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Earning ability over the life cycle*

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Abstract

We study how worker-specific ability to generate earnings evolves over the life cycle. We measure the dynamics of earning ability by extending the canonical AKM model of wage determination to allow worker effects to vary as individuals age. Age-dependent estimates of earning ability unveil heterogeneous career trajectories, with high ability workers sorting into higher-paying employers early in their careers and moving to different firms to a lesser extent thereafter. We show that earning ability significantly decreases after job loss, suggesting that it is at least partly match-specific. This result is particularly pronounced for high-ability workers, who, conversely, are the ones experiencing the lowest penalties in employer pay after job loss.

JEL Classification: J31, J21.

Keywords: Earning ability, AKM model, ageing.

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I. Introduction

How do individual productivity profiles evolve over the life cycle? Answering this question is crucial in an ageing society. Globally, the median workforce age has increased by six years since 1990, reflecting surging life expectancy and lengthening working lives. While the age-wage gap has significantly widened in favour of older workers (Bianchi and Paradisi, 2022), several studies show that productivity peaks around age 50 due to cognitive skill decline (e.g., Cardoso et al., 2011). Moreover, the evolution of productivity is likely heterogeneous. While returns to experience are increasing in complex occupations (Deming, 2021), older workers lacking advanced and general education are less adaptable to technological change (Hanushek et al., 2017). Overall, the direction in which productivity evolves with age is ambiguous and likely differs by sector and occupation.

We uncover individual productivity trajectories by extending the classical model of wage determination proposed by (Abowd et al., 1999, , hereafter, AKM). Person effect estimates from the AKM model can be interpreted as a worker's earning ability that is portable across firms (Card et al., 2018). Exploiting nearly 40 years of administrative data on the population of Italian private-sector workers, we allow earnings ability and firm effects to drift over the life cycle as workers age. With age-varying individual estimates at hand, we provide evidence on the heterogeneous evolution of individual productivity. Finally, we investigate how labour market shocks affect individual productivity and firm effects by estimating event studies around plant closures. This allows us to test the interpretation of earnings ability as portable, i.e., whether it represents general human capital rather than sector, firm, or match-specific productivity.

A vast literature has examined the sources of wage growth (Adda and Dustmann, 2023, most recently,). While many works focus on firm-to-firm transitions, the role of which is emphasised by job ladder models, we investigate the evolution of individual productivity net of the predictable effects of employer changes.

Mounting effort has been produced to extend and validate the AKM model. While Lachowska et al. (2022) show that firm effects drift over time, the evolution of person effects with a worker's age is previously unexplored. Bingley and Cappellari (2022) show that ernings ability is the driver of growing earnings dispersion over the workers' life cycle. Departing from their work, we focus here on individual-specific trajectories rather than wage inequality.

II. Wage model

We extend the AKM model of wage determination to allow person effects to vary by worker's age. Specifically, we estimate the following model:

$$log(w_{ijt}) = \beta' X_{it} + \alpha_{ib} + \phi_{jf} + \varepsilon_{ijt}, \qquad (1)$$

where w_{ijt} is the weekly wage earned by worker i in firm j in year t; $j = j(i,t)$ is worker i's firm in year t; $b = b(i,t)$ is worker i's age bracket in year t: $18-25, 26-30, \ldots, 61-65$; $f = f(j,t)$ is firm j's age bracket in year t: $0-5, 6-10, 11-25, 26-50, \geq 51$. Statistical identification of the coefficients from this model requires similar conditions to the classic AKM model. Specifically, as long as firm effects are invariant with the age of the worker, they are identified by movers within a given firm's age bracket f regardless of the movers' age. In other words, we do not need movers within each worker's age bracket b. We additionally include year-by-cohort dummies to net out our estimates from general cohort and business cycle effects. We estimate equation (1) separately by gender.

Estimation of equation (1) yields a set of individual earnings ability and firm effects estimates for each worker's and firm's age bracket. Earnings ability is estimated by coefficients α_{ib}, representing the component of a worker's earnings that is portable across firms (Card et al., 2018). This productivity measure, indeed, is net of predictable changes from firm-to-firm transitions, estimated by ϕ_{jf}. We describe firm effects by averaging ϕ_{jf} estimates within a worker-age cell, representing the average employer pay level experienced by worker i in age bracket b.

