistent with the evidence we report in this paper, but not entirely consistent with the model they use. [Manovskii and Kambourov \(2005\)](#) is a model with learning-by-doing and general as well as specific human capital (linearly aggregated). However, eventually learning is zero and total human capital declines. At that point the wage rate (which is the product of total human capital and individual-specific productivity shocks) declines too. So the implied wage profile is hump-shaped like in the benchmark human capital model.

Huggett, Ventura, and Yaron (2007) use a human capital model and PSID data to understand the sources of income inequality. They use the family file of the PSID and follow cohorts defined by 5-year age bins, like we do in this paper. They are concerned with separating age from time and cohort effects, and only look at mean earnings. These have the conventional hump-shape both in the data and the model (figures 1 and 2 in their paper). We too find this hump-shape in earnings and we show, in addition, that it is driven by a fall in mean hours while the mean wage is not declining. This is inconsistent with the human capital model Huggett, Ventura, and Yaron employ.

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, respectively. The model is estimated using data from the NLSY, like Kuruscu (2006), and produces out-of-sample (i.e. after age 40) predictions that, not surprisingly, have the shape of the profiles in Figure 2. 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.

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 (specifically, a flat initial portion of the function that turns hours of work into labor services) that generates motives for entering and leaving the labor force at specific points in the life cycle (the “reservation property” of hours). Their model takes individual productivity to be 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 individual productivity is not hump-shaped is by assuming that the disutility of working increases at later stages in the life cycle.

## 3 Data

### 3.1 Data sources and data selection criteria

After the release of the 2007 wave in August 2009, the PSID offers the unique opportunity to observe life cycle profiles of individuals for wages, hours, and earnings spanning 39 years (from 1967 to 2006), i.e. nearly the entire working life of the cohort who entered the labor market in 1967. For this reason, this is the main cohort we look at, although we consider older cohorts as well. We compute weighted averages (using PSID sampling weights) of wage rates, hours, and earnings for a given cohort in a given year to trace the life cycle profiles of individuals in that cohort.

Wage rates are directly observed for workers paid by the hour (these oscillate in time between 23% and 46% of the total in our final sample) and are estimated by the ratio between annual hours and annual earnings for those who are salaried. It is well known that this procedure may introduce substantial measurement error. However, this problem is vastly mitigated by averaging the variables of interest across the cohort. Since we do not average zeros (i.e. we look at workers only) sample selection is an issue. Furthermore, in order to follow individuals during their working life we only use workers who are present in the PSID since the beginning of the survey in 1967. The drawback is that we have substantial attrition for this initial sample over a period of 40 years. We will address self-selection and attrition below.

To overcome the difficulties associated with attrition and small sample size, we also collected

data for the same PSID cohorts from the Outgoing Rotation Groups of the CPS and constructed (after applying the same data selection criteria described below) the same life cycle profiles from a much larger dataset—the rotation group provides labor market information for about 100,000 individuals every year. The disadvantage of course is that the CPS is not a standard panel, and so one should expect a volatile series relative to the PSID despite the large sample size. Yet, large repeated cross sections (or rotation panels, in the case of the March CPS) provide an approximation that is good enough for the purposes of checking the long-run trend of a relatively small panel. The CPS contains no information on hourly wages until the early 1980s, so the corresponding series will be shorter than the PSID series.

We apply the following data selection criteria. We use the PSID core sample and the associated sampling weights so that the sample statistics are representative of the corresponding US population.<sup>3</sup> We use the family-level data file, because it allows us to exploit a number of covariates of interest. This means that we have full longitudinal information for household heads only. These are mostly men, so we discard women in order to have an accurate picture of a homogeneous group. 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, men 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. 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. All nominal quantities are expressed in constant 1982 dollars using the CPI-U. We exclude individuals whose nominal wage rate in a given year is below the federal minimum wage in force that year. Furthermore, 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 one or two observations every year. In addition to the main labor market variables of interest (wages, hours, and earnings), we observe a number of useful covariates: age, education, health, non-labor income, number of children, and family size.

## 3.2 Empirical profiles

We begin with an illustration of profiles estimated from weighted averages without attempting any selection-correction to account for the retirement process or attrition. [Figure 4](#) shows the wage profile for the 23 years old cohort—the youngest cohort in the sample. The profile is increasing until age 40, real wage growth is modest afterwards, but there is no clear tendency for the profile to decline at retirement age. This pattern is confirmed by the shorter CPS series reported in the same figure. Despite the much larger sample size, the CPS profile is more volatile, being a rotating panel. However, the two surveys agree on the absence of negative wage growth for this cohort towards the end of the working life. [Figure 5](#) reports the PSID profile with the 95% confidence interval of the estimated means. These estimates become progressively noisier as sample size decreases (because of attrition and retirement) but the picture confirms that the most likely trend for the wage profile is non-decreasing.

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<sup>3</sup>The PSID core sample is the combination of the 1968 SCR sample (a representative sample of about 3,000 households) and the 1968 SEO sample (a non-representative sample of about 2,000 low-income families).

