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Abstract

Cross section data suggest that the relationship between age and hourly earnings is an inverted-U shape. Evidence from panel data does not necessarily confirm this finding suggesting that older workers may not experience a reduction in earnings at the end of their working life. In this paper we use panel data on males for Great Britain in order to examine why the two types of data provide conflicting conclusions. Concentrating on the over 50s, several hypotheses are examined: overlapping cohorts, job tenure, job-changing, labour supply behaviour and selectivity bias. Cohort and individual fixed effects partly explain the divergent conclusions. However, for fully, year-on-year employed individuals, there is no evidence of earnings decline at the end of working life. We find no role for selectivity due to retirement, although shorter working hours or partial retirement along with job-changing late in life do provide an explanation for why hourly earnings decline for certain older workers. We find no evidence that the process of ageing itself leads to lower earnings as suggested by the cross section profile.

Keywords : age-earnings profile; older workers; labour supply; cohort effects.

JEL classification : J.3, J.14, J.24.

The labour market for older workers has attracted increased interest in recent years. From a policy-maker's point of view, the issues of pension finance and of the costs of providing health care in the face of an aging population have raised serious questions concerning the duration of working life. Most countries with contribution-based state pension systems have already increased the minimum retirement age and taken measures to deal with the problem of financing longer periods of retirement. In contrast, participation rates among the over 50s have significantly declined with age in the last thirty years, as individuals begin to leave the labour force and enter retirement earlier[1]. For example, in Great Britain in the 2000s, the participation rate falls from over 80% among 50 to 54 year olds to around 70% for the 55 to 59 age group, and less than 50% for those aged 60 to 64. The figures are even more striking for France (around 80%, less than 60% and around 15%, respectively). There is also evidence in some countries that older workers may be subject to discrimination in recruitment and retention. Each of these mechanisms will involve lower pension contributions thereby exacerbating the financing problem.

Related to these stylised facts is the cross section observation that average earnings are lower for individuals who are at the end of their working life – or put another way, that the age-earnings profile has an inverted U shape. There are various implications for policy if individuals' earnings do in fact decline as they become older. First there could be an incentive to reduce labour supply as leisure becomes relatively less expensive. This mechanism will also interact with the prospect of increased non-labour income through different forms of pension provision which are possible in certain countries. Second, if the monthly earnings of older workers decline, pension contributions (when set as a proportion of earnings) will follow.

This paper addresses the issue of whether hourly earnings do in fact decline as a consequence of ageing. In a typical earnings equation, the age-earnings profile is specified as a smooth, concave function and usually reaches a maximum during a typical individual's working life – generally in the 40 to 50 age interval (see Figure 1a). This concave relation is predicted by human capital theory and is borne out in the cross section analysis of earnings differences[2]. Investments in human capital will normally decline towards the end of a working life since they are less profitable. Furthermore, investments made at an earlier age will be depreciating and

[1] There is some evidence that this may be starting to change as a consequence of recent pension reforms.

[2] Murphy and Welch (1996) explore various polynomial forms for this relation and categorically reject the quadratic specification that was derived and applied by Mincer (1974), and adopted widely since.

productivity will start to diminish. The consequence is a slowdown and eventual decrease in earnings with age, as depicted in Figure 1b. Several studies at the firm level have attempted to assess the importance of productivity decline among older workers (for example Aubert and Crépon, 2003 for France, and Van Ours and Stoeldraijer, 2010 for the Netherlands).

Studies that use panel data on individuals however find that earnings do not necessarily decline with age at the individual level (see for example, Johnson and Neumark, 1996 for the US and Myck, 2010 for Great Britain and Germany). This is at odds with the predictions of human capital theory; productivity may not decline at the end of an individual's working life (see for example, Hægeland and Klette (1999)). This outcome is consistent with theories of incentive contracts which show that wage growth is possible in absence of human capital growth. For instance, Lazear's (1981) model or deferred compensation contract predicts that the earnings increase over a career with the same employer. Older workers receive higher wages in order to address the problem of moral hazard and imperfect information. In this model, firms use seniority wages to motivate workers to supply a higher level of effort and to avoid leaving the company as retirement approaches. Elsewhere, empirical studies suggest that older workers are appreciated in the world of work for their professional skills, experience and dedication. Several studies indicate that non cognitive or social skills are as important as cognitive skills and are associated with wage premia (Heckman and Rubinstein (2001), Postlewaite and Silverman (2006)). An individual's personality (behaviour, motivation, sociability, leadership) is valued by employers and contributes to raising individual earnings. All these conflicting elements leave open the question of how the cross-section regularity can be explained.

An alternative explanation may be related to the dynamics of the working population. Each cohort may have a monotonic upward-sloping earnings profile but overtakes the preceding cohort. A cross section will pick up members of different cohorts at each age rather trace the life-cycle earnings profile of a typical individual (as in Figure 1c). A further possibility is that earnings fall for a subset of older workers who change employer or job status in the latter part of their working life. This may be planned and therefore voluntary, as suggested by Casanova (2012), or involuntary if firms use age as a criterion for lay-offs and displaced older workers subsequently take lower paid jobs. Finally, given the substantial decline in the participation rate from the age of 50 onwards noted above, there may be a selectivity bias in earnings regressions if those leaving the labour force are also those who tend to have higher earnings potential (see Figure 1d).

In this paper we explore these different possibilities using panel data on males for Great Britain. The first section describes the data source used and the definitions of earnings that are used in the subsequent analysis. The following section contains a descriptive analysis of earnings profiles by age and by cohort. The third section exploits the panel dimension of the data and looks at the age-earnings profile using a fixed effects specification. We examine the role of tenure, job mobility and partial retirement as possible explanations of the observed downturn in hourly earnings for older workers in cross section data. The penultimate section assesses the role of early retirement and other selection mechanisms that may affect the shape of the age-earnings profile, while the final section draws together our conclusions.

1. Earnings and the British Household Panel Survey

The data used are taken from the British Household Panel Survey (BHPS) for the period 1991 to 2007. We are primarily interested in older workers who are defined as those aged 50 or over, and so the main sample used are males born between 1936 and 1956. Each individual born between these two years will have been observed at some point or all their life in the survey while they are in the older workers category (aged 50 or over). The sample is truncated at the age of 65. Since this sample of the panel is not balanced, the numbers of individuals in each age interval will differ according to the cohorts that are followed through the period 1991 to 2007. An idea of the variability of the sample numbers is presented in Table 1 for *all cohorts* of males of working age. At the beginning of the panel survey in 1991, some 3,260 males are aged between 16 and 65, and this number declines over the period of the operation of the survey to around 1,860. Exits exceed entrants and the sample size diminishes. However, given the dynamics of the population, the size of main sample used, which is the 50 to 65 age group is more stable and varies between 600 and 800 per year.

In cross section analysis, a snapshot is taken of an individual's labour market situation at particular point in his life-cycle. A significant proportion of individuals will not declare current earnings due to non participation or non employment, and this sub-group may not have the same observed or unobserved characteristics as the overall population of working age. In a panel survey, individuals may move between different types of labour status, and therefore will not provide data for a continuous earnings profile. Furthermore, many individuals are unable to declare an hourly wage or monthly earnings at the time of interview, but can declare earnings for the previous twelve month period. As in many surveys, respondents in the BHPS are asked to specify usual earnings.

Three concepts of gross hourly earnings[3] with variable response rates are used:

(a) current hourly earnings

(b) usual hourly earnings if these differ from current earnings

(c) hourly earnings imputed from annual earnings

Since earnings are being compared over a long time span, the figures used are converted into real terms using a price deflator. The latter indicates that prices increased by 36% between 1991 and 2007, at an average rate of 1.85% per annum.