We additionally propose an "unconditional" earnings ability measure to account for nonemployment spells. One potential limitation of estimates from equation (1) is that they are conditional on observing a positive salary, i.e., on employment in a private-sector firm. We account for nonemployment in two steps. First, we subtract firm effects from the observed log weekly wage for workers employed in a given year. From this quantity, we compute absolute weekly earnings net of firm average pay. We assign zero earnings to workers who are not employed in a given year. Second, we control for age-cohort shocks by regressing the latter measure on the same set of controls as in equation (1) but firm dummies. Worker-age dummies in this regression estimate unconditional earnings ability for each worker and age bracket, measured in euros per week and including non-employment spells.

III. Earning ability trajectories in Italy

Data

We exploit administrative data from the Italian Social Security Institute (Istituto Nazionale di Previdenza Sociale, INPS), covering the population of firms and workers in the private nonagricultural sector. The main source of information is the form that employers have to complete in order to pay state pension contributions for their employees, digitized since 1983. In this form, employers report gross pay, covering all forms of monetary compensation and including employee pension contributions and labor income taxes. Moreover, for each employment spell, employers report total working days, start and end dates (start dates are censored at February 1974) and broad occupational categories (apprentices, blue collar, white collar or manager). These spell data are supplemented with firm-level information about location, date of establishment and date of closure. While spell data include workplace location, we maintain firms as the unit of analysis on the employer side.

Demographic information on workers includes gender and year of birth but not education. For each worker in each year, we define the prevalent employer as the firm where she is employed for the most working weeks. We drop left-censored spells, i.e. where a prevalent employment that is ongoing in January 1983 started before February 1974. We consider gross salary, including amounts exceeding the yearly earnings threshold on which social security contributions are computed ("*eccedenza massimale*"). We proxy a worker's education level using the age when first observed in the labour market.

We consider all men and women aged between 18-65 employed in 1983-2022 conditional on working 8 full-time-equivalent weeks in a given year. This selection yields 34 million workers, 62% of which are men. While we use the full working sample to estimate our wage model, we mostly focus in the subsequent analysis on cohorts potentially observed throughout the age brackets 26-30 to 56-60. The latter are 7 million workers born between 1954 and 1965. Using the full population when estimating equation (1) is necessary to obtain consistent estimates of firm effects.

Descriptive evidence

We start by motivating age-varying earnings ability with two pieces of evidence. First, growth in earnings ability between ages 26-30 and 56-60 captures most of the growth in wages over the same age span. Figure 1 plots the distribution of log differences in weekly earnings, earnings ability, and firm effects. While the distribution of firm effects growth (Panel C) is less dispersed and centred around zero, the distribution of earnings ability growth (Panel B) is more dispersed and is close, on average, to the total wage growth (Panel A). This result suggests that most wage growth occurs over and beyond average wage changes from job-to-job movements.

Second, we compare the estimates obtained from equation (1) to analogous estimates of a canonical AKM model where person (and firm) effects are fixed throughout a worker's career. In Figure 2, we focus on workers observed in the labour market throughout ages 26-60 to avoid compositional changes that may confound lifecycle patterns. Estimating age-invariant profiles by design, the canonical AKM model undervalues the earning ability of older workers and overvalues the one of younger workers, both in the conditional and unconditional versions (Panels A and B, respectively). Unconditional earnings ability, however, peaks at age 51-55, reflecting relatively early exit from the labour market in the cohorts we consider. Finally, firm effects vary over the lifecycle in both models by virtue of employer-to-employer transitions. Both models present similar lifecycle patterns of initially increasing and later declining employer premia, with our extended version generating smaller estimates across the board. This suggests that a substantial fraction of the employer premium estimated by the canonical AKM model is accounted for by the differential productivity of workers of different ages, regardless of the firm at which they are employed.