We gain further insight by estimating the following model:

$$w_{it} = \mathbf{a}_{it}\boldsymbol{\beta} + \mathbf{x}_{it}\boldsymbol{\gamma} + \theta_i + \varepsilon_{it}, \quad (1)$$

where  $w_{it}$  is the wage rate of individual  $i$  at time  $t$ ,  $\mathbf{a}_{it}$  is a fourth-order polynomial in time (Murphy and Welch (1990)),  $\mathbf{x}_{it}$  is a vector containing a constant and time varying individual controls (health, non-labor income, family size, number of children), and  $\theta_i$  is an individual fixed-effect. By averaging the predicted values from this regression we obtain a "filtered" wage profile, i.e. the profile resulting from washing out anything that is not the effect of age, observables, and fixed effects.<sup>4</sup>

Figure 4: Wage profile, 23 year old cohort

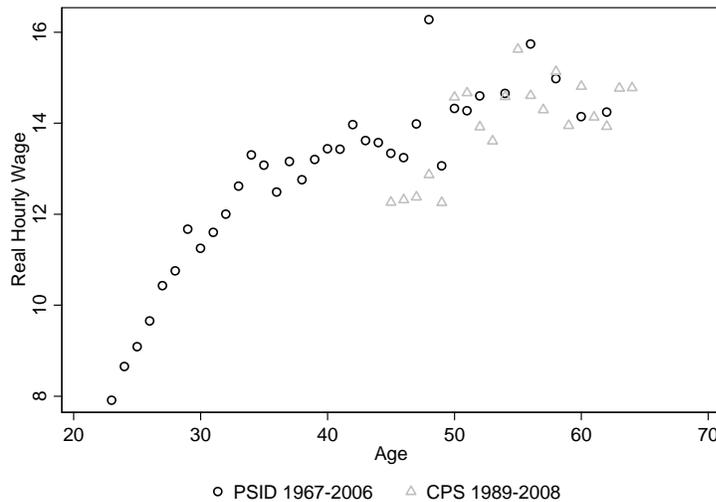


Figure 6 depicts the filtered wage profile. This picture corroborate the presumption that the returns on age are not declining for workers in this cohort.

We can look separately at the wage profiles of workers with different skills, using education as a proxy. Figure 7 shows the wage profile for workers with and without a college degree. This picture shows that skilled and unskilled workers experience similar wage growth during the first 10 years in the labor market. Subsequently, skilled workers continue to experience positive wage growth, with the wage profiles that hardly flattens out. Unskilled workers, instead, experience a clearly flat wage profile for the rest of their career, with possible negative wage growth at the very end of the working life.

So far we have looked at a single cohort. The wage profile of this group may be non-declining due to positive aggregate shocks at the end of the time span we are looking at, so it's important to

<sup>4</sup>Coefficients are obtained from the fixed-effects estimator.

Figure 5: Wage profile, 23 year old cohort, 95% Confidence Interval

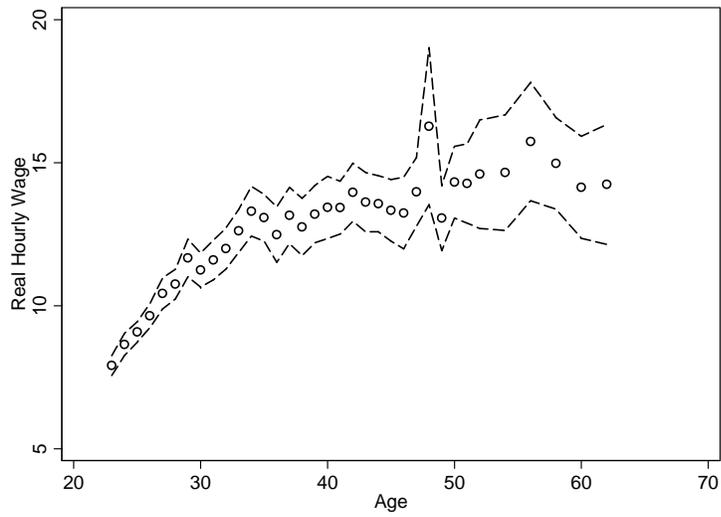


Figure 6: Filtered Profile

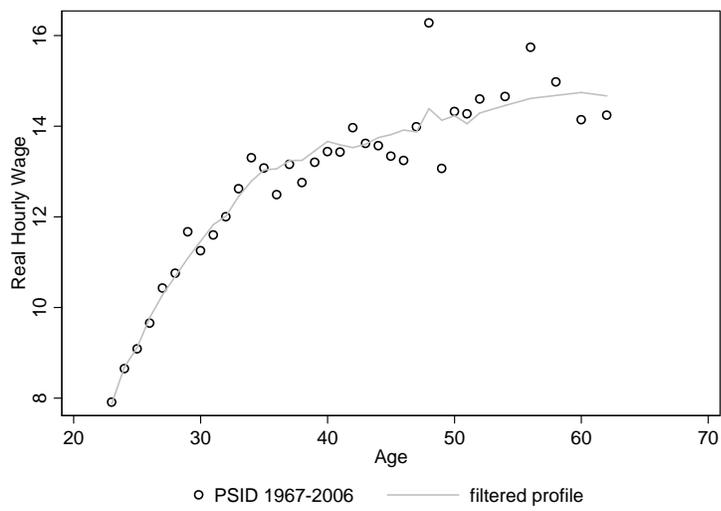
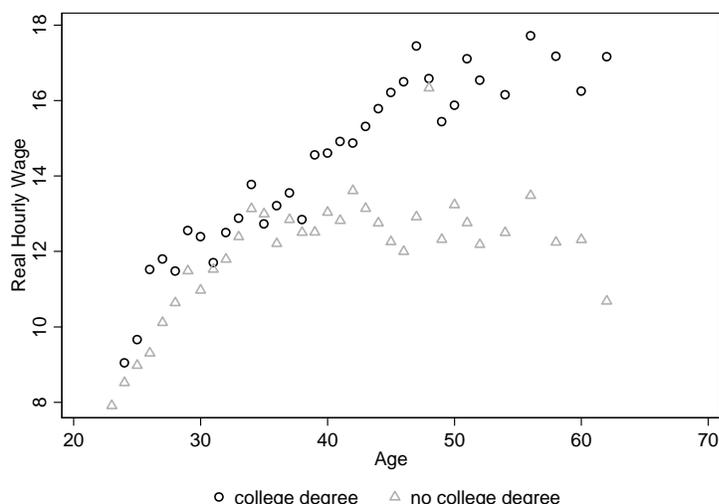