There is an interesting issue concerning education level in this context. The older section of labour force in the year 2000 will contain persons born before 1950 (figures by cohort are given in Table 2). At this time, and until the 1960s, only a minority of individuals would remain in education after the age of 16. The minimum school leaving age was 14 and the options for post-school training were relatively limited for these individuals. For those born prior to 1940, a majority had no formal qualifications, and less than 8% went to university. Of those born between 1950 and 1955, only a fifth had no formal educational qualifications, while 62% finished education with GCSE O- or A-levels, with 16% going to university. It therefore is difficult to examine differences in earnings between cohorts for a given education level across a period in which qualifications and access to education changed so dramatically.

2. Cross section and cohort age-earnings profiles

Figure 3 shows the cross sectional hourly earnings profiles for 1991 and 2007. The age-average hourly earnings relation in both cases has the typical concave inverted U-shape found in cross section data. Average earnings of those aged over 60 are around those earned by those in the 25 to 30 year age group. In the final year, 2007,

[3] In each case the respondent is asked to declare the amount earned and the corresponding number of hours worked. Hourly earnings are obtained by dividing total earnings by total hours declared.

there appears to be more variation in the 40 to 50 age interval. For 1991, the maximum is situated on a plateau somewhere between the ages of 30 and 50, and average earnings appear to be lower for those aged 50 and over. For 2007, higher dispersion means that the profile is not very smooth and the observed maximum actually looks like an outlier and occurs at the age of 48. However it is not clear whether earnings in the age interval 45 to 50 are always higher than in the 40 to 45 interval. Since earnings are expressed in real terms, the positions of the profiles are comparable. The introduction of the national minimum wage in 1999 will have affected the starting point for the earnings of those entering the labour market from that year onwards.

The same age profiles are presented for real annual earnings in Figure 4. Obviously annual earnings include a labour supply dimension, and do not simply reflect the price of an individual's labour services. However, in consumption terms, total earnings are the relevant variable for decision-making and in terms of the well-being it is relevant to examine total rather than hourly earnings. The annual earnings profiles fall away in a more pronounced manner than for hourly earnings showing that labour supply is an important component.

This observed inverted U-shaped profile could be the consequence of aging itself, as the human capital model suggests. However, it may simply be a statistical artefact found in cross section data and result from the tendency of successive generations or cohorts to earn more on average the preceding ones. This over-taking phenomenon can in theory generate a concave inverted U-shaped age-earnings profile in cross section data. Upward-sloping cohort age-earnings profiles are reproduced in a stylised manner in Figure 1c. In a cross section each cohort is observed at a particular point in its life-cycle, and the data will take the form of a series of clusters, one per cohort. When these are used to produce the cross section profile, in the case of over-taking there will be a concave inverted U-shape while the age-earnings profile for the cohort itself may never decline.

Using the same data source as for the cross section profiles in Figure 3, the cohort age-average earnings profiles are presented in Figures 5a and 5b. These bear out the notion of overtaking, and the slope of the cohort earnings profile does not in general become negative from around the age of 50 as the cross section data would suggest. In fact there is very little evidence to suggest that the slope becomes negative – except for the very oldest cohorts born before 1945, and then from around the age of 55. The age-earnings profiles by cohort present a very different picture from the cross section relationship. A fuller analysis using an age-period-cohort decomposition is undertaken in Charni (2015).

3. Individual earnings of males – cross section versus panel data

The previous section suggests that cohort effects may be a key element in explaining the inverted U-shape of the age-earnings profile observed in cross section data. In this section, individual earnings profiles for males are examined using panel data methods. This form of data also allows an individual effect to be taken into account which will contain the effect of cohort membership plus other time invariant individual-specific characteristics:

$$w_{it} = {}^{-}_{i} + \cdot_{t} + x_i \quad + g(A_{it}) + u_{it} \qquad (3)$$

The equation for the logarithm of earnings (w_{it}) contains individual effects (${}^{-}_{i}$), time effects ($\cdot_{t}$), a vector of time invariant characteristics (x_i) and a function of age (A_{it}). In what follows only the part of the profile for the group aged 50 or over is considered. The sample used here is an unbalanced panel, due to absences at the time of the survey, non-declaration of earnings due to current labour market status, early retirement and most importantly in terms of the numbers concerned, truncation at the age of 65. For example, an individual born in 1940 will no longer be in the sample from 2006 onward.

One of the first studies of the age-earnings profile using a lengthy panel survey was undertaken by Johnson and Neumark (1996). In order to allow for the most flexible form of relation between the two variables, they define a dummy variable for each year of age such that

$d_{ait} = 1$ if individual i is aged a years *or older* in year t and $d_{ait} = 0$ otherwise

These are used in a panel data earnings equation of the following form :

$$w_{it} = {}^{-}_{i} + \cdot_{t} + x_i \quad + \sum_{a=2}^{A} \text{¢}_a d_{ait} + u_{it} \qquad (4)$$

The individual components (${}^{-}_{i}$) are treated as fixed (rather than random) effects and, along with the vector of time invariant characteristics (x_i), will be swept out when estimating the parameters of interest (¢_a). The coefficient on each dummy gives the marginal change in (log) earnings at that age. The sum of these coefficients up to a given age gives the total effect of age on earnings at that point in the life cycle. Since only the part of the profile for the group aged 50 or over is considered, the constant term along with the means other explanatory variables will determine the reference for someone aged 49. In order to have larger sample numbers per cell, the dummies are defined in two year steps – 50 or over, 52 or over and so forth[4].

To begin with, the pooled estimates (that is, ignoring the individual fixed effects) are presented. These equations are estimated using the three definitions of hourly earnings mentioned above and include controls for education, marital status, family and personal background and year dummies. The results, presented in Table 3, indicate that there is evidence of declining earnings at the end of an individual's career, but only from the age of 58. The estimates based on all definitions of hourly earnings show the same phenomenon: a statistically significant decline in average earnings that begins at the age of 58 and continues to decline thereafter. This is at odds with the cross section profile since any earnings decline occurs very late in working life.

Based on current and usual hourly earnings, someone aged 58 or over will earn 4.7% less than someone aged 56; an individual aged 60 or over, more than 11% less than one aged 59, and a further 7% from the age of 62. The estimates based on dividing annual earnings by annual hours of work are less clear-cut but still show that hourly earnings decline: the size of the decline is more pronounced (7% from the age of 58) and the coefficient on the dummy for aged 62 or over is not significant at the 5% level. The pooled estimates therefore indicate declining earnings for older workers after from the age of 58 onwards.

Estimating the age-earnings profile using fixed effects amounts to replacing any time-invariant influence on earnings with an individual-specific constant. This has the advantage of bringing into the model any variable or influence that affects earnings that remains unchanged over time, including factors that have not or cannot be observed. This is achieved at the price of aggregating these influences into a single coefficient and not being able to identify their separate effects. Interestingly in the current context, any cohort effects will be included in the fixed effect. The results are presented in Table 4.

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[4] This also enables the effect of age to be identified separately from that of cohort membership or period effects common to all cohorts – see Browning et al (2013).

As in the pooled regressions, the age-earnings profiles corrected for fixed effects still indicate that earnings decline at the end of a working life. However, this occurs a little later - from 60 onwards compared to 58 according to the pooled estimates - except in the case of hourly earnings imputed from annual earnings, when the decline occurs from the age of 62. The age effects on earnings are however of much smaller magnitude. The extent of the decline is 3.7% from the age of 60 onwards when we use usual hourly earnings or the definition derived from annual earnings, and 4.7% for the current hourly earnings and does not decline any further thereafter. Thus while the fixed effect will pick up cohort effects, there is still a downturn detected in hourly earnings in the typical age-earnings profile for males. It is worth noting that this effect is only just significant at the conventional 5% level.

4. Tenure and job-changing

The estimated decline in earnings for older workers could be the consequence of events that occur later in life rather than the effect of ageing itself, such job-changing – voluntary or not – and labour supply behaviour. Johnson and Neumark (1996) for example compare three categories of employee: career, continuous and non-retirees. The first group are those who are in the job with the longest tenure (with the same employer) in their career. Continuous workers are those who remain in employment (even though they may change employer) throughout the sample period or until the age of 65, whichever occurs first. These individuals are able to declare earnings in each year of the survey. Non-retirees are those who may not always be employed in each year over the sample period but who do not consider themselves to be retired when not in work.