Figure 7: Profiles by Education



consider the profiles of older cohorts as well. We have constructed wage profiles for the adjacent cohorts, i.e. the 28 years old cohort (those who were 26-30 years old in 1967 and so are 65-69 years old at the last observation in 2006), and so on, moving the 5-years bin forward. In order to render these multiple profiles clearly in a single picture, we estimated filtered profiles according to Eq. (1). The result is illustrated in Figure 8. This figure shows two things. First, there is visible growth in productivity over time: the profiles tend to shift upward from one cohort to the next. Second, hump-shaped wage profiles are the exception rather than the rule: the only cohorts for which we see a clear wage decline at the end of the working life are "cohort 43" and "cohort 48", i.e. men that were between 41 and 45, and between 46 and 50 years old in 1967, respectively. The wage decline for *both* these cohorts begins around 1977, when the two groups are between 51 and 55, and 56 and 60 years old, respectively, and continues afterward until they reach retirement age in 1987 and 1982, respectively. Obviously, there may exist cohort specific shocks, for example effects from large recessions, that might affect some cohorts more than others. We leave for future work the possibility that these older workers may have been more adversely affected by the 1970s and 1980-1982 recessions.

More macro-oriented research has typically focused on earnings profiles, finding that they are hump-shaped. For such studies it seems crucial to separate the productivity over the life cycle from that of earnings, which are the effect of both wages and *choices* of hours of work. Examples, among the others, are Huggett et al. (2007), and Heathcote, Storesletten, and Violante (2008). We next analyze earnings profiles. Figure 9 reports the earnings profile of the 23 years old cohort, both in the PSID and in the CPS, repeating the exercise underlying Figure 4. It is clear that both these profiles exhibit the typical hump-shape: labor income starts declining visibly after age 50.

Figure 8: Profiles of adjacent cohorts

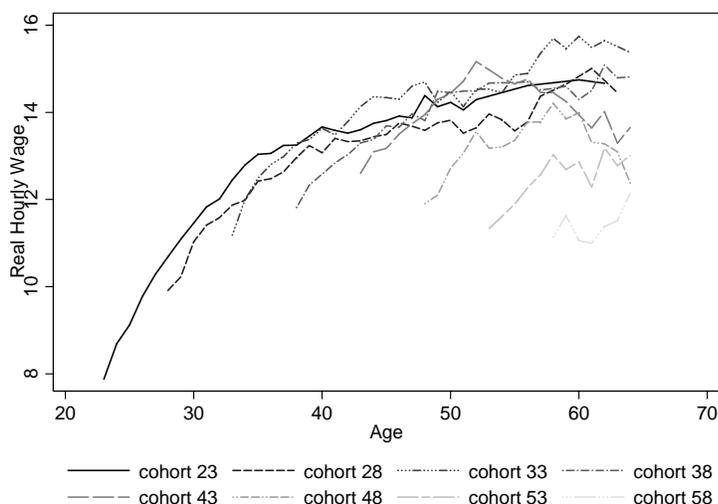


Figure 10 shows the earnings profile conditional on education, which confirms this pattern for both skilled and unskilled workers. The latter enjoy higher earnings for the first few years in the labor market and then experience a sharper reduction after age 50.

Declining earnings and non-declining hourly wages imply that earnings fall because of a reduction in hours of market work. The PSID hours profile of the 23 years old cohort is reported in Figure 11. As before, we overlap the corresponding series constructed from the CPS and we condition on education, as illustrated in Figure 12. These pictures forcefully show that workers begin to reduce labor supply after age 50. In the PSID, the cumulative reduction between ages 51 and 62 with respect to average hours worked between ages 30 and 50 is about 380 hours, or about 17%. When conditioning on education we see that the drop in hours is similar, although it begins about 5 years earlier for the unskilled. This overall pattern 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). Indeed, in the data we analyze many workers start a smooth transition into retirement by working progressively fewer hours during the preretirement years, i.e. after age 50. The earnings and hours profiles of older cohorts exhibit the same pattern, so we do not report them here.<sup>5</sup>

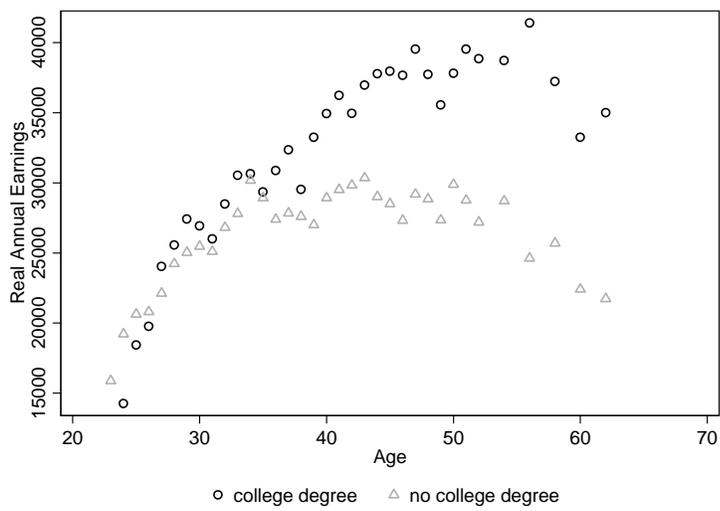
How do these workers manage to reduce hours? The main margins of adjustment are likely two: switching from full-time to part-time and reducing overtime hours. Figure 13 shows that this is exactly what happens. The figure shows kernel density estimates (Epanechnikov kernel) of the distribution of hours for the 23-years old cohort in 1994 (that is, at the peak of hours, when the

<sup>5</sup>These additional statistics are available from the authors upon request.