Because the fact of not working during a certain period involves a loss in labour market experience and may affect the evolution of earnings, we re-estimate the equation on a subsample of 'continuous' workers who are defined as those who remain employed over the survey. The estimates are presented in column (2) of Table 5 for usual hourly earnings and are qualitatively similar as those obtained using fixed effects in column (1) except that there is no evidence of a decline in earnings after the age of 60 (the coefficient is smaller in absolute value and not significant even at the 10% level). The decrease in earnings at older ages may therefore be result of a bias due to certain individuals who do not work during all the period (this was illustrated in a stylised fashion in Figure 1d). The earnings profile for older workers who remain employed seems to be flat.

In columns 3, 4 and 5 of Table 5, we analyse the incidence of specific human capital on earnings by distinguishing between job stayers and job movers because the wage profile would be expected to be different. Because the transition between two jobs could be involuntary, we also differentiate two forms of job transition: voluntary and involuntary mobility, where the latter is defined as being a job change involving an intervening spell of unemployment.

4.1 Stayers - the effect of tenure on earnings

There may be a link to the role played by human capital on evolution of earnings, in particular the returns of specific human capital. Since the latter can be approximated by job tenure where human capital is accumulated through work experience with the same employer, and is not transferable between firms, there is a cost to switching employers due to the loss of the returns to this type of human capital. The earnings equation for a worker can be rewritten in the following way:

$$w_{it} = {}^{-}_{i} + \cdot_{t} + x_{i} \quad + \sum_{a=2}^{A} ¢_{a} d_{ait} + T_{it}¥ + u_{it} \qquad (5)$$

where T_{it} is tenure with the current employer. As expected, tenure has a positive effect on usual hourly earnings (Table 5, column 3). Staying one additional year with the same employer leads to an increase of 0.6% in the real hourly wage. While there is some debate about what this effect means, it is present. One possibility is that longer job tenure increases the stock of specific human capital which entails higher productivity to the firm and leads to higher earnings. Abraham and Farber (1987) argue that longer tenures reflect high quality matches between employer and employee, producing rents that are shared in terms of earnings premia. In this equation there is still a significant negative coefficient on the dummy for those aged 60 or over suggesting that other things equal earnings decline by 3.5%, although there is some uncertainty concerning its importance (it is not significant at the 5% level).

4.2 Movers and the consequences of job mobility

An alternative way of looking at this is to examine the earnings consequences of changing job late in life. This could constitute an explanation for the decline in earnings observed in cross-section and picked up partially in panel data. Older workers may decide to change job/employer in order to work less (part-time work or less taxing work), or possibly for jobs with higher pay. They may also be laid-off and find alternative employment with lower pay. We define job mobility as any transition from one employer to another and we want to estimate the effects of changing employer on earnings. We use the information of past employment spells to construct a job mobility variable and distinguish two cases: voluntary mobility which is characterised by direct transition between jobs, and involuntary mobility which involves a spell of unemployment between jobs.

The earnings equation in this case takes the following form:

$$w_{it} = {}^{-}{}_{i} + \cdot{}_{t} + x_{i} \quad + \sum_{a=2}^{A} ¢_{a} d_{ait} + E_{it} ¥_{1} + U_{it} ¥_{2} + u_{it} \qquad (6)$$

where E_{it} is a dummy variable for voluntary job change and U_{it} a dummy when the transition involves a spell of unemployment which is considered to be involuntary mobility. Changing employer/firm after the age of 50 appears to have negative influence on earnings growth. Workers who voluntarily decide to change jobs/employers late in life earn 10.3% less than someone who does not (column 4). One explanation could be the loss of returns to specific human capital accumulated through work experience (and which is not transferable between firms). Alternatively, there may be a compensating differential due to non-wage characteristics of the new job obtained. Mobility between jobs has a negative impact on hourly earnings and this transition can explain why we observe an earnings decrease at the age of 60 in the column (1). In all, if we take into account all these facts, the earnings profile for older workers is relatively flat.

Job mobility involving a spell of unemployment entails substantial negative returns to hourly earnings. The fixed effects estimates show that involuntary job separations lead to earnings losses of 29% (column 4). We have also reported the impact of length of time spent unemployed (measured in months) which replaces the dummy variable

U_{it} in equation. Thus, for example, a worker who has been unemployment for a year has hourly earnings that are 12% lower than a worker who experienced no spell of unemployment (column 5). This could be associated with the loss of human capital or lack of motivation and drive caused by a spell of unemployment. In this situation, the worker is doubly punished by the market. Firstly, the wage is negatively affected because of the loss of returns to specific human capital and secondly, by the signal sent out by the fact of being out of work, which may result in lower productivity compared to an individual who is able switch directly between two jobs. The results show that the growth of earnings is positive and increases until the age of 60. In contrast to the previous case where we do not differentiate individuals who interrupt their career from others, a small decline in earnings is observed later in life and from the age of 60, although this is not significant at the 5% level.

4.3 Labour supply decisions

Another factor could be the impact of 'partial retirement'. There is evidence that 'partial retirement' plays a role in the decline of earnings at older age especially in the United States (Gustmann and Steinmeier, 1985; Johnson and Neumark, 1996; French, 2005; Casanova, 2012). The hourly wage of a worker who transits into partial retirement, characterised by a decrease in the number of hours worked, declines. Indeed, older workers do not necessarily go directly into retirement but instead choose to switch to part-time work in order to prepare a smooth transition into retirement and such jobs are usually lower paid than full-time positions. The sample used in the results of the basic model (column (1)) includes observations from workers who switch into part-time work. So, declines in wages could be attributable to a shift into this status rather than being due to age. To see whether the downward-sloping hourly earnings profile is determined by the transition into part-time jobs or jobs less paid just before the retirement, we introduce a variable representing 'partial retirement' for workers who transit from full-time work to part-time work[5]. The fixed effects estimates are presented in column (5).

[5] As a robustness check, we estimate the model using two definitions for 'partial retirement': employees who work i) less than 35 hours per week or ii) less than 30 hours per week. The results remain similar.

The estimated coefficients imply a 26% decline in the hourly wage for workers who reduce their labour supply. This is similar to the results of Casanova (2012) who finds a 32% decrease in hourly wages in the United States. At the same time, none of the age dummies are significantly negative and the profile remains flat after the age of 54. The negative impact of this move into partial retirement could therefore explain the decline associated with age identified in the basic specification. Once we control for this labour supply decision, there is no clear evidence of earnings decline at the end of working life as a result of the process of aging.

5. Selectivity effects in panel data

A final issue to be examined is the role of selectivity. In most analyses of earnings differences, the issue of bias due to endogeneity is a key concern. In the current case, the main issue for older workers will be the consequences of withdrawing completely from the labour force. While state pensions are paid in Great Britain from a minimum defined retirement age (for males 65), there exist other forms of replacement income from occupational pension funds, capital and housing wealth. Choices concerning retirement mean that labour supply decisions may have an impact on the estimated age-earnings profile if those with higher earnings tend to move into retirement at a faster rate, leaving a non-random sample of earners from which econometric estimates can be obtained. This is illustrated in a stylised fashion in Figure 1d. The participation issue is a key facet of the labour force behaviour of older workers, since it is high (85%) at the age of 50 and declines steadily up to the age of 59 (60%), decreases noticeably around the age of 60 (to 50%) and trends downwards through to the state retirement age of 65 (see Figure 2).

This selectivity issue in relation to retirement has recently been examined for the United States in unpublished papers by Casanova (2012) and Rupert and Zanella (2012). The approach essentially involves estimating panel data earnings equations with the inclusion of a Heckman-type selectivity correction term obtained using a first stage probit model of participation to generate inverse Mills ratios. The procedure is not as straightforward as the cross section case since with panel data, individuals may move in and out of employment or the labour force, declaring a wage one year and not another. This complicates the selectivity correction procedure as Wooldridge (1995, 2002) explains.

In line with Casanova (2012) and Rupert and Zanella (2012), we follow the Wooldridge approach to taking into account the potential impact of selection bias[6]. The method tests and corrects for sample selection in fixed effects models estimated using panel data. To allow for the correlation between unobserved individual effects and explanatory variables, Wooldridge makes the assumption of 'Mean Conditional Independence'. Unobserved individual effects are specified as a linear projection on the observable variables and selection bias in the presence of individual fixed-effects can be controlled for.

The empirical specification of the log earnings equation is as follows :

$$w_{it}^{*} = \alpha_i + X_{1it}\beta + Z_{1i}\gamma + \varepsilon_{it} \qquad \text{for } i = 1,....,n \text{ and } t = 1,.....,T \qquad (7)$$

where i refers to individuals and t to time periods. X_{1it} is a vector of time-varying regressors which includes age and additional over-identifying variables, Z_{1i} is a vector of time-constant regressors, α_i is an unobserved individual effect and ε_{it} is the idiosyncratic error term.

The participation selection equation takes the following form:

$$s_{it}^{*} = X_{2it}\delta_1 + Z_{2it}\delta_2 + v_{it} \qquad \text{for } i = 1,....,n \text{ and } t = 1,.....,T \qquad (8)$$

If $s_{it}^{*} > 0$, $w_{it} = w_{it}^{*}$ and the participation dummy, $S_{it} = 1$. Earnings are not observed when $s_{it}^{*} \leq 0$ in which case the participation dummy $S_{it} = 0$. In fact we study two separate cases, in which the selection equations are of the same form but the dependent variable is based on (a) current economic activity where $S_{it} = 1$ if the individual is working and declares a usual hourly wage and 0 if the respondent is not working, and (b) an observed annual hourly wage, where $S_{it} = 1$ if annual earnings are observed and 0 otherwise, respectively. The selection equation includes vectors of time-varying and time-invariant regressors present in the earnings equation, X_{2it}, and the time-varying identifying variables excluded from the earnings equation, Z_{2it}. v_{it} is an unobserved error term.

Wooldridge (1995) describes a test for selection bias in a panel data context. This requires that an Inverse Mills Ratio (IMR) be obtained from pooled probit estimation

[6] There are other approaches to selectivity see for example Dustmann and Rochina-Barrachina (2007).

of the selection equation. The equation of interest is then augmented by the IMR and is estimated using a fixed effects specification to eliminated unobserved heterogeneity and potential correlation between unobserved individual specific effects and observables characteristics. Wooldridge shows that the significance of the coefficient associated to the Inverse Mills Ratio can be used to test the presence of selection bias.

The advantage of using Wooldridge's model over some approaches is that allows for the unobserved individual effects in both equations to be correlated with the observables (which are assumed to be exogenous). This approach does not require knowledge of the distribution of the error term in the equation of interest, and allows for time heteroscedasticity and autocorrelation in the error terms in both equations. Normality of errors in the selection equation however is assumed. To allow for unobserved individual effects, v_{it} in the selection equation to be possibly correlated with the observable variables X_{2it}, Wooldridge assumes that unobserved individual effects are a linear projection on the (within) means of the regressors. The participation selection model for the both specifications is therefore rewritten as following:

$$s_{it}^{*} = X_{2it}¢_1 + Z_{2it}¢_2 + \bar{Z}_i¢_3 + v_{it} \tag{9}$$

where $v_{it}|Z_{2it}$ has a normal distribution. The selection equation also includes $\bar{Z}_i$, a time average of all time-varying regressors which captures the correlation with observables.

The exclusion restrictions (Z_{2it}) are variables that affect the probability of participation but do not directly influence hourly earnings. The restrictions used in most studies examining the employment selection issues involve family characteristics such as the number and ages of children. However, because the focus here is on individuals approaching retirement age, these instruments are less appropriate since the presence of young children in the household is unlikely. For this reason, the instruments used are non-labour income and three dummy variables. The first is equal to one for those with health problems, the second is equal to one if the individual lives with his spouse and the third dummy is equal to one if his spouse is in employment. These are all likely to play a role in determining labour supply of older workers but should not have direct effects on potential hourly earnings.

5.1 First stage results

The first step consists in estimating the selection equations for the both definitions of participation : (a) employed or not and (b) declare annual earnings or not. In the former case, non-employed include the unemployed (Tables 6 and 7). Both selection equations contain three types of explanatory variable that affect the decisions to participate in the labour market.

The first category includes time-varying regressors which in the current context are time dummies and age. As a key determinant in the decision of retirement, the decision to leave the labour market increases with age in the two specifications. The second set of variables included in the selection equation consists of time-constant regressors. The effects of these variables, which approximate the individual specific effects, are strongly significant in both specifications. Average age has a negative effect on participation (except for those who have worked during the last 12 months but no longer do so). Average age which approximates the cohort effect indicates that older cohorts (i.e. individual with a higher average age) have a higher probability of entering in retirement than younger cohorts at a given age. Average non labour income also has a strong negative effect on the probability of participation.

The effects of education are significant except for 'gcse'. Individuals with low levels of education tend to participate more than individuals with higher education. The coefficient for an individual with no qualifications is negative and significant at the 5% level. Individuals with no qualifications tend to continue working longer. College or university educated individuals are more likely to retire than individuals with A level at given age.

The final category of explanatory variables are variables representing the exclusion restrictions (excluded from the wage equation). They are all strongly significant bar one. The marital status variable is a dummy variable which is equal to one if the individual is married or living with a partner and zero otherwise. The estimated coefficient is negative but not significant. So living in a couple or not does not influence the probability of participating in the labour market *per se*. Whether the spouse is employed or not affects the decision to participate, but does not directly influence an individual's hourly wage. The situation of the spouse is an exclusion restriction variable because it captures the incentive of the individual to remain employed while his spouse is employed. Not unexpectedly, having an income other than labour income increases the probability of retirement. The health problems dummy negatively affects the decision to participate. An individual who has health problems is more likely with draw from the labour force than an individual in good health. The coefficients are similar for the both specifications.

5.2 Second-stage results

The results of the second stage of the Wooldridge approach are presented in columns 2 of Tables 6 and 7. The coefficients associated with the Inverse Mills Ratio are negative and not statistically different from zero in the both specifications. The null hypothesis of no selection bias cannot be rejected in both cases. This means that the unobserved factors that affect the participation decision do not influence the earnings determining process. The age-earnings profile for the oldest workers is not different from that for those aged 50 and the age dummies indicate that there is no evidence of a decline in earnings.

We have found therefore that after taking into account the possibility of selection, there is no evidence that the workers earnings decline at older age whichever definition of hourly earnings used. The decline observed at end of career is not due to a bias related to unobserved factors that influence decisions to leave the labour force. This evidence is consistent with the results of Casanova (2012) who finds no selection into retirement and suggests that the wage process for older workers is best represented by a step function.

6. Conclusions

Cross-section studies suggest that the age-earnings profile has a concave, inverted U shape, which implies that older workers see their earnings decrease as a consequence of ageing, as they approach retirement. In this paper we have explored a number of possible explanations for the decline in hourly earnings observed for older workers in cross section data. Using panel data for Great Britain, we find that this decline does not appear to be due to age itself. Part of the phenomenon is due to cohort effects: younger cohorts tend to earn more than their predecessors. However, changes in labour market status late in life are also contributory factors. Changing jobs, reducing hours of work and spending time unemployed in later life all lead to lower earnings. There is no decline in earnings due to age for employees remaining in employment with same employer. Altogether these results provide evidence that on average the age-earnings profile remains flat at older age.