Figure 9: Earnings profile, 23 years old cohort

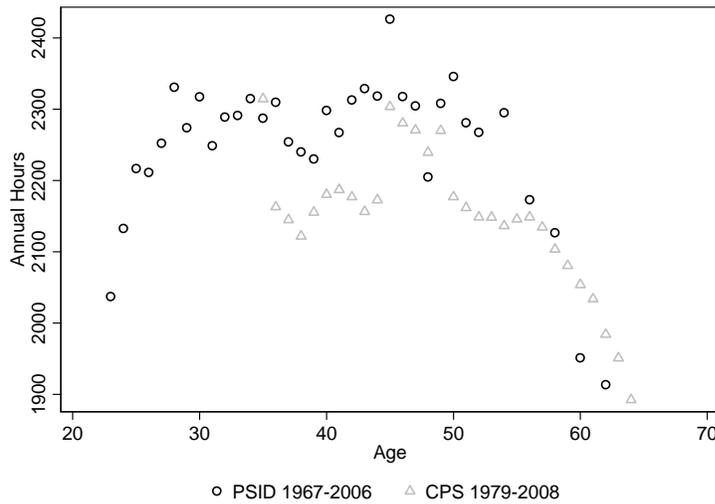


Figure 10: Earnings profile by education



cohort is 49 years old) and ten years later, in 2004. The figure shows that in 1994 the distribution is unimodal, with the mode at the full-time level of hours, and has a fat right tail, indicating that relatively many workers engage in overtime work. However, in 2004 the distribution has become almost bimodal, with a second peak around the part-time level of hours, and has a thinner right tail. Therefore, if we ignore selection (an issue we tackle below), this picture suggests that a non-negligible number of senior workers switch to part-time occupations and reduce overtime work.

Figure 11: Hours profile, 23 years old cohort



So far we have ignored selection and attrition issues. Do these processes bias the picture we want to render? We begin with selection. The problem is well-known: beginning shortly after age 60 workers are self-selecting into retirement. If less productive individuals leave the labor force earlier (e.g. because they have performed more fatiguing jobs for many years), then the uncorrected wage profile overestimates the average wage rate at the end of the working life. On the other hand, if more productive individuals retire earlier (e.g. because they were able to accumulate assets faster), then the uncorrected wage profile underestimates wage growth at the end of the working life. This specific question about the wage process of older workers is tackled by [Casanova \(2010\)](#) using panel data from the Health and Retirement Study. Casanova finds evidence of positive selection into retirement, i.e. evidence that in general the more productive, high-wage, workers retire first—with some notable differences across gender, health status, and pension schemes.

We correct the PSID wage profile for selection into employment in a similar way, following the procedure for selection correction in panel data developed by [Wooldridge \(1995\)](#). This extends standard two-stage methods valid for cross sectional data such as Tobit and Heckit. Specifically, we predict wages of individuals 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 a wage equation,

Figure 12: Hours profile by education

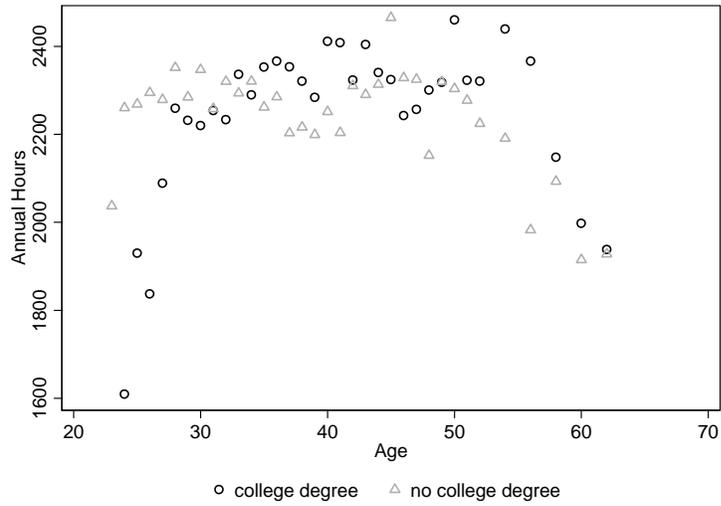
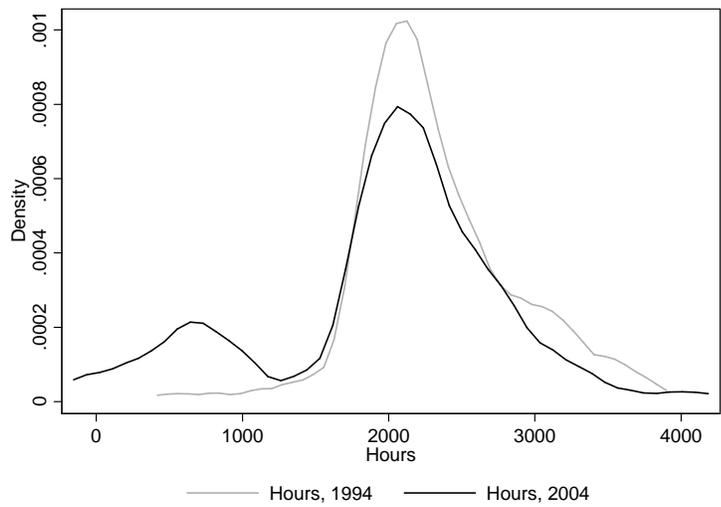


Figure 13: Distribution of hours in 1994 and in 2004



consistently estimated. Consistency is achieved as follows. The model is a pair of equations, an outcome and a selection equation:

$$w_{it} = \mathbf{x}_{it}\beta + \theta_i + \varepsilon_{it}, \quad (2)$$

$$h_{it} = \max(0, \mathbf{Z}_i\gamma + e_{it}), \quad (3)$$

where  $w_{it}$  is the wage rate,  $h_{it}$  hours,  $\mathbf{x}_{it}$  time-varying covariates (health status, non-labor income, family size, and number of children),  $\mathbf{Z}_i$  contains vectors  $\mathbf{z}_{it} \supset \mathbf{x}_{it}$  at all leads and lags (in practice, feasibility requires us to replace these with the corresponding longitudinal averages), and  $e_{it}$  is normally distributed and independent of  $\mathbf{Z}_i$ . Since  $\mathbf{x}_{it}$  is a subset of  $\mathbf{z}_{it}$  the additional elements of the latter are instruments for selection into employment: variables that affect the decision to work but not the wage rate.