We have also investigated the role of selection on the decline inearnings. We found that selection bias out of employment cannot explain the decline observed in the cross section age-earnings profile. After controlling for selection, we do not find any evidence of negative wage growth after the age 50. The inverted U-shape observed in cross section data is not the typical earnings trajectory of a worker in the later years of their working life. While this may be reassuring for policy-makers, changes in labour market status late in life are found lead to earnings reductions. While there is a voluntary, labour supply dimension in certain cases, our findings indicate that involuntary separations in later life are associated with substantially lower hourly earnings. Older workers who are laid-off may experience labour market disadvantage in terms of finding jobs at a similar level, spending time in unemployment and being forced to accept lower paid jobs. If earnings do decline at older ages for certain individuals, it is the consequence of events which are linked to age, rather than due to the process of ageing itself.

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Table 1: Cohort numbers by year (males)

Year of survey	Cohort (Birth year) 1931-35	1936-40	1941-45	1946-50	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85	Total
1991	267	306	378	437	409	497	469	404	440	0	0	3,261
1992	238	276	339	383	374	450	418	337	379	67	0	3,261
1993	219	252	308	356	340	409	389	316	350	137	0	3,076
1994	207	241	300	357	336	391	380	298	333	195	0	3,038
1995	198	231	281	343	314	369	367	280	314	244	0	2,941
1996	158	227	287	347	315	368	367	292	320	330	0	3,011
1997	111	220	278	334	311	361	360	279	303	317	63	2,937
1998	77	214	274	323	300	355	334	264	289	294	128	2,852
1999	33	207	268	313	296	341	331	258	272	280	178	2,777
2000	0	199	259	306	285	331	321	250	263	262	231	2,707
2001	0	156	250	290	274	329	313	241	263	239	281	2,636
2002	0	121	241	282	270	319	311	232	245	227	242	2,490
2003	0	74	236	279	265	310	287	227	226	218	232	2,354
2004	0	34	218	273	258	302	282	217	217	206	213	2,220
2005	0	0	217	265	251	290	266	202	213	196	206	2,106
2006	0	0	173	255	242	283	268	198	210	190	195	2,014
2007	0	0	119	247	232	268	253	194	203	173	176	1,865

Table 2: Summary statistics by cohort group (males)

Variable	Cohort (Birth year) 1931-35	1936-40	1941-45	1946-50	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85
Age	60.6	57.9	54.9	50.4	45.3	40.2	35.2	30.1	24.8	21.6	19.6
	(0.058)	(0.069)	(0.073)	(0.069)	(0.071)	(0.066)	(0.067)	(0.075)	(0.072)	(0.067)	(0.058)
Married	0.860	0.857	0.863	0.848	0.786	0.842	0.757	0.643	0.367	0.198	0.086
	(0.009)	(0.006)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.007)	(0.007)	(0.006)	(0.006)
University/	0. 062	0.074	0.110	0.127	0.156	0.200	0.162	0.193	0.124	0.119	0.067
college	(0.006)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
A level	0.244	0.347	0. 425	0. 418	0. 495	0. 431	0. 441	0. 462	0. 475	0. 419	0. 364
	(0.011)	(0.009)	(0, 007)	(0, 006)	(0, 007)	(0, 006)	(0, 006)	(0, 007)	(0, 007)	(0, 008)	(0, 010)
Gcse	0.113	0.147	0.116	0.173	0.122	0.163	0.193	0.179	0.232	0.273	0.258
	(0.008)	(0.007)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)	(0.009)
No qualification	0.566	0.428	0.343	0.278	0.218	0.202	0.193	0.150	0.156	0.130	0.226
	(0.013)	(0.009)	(0.007)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.009)

Table 3: Pooled earnings regression

	(1) log Real usual hourly wage	(2) log Real current hourly wage	(3) log Real hourly wage derived from annual labour income
age≥52	-0.0239	-0.0256	-0.0213
	[0.0187]	[0.0206]	[0.0211]
age≥54	-0.00367	-0.0222	-0.0118
	[0.0200]	[0.0221]	[0.0238]
age≥56	-0.0367	-0.0183	-0.0212
	[0.0216]	[0.0238]	[0.0266]
age≥58	-0.0466**	-0.0479*	-0.0747**
	[0.0235]	[0.0256]	[0.0369]
age≥60	-0.104***	-0.0985***	-0.0559
	[0.0265]	[0.0306]	[0.0386]
age≥62	-0.0684**	-0.0825**	-0.0710**
	[0.0271]	[0.0316]	[0.0290]
Observations	6335	5392	6387
Adjusted R^2	0.172	0.169	0.105

Note: In addition to variables shown, an intercept and controls for education, marital status, origins, and years were included in all specifications.
Standard errors, in brackets, are corrected for clustering * indicates significance at 10%, ** 5%, *** *at* 1%.

Table 4: Fixed effects estimates of earnings equations

	Dependent variable		
	(1) log Real usual hourly wage	(2) log Real current hourly wage	(3) log Real hourly wage derived from annual labour income
age≥52	0.003	0.002	-0.002
	(0.015)	(0.017)	(0.016)
age≥54	0.029*	0.007	0.004
	(0.016)	(0.018)	(0.016)
age≥56	0.013	0.016	0.012
	(0.015)	(0.016)	(0.018)
age≥58	-0.000	0.004	-0.025
	(0.018)	(0.017)	(0.026)
age≥60	-0.037**	-0.047**	0.004
	(0.019)	(0.022)	(0.035)
age≥62	-0.019	-0.032	-0.063**
	(0.020)	(0.023)	(0.029)
Observations	6323	5381	6377
R^2	0.021	0.020	0.014

Note: Time dummies included.
Standard errors, in brackets, are corrected for clustering,* indicates significance at 10%, ** 5%, *** *at* 1%.

Table 5: Movers and stayers

	Dependent variable Log Usual hourly wage					
	(1) All workers	(2) 'Continuous' workers	(3) 'Stayers'	(4) 'Movers'[7]	(5) 'Movers'[8]	(6) 'Partially retired'
age≥52	0.003	0.006	0.002	0.008	0.005	0.008
	(0.015)	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)
age≥54	0.029*	0.038**	0.031**	0.029*	0.031**	0.032**
	(0.016)	(0.018)	(0.016)	(0.015)	(0.016)	(0.016)
age≥56	0.013	0.013	0.013	0.011	0.011	0.012
	(0.015)	(0.016)	(0.015)	(0.014)	(0.015)	(0.015)
age≥58	-0.000	-0.024	-0.004	0.002	0.001	0.002
	(0.018)	(0.019)	(0.017)	(0.017)	(0.018)	(0.017)
age≥60	-0.037**	-0.008	-0.035*	-0.036**	-0.035*	-0.024
	(0.019)	(0.021)	(0.019)	(0.018)	(0.019)	(0.019)
age≥62	-0.019	-0.010	-0.018	-0.024	-0.021	-0.019
	(0.020)	(0.022)	(0.020)	(0.020)	(0.020)	
tenure			0.006***			
			(0.001)			
voluntary mobility				-0.098***	-0.089***	
				(0.021)	(0.021)	
involuntary mobility				-0.252***	-0.010**	
				(0.041)	(0.003)	
partially retired						-0.231***
						(0.061)
Observations	*6323*	*4010*	*6323*	*6323*	*6323*	*5754*
Adjusted R^2	*0.021*	*0.035*	*0.039*	*0.051*	*0.033*	*0.039*

Note: Standard errors, in brackets, are corrected for clustering * indicates significance at 10%, ** 5%, *** *at* 1%. All regressions include time dummies

[7] Involuntary mobility defined as a dummy variable

[8] Involuntary mobility defined as the length of unemployment spell (in months) prior to current job

Table 6: Wooldridge approach based on usual hourly wages

	(1) Pooled Probit participation	(2)Fixed Effects Usual hourly wage
Time-Varying Regressors		
age≥52	-0.026	0.002
	(0.074)	(0.015)
age≥54	-0.114	0.030*
	(0.072)	(0.016)
age≥56	-0.176**	0.016
	(0.067)	(0.015)
age≥58	-0.205**	0.004
	(0.064)	(0.018)
age≥60	-0.304***	-0.027
	(0.062)	(0.019)
age≥62	-0.303***	-0.007
	(0.057)	(0.022)
married	-0.007	
	(0.047)	
Lambda		-0.068
		(0.046)
Time-Constant Regressors		
average age	-0.026*	
	(0.014)	
average non-labour income	-0.274***	
	(0.020)	
education=college/university	-0.165**	
	(0.055)	
education= gcse	0.007	
	(0.055)	
education= no qualification	-0.076**	
	(0.039)	
Exclusion Restrictions		
non labour income	-0.162***	
	(0.014)	
health limit	-0.195***	
	(0.034)	
partner employed	0.578***	
	(0.037)	
Constant	1.984**	2.378***
	(0.719)	(0.069)
Observations	8966	6323
Adjusted R^2	0.2805	0.0217

Note: Standard errors, in brackets, are corrected for clustering
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
All regressions include time dummies

Table 7: Wooldridge approach. Annual hourly wage

	(1) Pooled Probit participation	(2) Fixed Effects Annual hourly wage
Time-Varying Regressors		
age≥52	-0.090	-0.001
	(0.070)	(0.016)
age≥54	-0.065	0.004
	(0.068)	(0.016)
age≥56	-0.154**	0.015
	(0.064)	(0.018)
age≥58	-0.194**	-0.020
	(0.062)	(0.027)
age≥60	-0.315***	0.015
	(0.060)	(0.032)
age≥62	-0.326***	-0.050
	(0.056)	(0.030)
married	-0.040	
	(0.046)	
Lambda		-0.068
		(0.067)
Time-Constant Regressors		
average age	-0.019	
	(0.013)	
average non-labour income	-0.238***	
	(0.019)	
education=college/university	-0.215***	
	(0.053)	
education= gcse	0.062	
	(0.053)	
education= no qualification	-0.034	
	(0.038)	
Exclusion Restrictions		
non labour income	-0.150***	
	(0.012)	
health limit	-0.184***	
	(0.033)	
partner employed	0.503***	
	(0.036)	
Constant	1.632**	2.365***
	(0.685)	(0.102)
Observations	8966	6377
Adjusted R^2	0.2503	0.0144

Note: Standard errors, in brackets, are corrected for clustering

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All regressions include time dummies