Since we are mostly interested in obtaining an unbiased picture of life cycle profiles at the end of the working life, we use as instruments two dummies for being over 62 and over 65 years old. These instruments are motivated by the work of French (2005), who identifies a major role of the social security system in pushing workers out of employment after age 62 and after age 65 in the US, and have been employed by Aaronson and French (2004) to identify the full-time wage premium. Wooldridge (1995) shows that, for some random variable  $\zeta_i$ , under the assumption

$$\mathbb{E}[\varepsilon_{it} | \mathbf{Z}_i, \zeta_i, \theta_i, \{e_{it}\}_{t=0}^T] = \mathbb{E}[\varepsilon_{it} | \zeta_i, e_{it}] = \zeta_i + \rho e_{it}, \quad (4)$$

$\beta$  can be consistently estimated after including in Eq. (2) the Tobit residuals from Eq. (3), estimated for each period. 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 profile of wages for the 23 years old cohort are reported in Figure 14. Correcting the profiles of older cohorts produces similar pictures.

Figure 14 shows that the non-declining wage profile we have documented is not an artifact of selection. Correcting the hours profile (and so the earnings profile as well) is harder with this procedure: 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.

The finding of Casanova (2010) in the HRS is therefore confirmed by the PSID: high-wage workers retire sooner than low-wage ones. This evidence is consistent with the idea that high-wage individuals accumulate assets faster and so can afford to retire earlier. To the extent that wages reflect true productivity, this evidence is also consistent with the model of Wolfe (1985), where the only purpose of retirement is to invest in health. Wolfe argues that more productive individuals have higher aspirations for retirement health. As a consequence, they will retire faster than the average.

We next address attrition. Focusing on a specific cohort of male household heads in a panel that included about 5,000 households at its outset in 1967 means working with relatively few individuals. Furthermore, attrition is likely severe over a 40-year horizon. Figure 15 illustrates these facts for the 23 years old cohort.

This picture shows that the 23 years old cohort in 1967 comprised almost 400 men, almost 300 of which worked after the application of the data selection criteria described above. The decline of cohort size in time illustrates that attrition is substantial. However, the parallel decline in the

Figure 14: Wage profile, 23 years old cohort, selection-correction

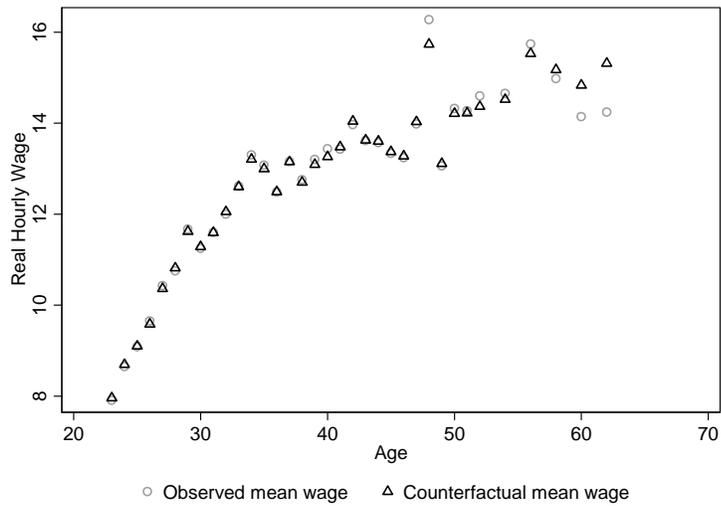
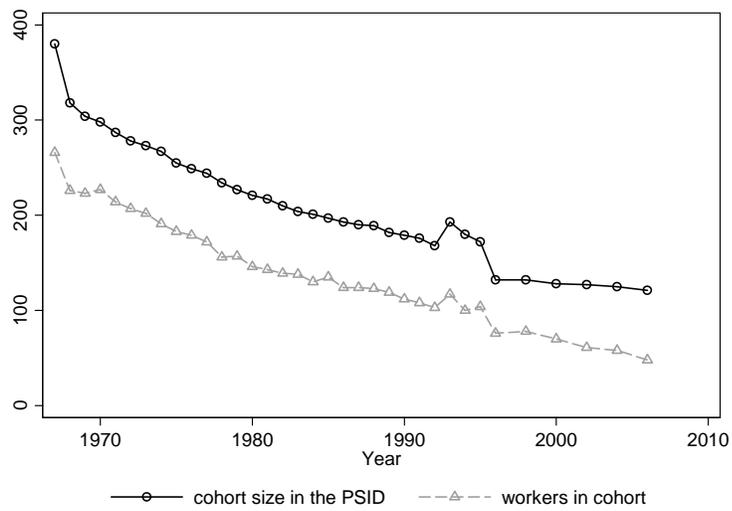