Figure 1a

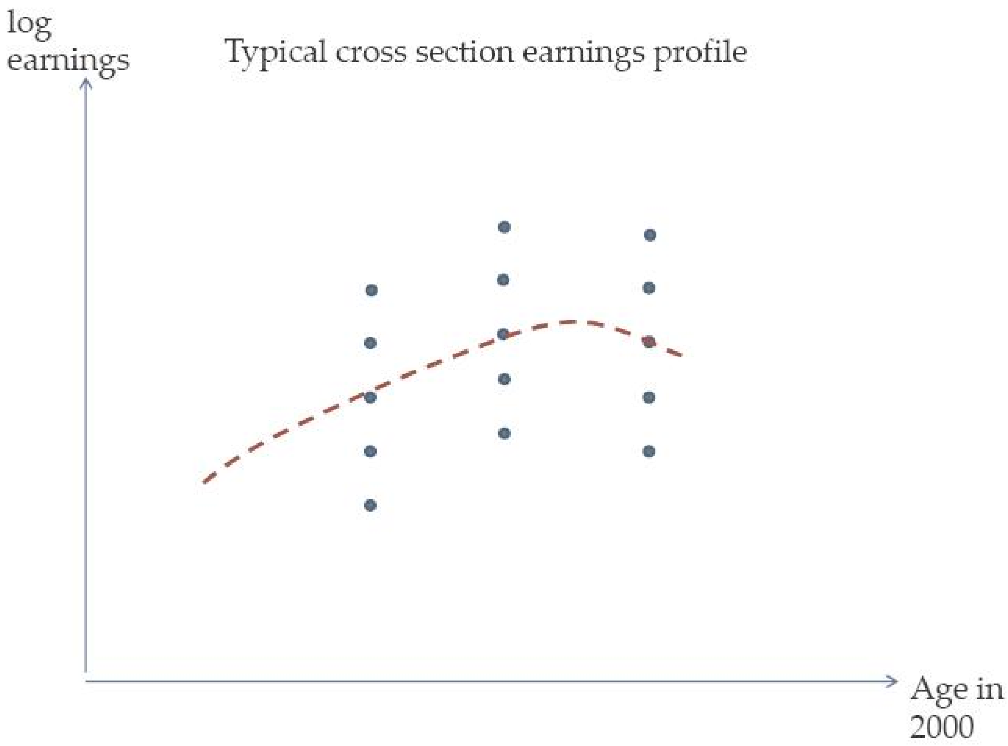

Figure 1b

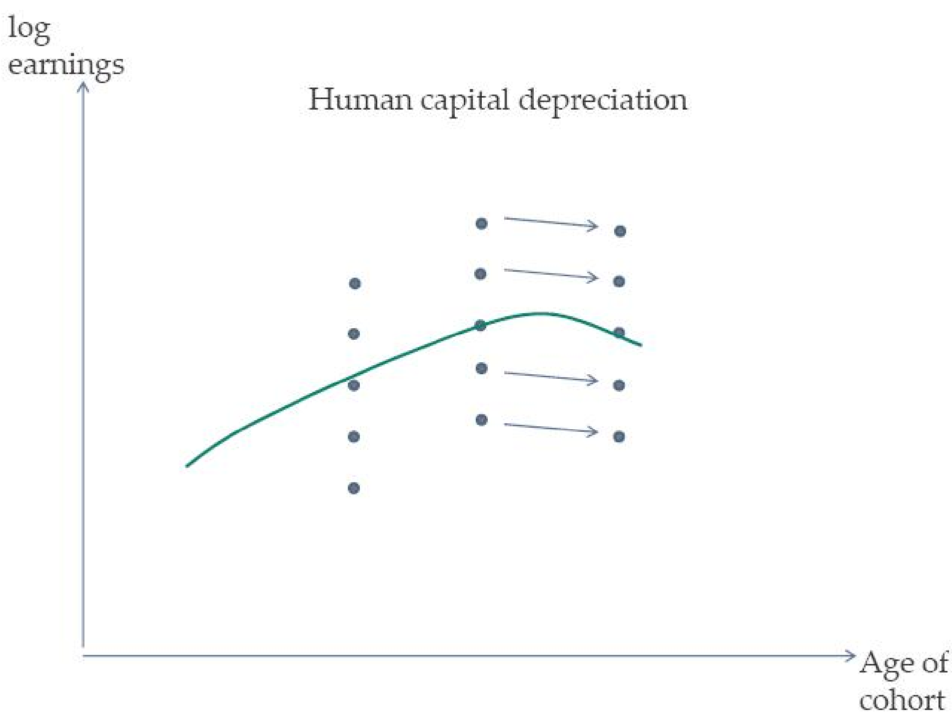

Figure 1c

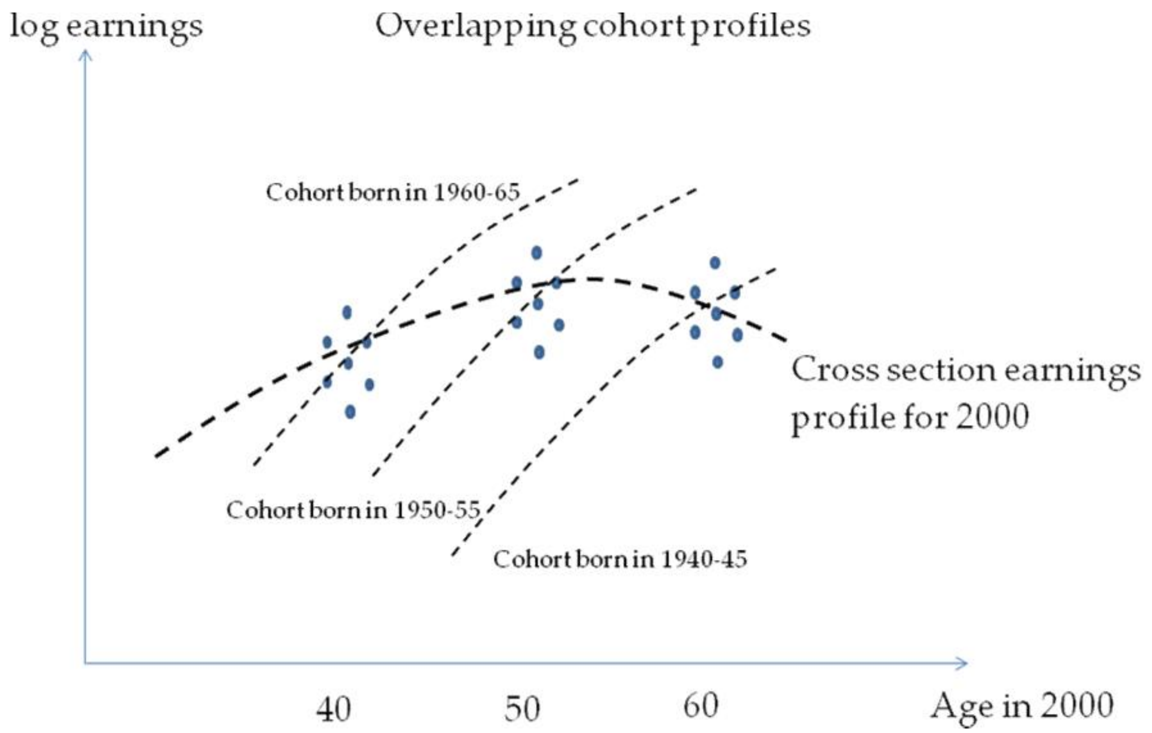

Figure 1d

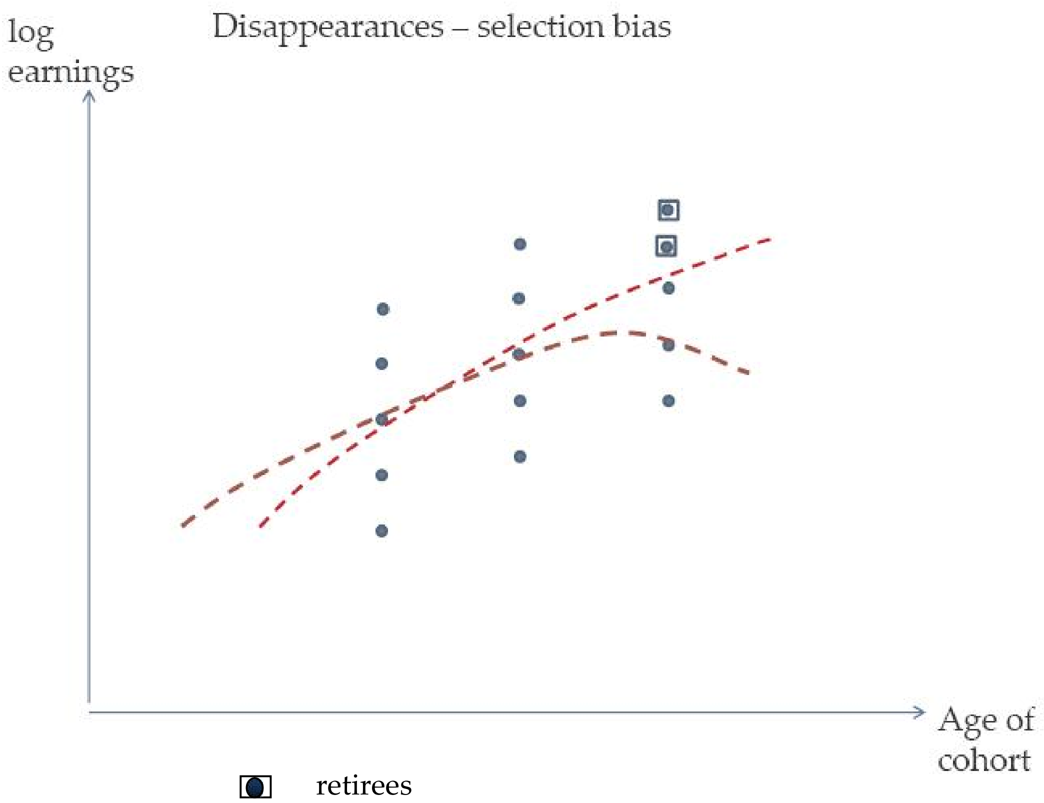

Figure 2 Participation rates by age and by cohort (males)