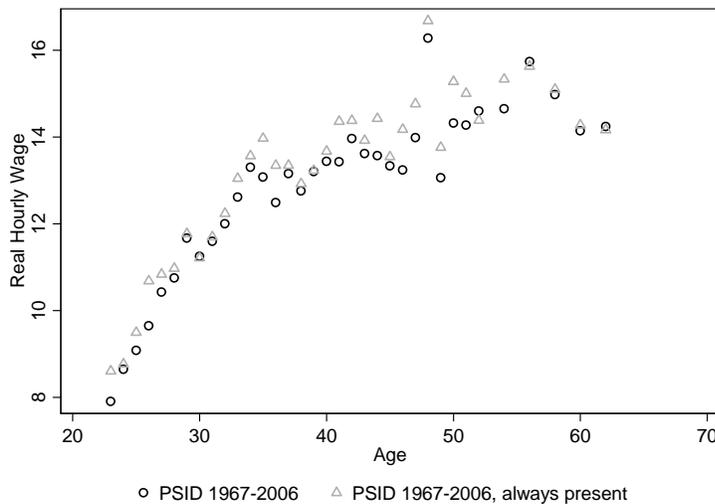
Figure 15: Number of individuals and number of workers, 23 years old cohort



number of workers suggests that attrition should not be systematically related to employment.<sup>6</sup> Notice that after the mid 1990s there is very little attrition in this cohort while the number of workers declines steadily due to the process of retirement. The last data point is 2006, individuals in the cohort are between 60 and 64 years old and we have only about 50 observations for which wages and hours are observed.

We first provide an informal check on the effects of attrition for the wage, earnings, and hours profiles in our data. We continue to focus on the 23 years old cohort. The check consists of comparing the profiles of the full, but selected (because of both attrition and retirement), sample with the profiles of the group of workers who are always present in the survey, from 1967 to 2006. After applying our data selection criteria, these are the 50-odd aforementioned observations. 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 16, Figure 17, and Figure 18. These pictures suggest that attrition looks very much random with respect to wages, earnings and hours. The similarity among each pair of profiles is particularly striking at the beginning of the period, when the group of workers who are always present in the survey and for which we observe labor market variables (the triangles) is only a small fraction of the full, shrinking sample (the dots).

Figure 16: Wage profile, 23 years old cohort, attrition check



We tested the presence of attrition bias more formally, following Wooldridge (2002), chapter 17. Wooldridge suggests first-differencing the data and working with the usual pair of equations,

<sup>6</sup>The increase in sample size in 1992 is due to the reappearance of “recontacts”, individuals who where present in 1967, had left the sample, and were recontacted that year.

Figure 17: Earnings profile, 23 years old cohort, attrition check

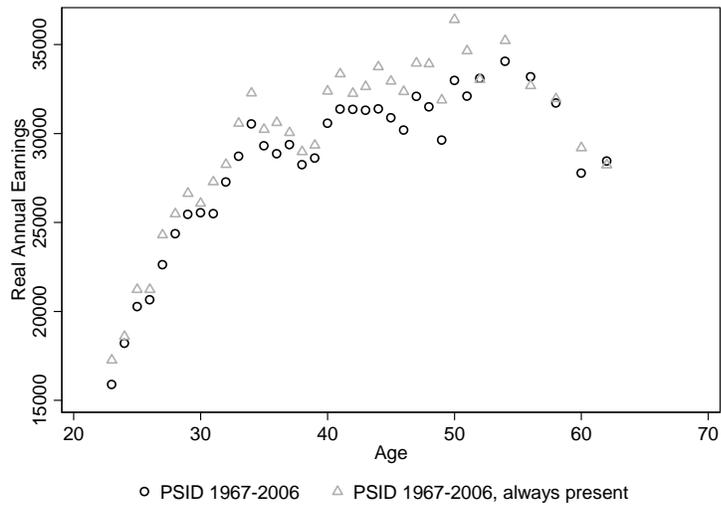
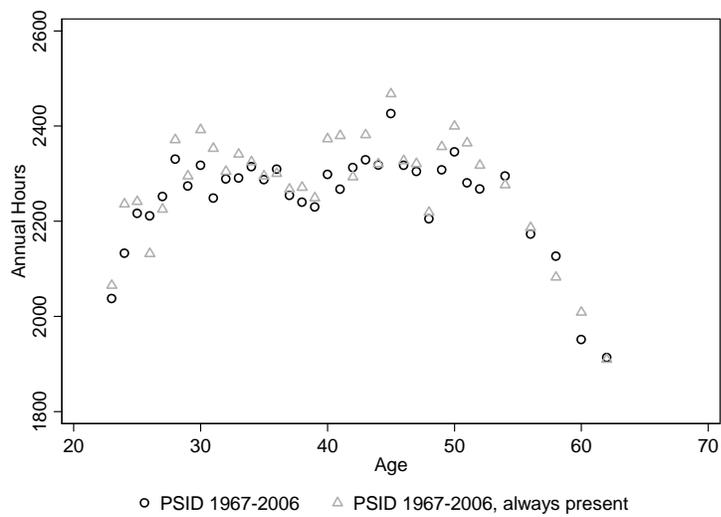


Figure 18: Hours profile, 23 years old cohort, attrition check



one for outcome and one for selection:

$$\Delta y_{it} = \Delta \mathbf{x}_{it} \boldsymbol{\beta} + \Delta \varepsilon_{it}, \quad (5)$$

$$s_{it} = \mathbb{I}[\mathbf{q}_{it} \boldsymbol{\gamma} + e_{it}], \quad (6)$$

where  $y_{it}$  is the variable of interest (wage rate, earnings, or hours in this case),  $\mathbf{x}_{it}$  time-varying covariates (health status, non-labor income, family size, and number of children),  $\mathbb{I}[\cdot]$  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 ( $s_{it} = 0$ ), and  $e_{it}$  is normally distributed. Vector  $\mathbf{q}_{it}$  contains observables that may correlate with the attrition process. Since these must be observable after attrition, we use age, the pre-attrition education level, and the first lag of  $\mathbf{x}_{it}$ .