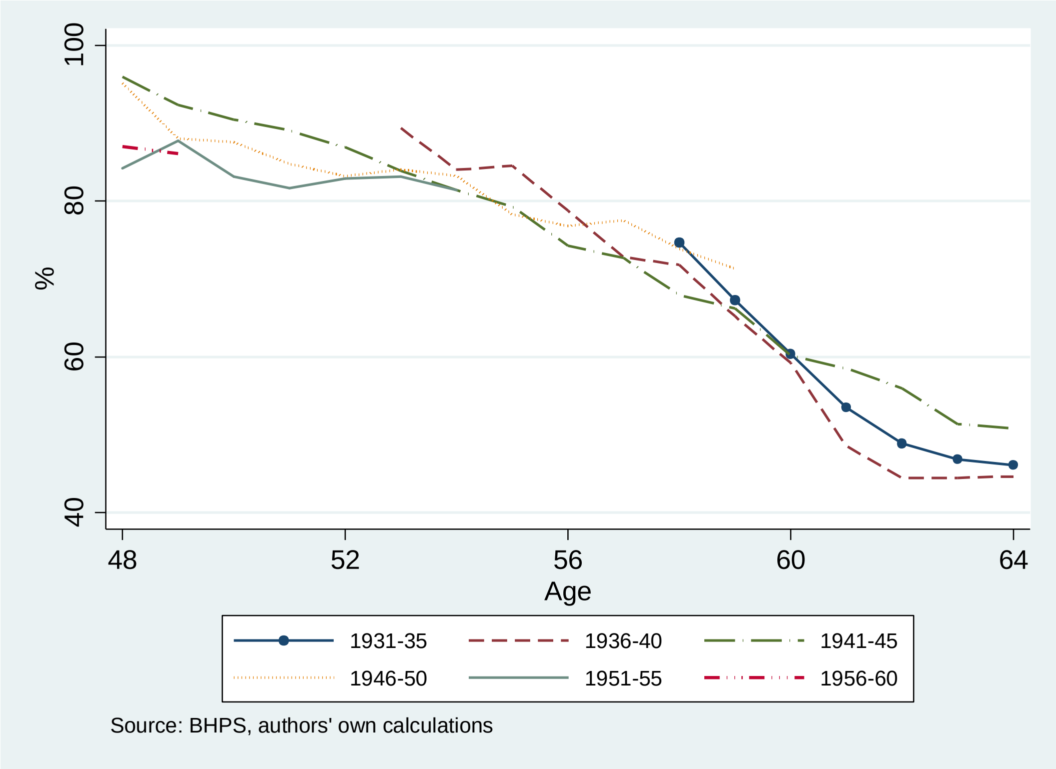

Figure 3 Cross section age-hourly earnings profiles

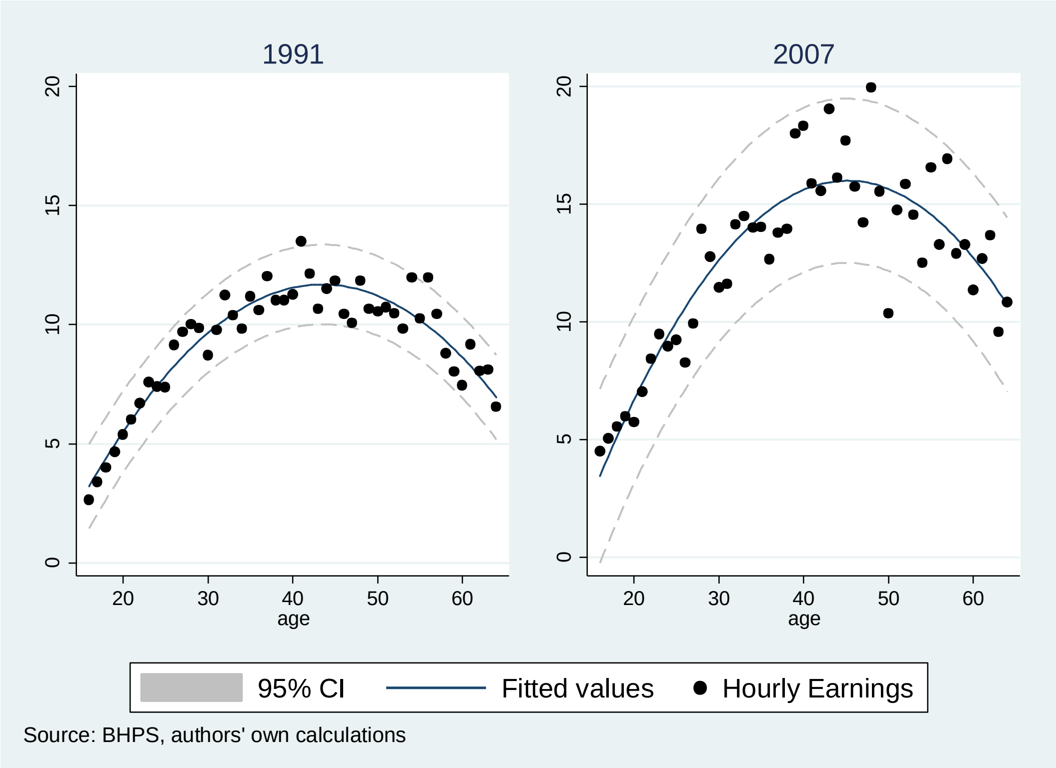

Figure 4 Cross section age-annual earnings profiles

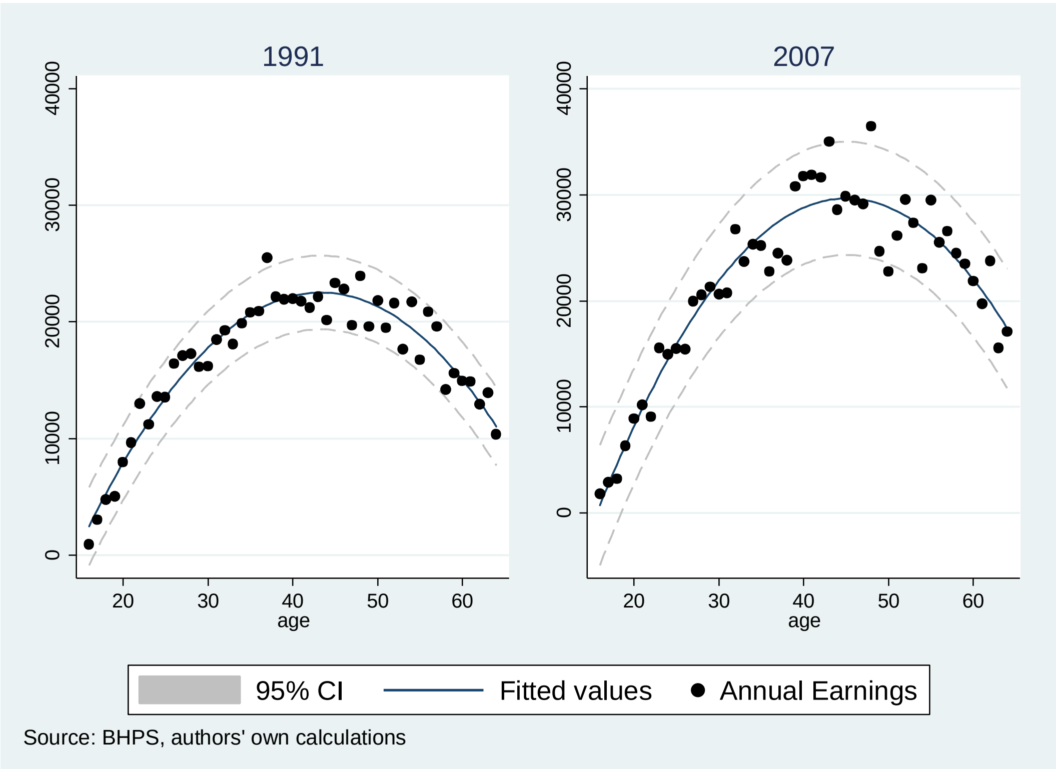

Figure 5a Cohort-specific age-hourly earnings profiles 1991-2007

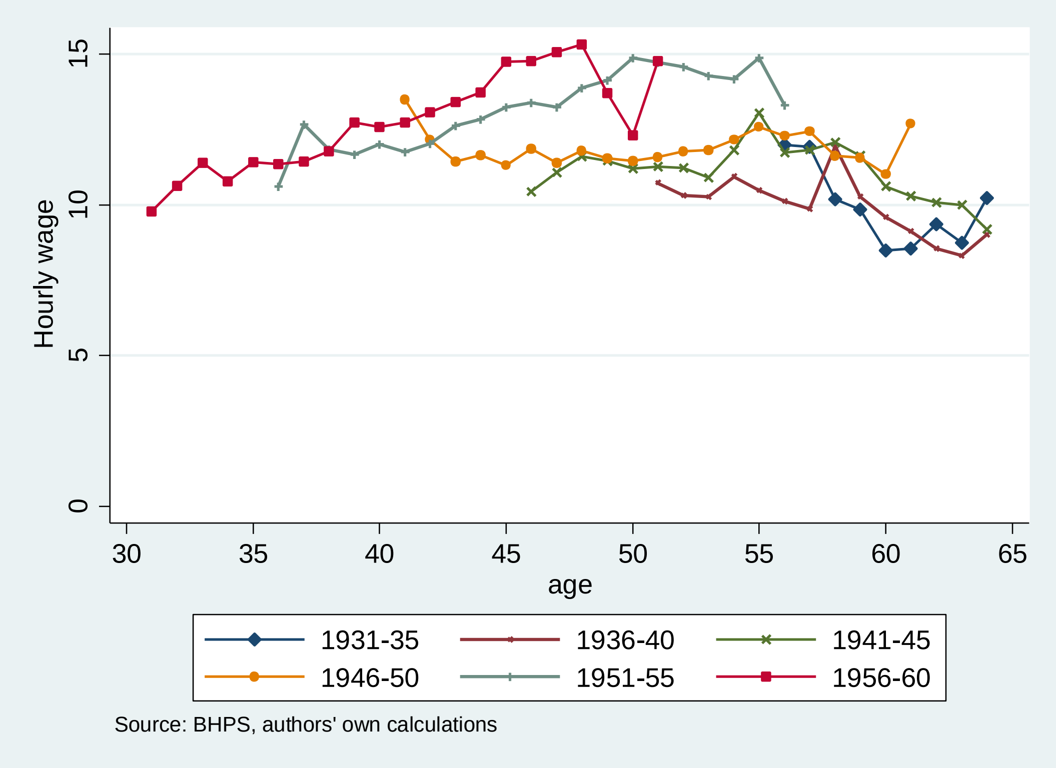

Figure 5b Cohort-specific age-hourly earnings profiles 1991-2007