The test is of the usual parametric, Heckman-type class and works under three assumptions. First, attrition is an absorbing state, i.e.  $s_{it+j} = 0$  for all  $j > 0$  when  $s_{it} = 0$ . This is easy to impose on the data. Second,  $\Delta \varepsilon_{it}$  and  $e_{it}$  are jointly normal. Third,  $\Delta \varepsilon_{it}$  is conditionally independent of observables and attrition status in the previous period, i.e.:

$$\mathbb{E}[\Delta \varepsilon_{it} | \mathbf{z}_{it}, \mathbf{q}_{it}, s_{it-1}, e_{it}] = \mathbb{E}[\Delta \varepsilon_{it} | e_{it}], \quad (7)$$

where  $\mathbf{z}_{it}$  are instruments for  $\Delta \mathbf{x}_{it}$ . Then, it follows from joint normality that

$$\mathbb{E}[\Delta y_{it} | \Delta \mathbf{x}_{it}, \mathbf{z}_{it}, s_{it} = 1] = \Delta \mathbf{x}_{it} \boldsymbol{\beta} + \rho_t \lambda(\mathbf{z}_{it} \boldsymbol{\gamma}), \quad (8)$$

where  $\lambda(\cdot)$  is the inverse Mill's ratio. This can be estimated for each period via pooled Probit and interacted with time dummies. Then, the hypothesis of no attrition bias is equivalent to the joint hypothesis that  $\rho_t = 0$  in each period, which is straightforward to test. Eq. (5) is estimated using the 2nd and higher-order lags of  $\mathbf{x}_{it}$  and of age and education as instruments for  $\Delta \mathbf{x}_{it}$ . We cannot reject the null for wages and earnings (the P-values of the F-test are 0.40 and 0.66) although we do reject for hours (P-value 0.003). Based on this formal and informal evidence we conclude that attrition, although severe, 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, Gottschalk, and Moffitt \(1998\)](#) 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. However, the negative result for hours suggests some caution in the interpretation of [Figure 13](#), because the 2004 sample may be selected, as far as hours are concerned, relative to the 1994 sample.

Summing up, the picture that emerges from these empirical profiles is the following. First, the wage profile is increasing over the life cycle and does not decline until individuals are well into their 60's. Small sample size after age 65 prevents us from concluding that there is never negative wage growth, although data from the CPS suggests that this is in fact the case. Second, the earnings profile increases over the life cycle and declines after age 50. Third, the hours profile is increasing at early ages, then is roughly constant before declining sharply after age 50. This suggests that labor supply drives the decline in earnings: men choose to work less after age 50. Selection into employment and attrition do not affect these conclusions.

We do not take a stand on why the wage profile is not declining before age 65 (as we have briefly discussed above, it could be that human capital does not depreciate or that there are incentive or insurance schemes at work) nor do we attempt to identify separately time, age, and cohort effects. Rather, we are interested in the challenge that our results pose to a standard life cycle model. This is what we discuss next.

## 4 A Standard Life Cycle Model

We now present and calibrate a simple, standard, life cycle model to show what the hours profile would look like given the productivity profile we have uncovered in the PSID. In particular, we show that with the value of leisure/disutility of labor constant, hours do not fall over the life cycle. Consider the following framework, which can be regarded as a “reduced-form” version of a human capital model—in which investment in skills is left in the background and the wage rate is exogenous.

A representative worker enters the labor market at age 0 and retires at age  $A$ . Age is indexed by  $a$ , and time by  $t$ . The problem for the individual is to choose sequences of consumption,  $\{c_a\}$ , labor supply,  $\{h_a\}$ , and assets,  $\{k_{a+1}\}$ , given the wage profile,  $\{w_{a,t}\}$ , a sequence of real interest rates,  $\{r_t\}$ , and initial assets  $k_0$ , to maximize utility over the working life:

$$\begin{aligned} \max_{\{c_a, h_a, k_{a+1}\}} & : \sum_{a=0}^A \beta^a \left[ v(c_a) - \gamma_a \frac{h_a^{1+\varepsilon-1}}{1+\varepsilon-1} \right] \\ \text{s.t.} & : c_a + k_{a+1} \leq k_a(1+r_t) + w_{a,t}h_a \\ & : h_a \leq \bar{h} \end{aligned} \quad (9)$$

where  $\beta$  is the discount factor,  $v(\cdot)$  a quasi-concave increasing function,  $\gamma_a$  the disutility of labor relative to consumption (or, equivalently, the value of leisure),  $\varepsilon$  the intertemporal elasticity of substitution of leisure, and  $\bar{h}$  the time endowment. The dynamics of hours in this model, for  $a < A$ , is given by:

$$\frac{h_{a+1,t+1}}{h_{a,t}} = \left[ \frac{1}{\beta(1+r_t)} \frac{w_{a,t+1}}{w_{a,t}} \frac{\gamma_a}{\gamma_{a+1}} \right]^\varepsilon. \quad (10)$$

The term  $1/\beta(1+r_t)$  is the ratio between the multipliers on the budget constraint in two adjacent periods and so captures income/wealth effects, since the worker is accumulating assets optimally. The term  $w_{a,t+1}/w_{a,t}$ , on the other hand, captures substitution effects. If  $\gamma_a = \gamma$  for each  $a$ , and if the income/wealth effect is not too strong (i.e.  $\beta(1+r_t)$  is not greater than 1) then the shape of the wage and hours profile is necessarily the same: hours cannot fall if the wage rate does not.

We calibrate [Eq. \(10\)](#) to predict the hours profile of the 23 years old cohort in the PSID under the assumption of a constant  $\gamma$ . In our calibration we set  $\beta = 0.96$ , and  $\varepsilon = 0.08$ . This low value of the intertemporal elasticity of substitution is the appropriate value for continuously employed men in the PSID, and is taken from [Fiorito and Zanella \(2009\)](#) who also show it is not in conflict with the much larger elasticity used in quantitative aggregate models. Finally, we estimate the series of

$r_t$  with the difference between the 6-Month Treasury Bill rate (Secondary Market) and the CPI-U (all urban consumers, all items) inflation rate from 1967-2006<sup>7</sup>. We set  $h_{0,t}$  to the actual PSID value and simulate hours forward based on the actual PSID wage profile.

The result of this simulation is shown in [Figure 19](#). This picture shows that the model with constant  $\gamma$ , is in fact unable to reproduce the fall in hours. This difficulty extends to versions of the model that explicitly take into account investment in human capital; as the work of [Huggett et al. \(2007\)](#) makes clear, even in its modern, fully-fledged general equilibrium version the human capital model generates hump-shaped life cycle profiles when calibrated with realistic parameters. Our simulation shows that the model underestimates hours growth until age 40, roughly reproduces actual hours between 40 and 50, and then overestimates hours growth after age 50. In particular, it predicts modest hours growth after this age while actual hours are actually declining. This evidence is consistent with the findings of [Gomme, Rogerson, Rupert, and Wright \(2004\)](#): a standard life cycle model does not perform well when trying to explain the hours of very young workers as well as the hours of older workers.

We can go further and ask how the value of leisure/disutility of labor should evolve in this model to reproduce the observed hours profile. This is a trivial but useful exercise: back-out a hypothetical index of  $\gamma_a$  from the actual and the simulated wage profile, i.e. solve [Eq. \(10\)](#) for  $\gamma_{a+1}/\gamma_a$ , set  $\gamma_0 = 1$  and construct the full sequence. The result of this exercise is shown in [Figure 20](#). Not surprisingly, the profile of  $\gamma_a$  is J-shaped: it declines slightly for very young workers, then shows no trend until the early 50s, when it picks-up very quickly. The dynamics suggests that, in this model, the value of alternatives to market work declines for young men, is stable throughout prime-age, and then increases fast. For young men, this may reflect the end of the period of formal education and initial job search. 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.

Given a non-declining wage profile, model [\(9\)](#) reproduces the empirical hours profile if the value of leisure/disutility of work increases shortly after age 50. Except for the dependence of  $\gamma$  on age and the identity between hours of work and labor services, this model is the discrete-time version of the model in [Rogerson and Wallenius \(2009\)](#). They assume that the wage profile is hump-shaped. Alternatively, their results can be obtained with a concave but nondeclining wage profile and a J-shaped profile for the value of alternatives to market work. Our results indicate that the latter is a better assumption.

## 5 Conclusions

This paper shows 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 the consensus view in labor economics, that the wage profile is hump-shaped, declines around age 50-55, and this triggers a reduction in labor supply. This new evidence raises several interesting issues regarding human capital investment and choices of hours of work over the life cycle. Future research should address the question of why workers reduce labor supply during the pre-retirement years when facing a non-declining wage profile.

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<sup>7</sup>This is the asset for which we were able to find a consistent 40-years series of interest rates

Figure 19: Actual and Simulated Hours Profile)

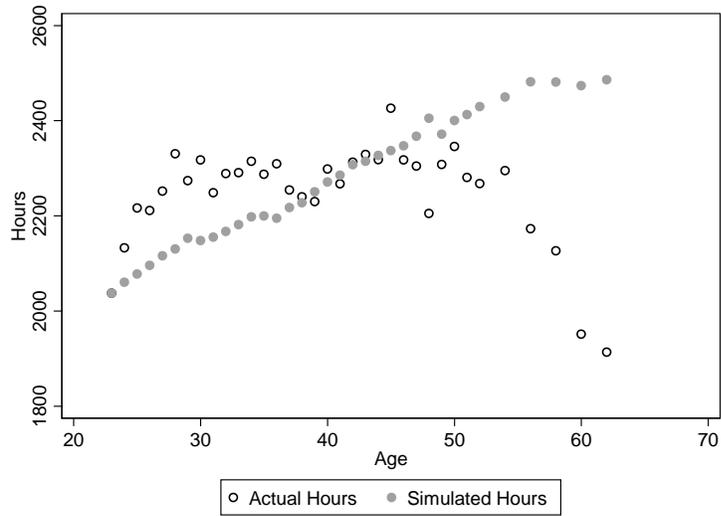
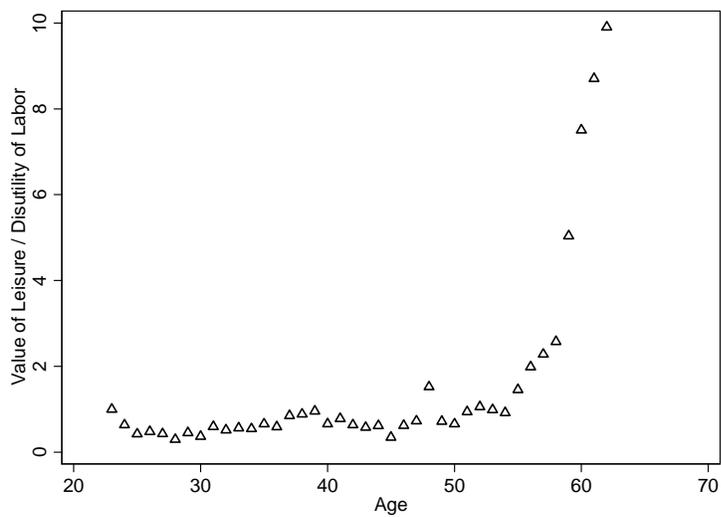


Figure 20:  $\gamma_a$  index



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