We show in Figure 3 how earnings ability and employer pay evolve over the life cycle by gender, on average. Although weekly wage markedly increases with age for both genders, we observe a persistent gender gap of around 15 log points favouring men (Panel A). Since we estimate equation (1) separately by gender, this persistent gap does not appear in earnings ability and firm effect estimates. The gap slightly widens with ageing, especially since age 36-40, consistently with the mounting evidence on the child penalty (Kleven et al., 2019). While earnings ability slightly diverges across genders after age 36-40 (Panel B), the largest driver of this pattern is a swift decline in employer pay for women in childbearing age(Panel C). Accounting for labour force participation, the gender gap in earnings is even larger, additionally reflecting employment child penalties (Panel D). Only a part of this gap is accounted for by unconditional earnings ability (Panel E). Women exhibit markedly lower mobility across employers, especially until age 40 (Panel F). Additional results not reported here also point to a dramatically higher incidence of part-time contracts among women.

We next show correlations of earnings ability and firm effects over the life cycle. First, correlations between individual and firm productivity indicate the extent of sorting of better workers into better firms. Figure 4 shows that sorting markedly increases over the life cycle for both genders, but is everywhere substantially weaker for women. Second, the autocorrelation of earnings ability and firm effects as a worker ages represents their persistence. Figure 5 shows that earnings ability is highly persistent, especially for men, while firm effects are more persistent than earnings ability for women. Unconditional earnings ability exhibits the lowest persistence, especially at later stages, highlighting that labour force participation plays an important role.

Persistence of individual and firm productivity is especially high at the top of the distribution. We compute transition matrices of worker-firm groups by defining four groups based on earnings ability or firm effect being below or above the median ("low worker", LW, or "low firm", LF vis-à-vis "high worker", HW, or "high firm", HF). Table 1 shows high persistence at age 56-60 for workers starting with high productivity in a high firm at age 26-30, especially for men. It is generally more likely to transition from low to high individual productivity than from low- to high-paying firms.

Average evolutions of individual and firm productivity mask substantially heterogeneous trajectories. We group workers by ventile of starting earnings ability (age 26-30) and compute log differences in individual and firm productivity by age 56-60. Earnings ability substantially grows throughout the distribution but it increases to a larger extent for workers with high starting productivity, apart for a spike in the first ventile likely reflecting regression to the mean (Figure 6, Panel A). On the contrary, it is easier to climb the job ladder for workers starting in less-productive firms, while employer pay even shrinks on average for workers starting in the highest part of the distribution of firm effects (Panel B). However, when plotting firm effect evolution against worker starting productivity, we find that employer pay substantially increases for more-productive workers while it significantly declines for less-productive ones (Panel C). This is consistent with our results on sorting above, and suggests the existence of heterogeneous job ladders in line with Borovickova and Macaluso (2025). Figure 7 further shows labour market outcomes at age 56-60 by starting individual productivity. More productive workers are much more likely to be employed, to work almost full-year, and to have a permanent contract. Similarly to Borovickova and Macaluso (2025), more productive workers are also less likely to change employer in the final part of the career.

Cross-sectional inequality markedly increases over the life cycle. We plot in Figure 8 individual and firm productivity compared to ages 26-30 for the 10th, 50th, and 90th percentiles in each age bracket. Weekly wage at the 90th percentile drifts reaching 60 log points increase from ages 26-30 compared to 20 and 10 log points for the 50th and 10th percentile, respectively (Panel A). This divergence is mostly accounted for by earnings ability (Panel B), while firm effects are persistently higher at higher percentiles but evolve more parallelly (Panel C). While the composition of workers at these percentiles can change with age, we additionally identify workers in the 10th, 50th, and 90th percentile of lifetime earnings and plot their trajectories in Figure 9. Earnings ability exhibits sustained growth for 90th percentile workers, while this growth is weaker for median workers, especially after age 35. Workers in the 10th percentile exhibit an often declining earnings ability for most of their career. On the other hand, firm effects moderately grow for 90th percentile workers, are substantially flat for median workers, and vary much more substantially for 10th percentile workers, swinging around relatively very low levels.

In terms of observable characteristics, we show in Figure 10 that large increases in earnings ability over the life cycle mostly accrue to college graduates, in very large firms, and for Italian citizens. We plot estimated coefficients from regressions of earnings ability and firm effects on individual demographics or starting labour market outcomes separately estimated by age bracket. Education is proxied by the age of entry in the labour market.

IV. Earning ability and labour market shocks

We test how earnings ability and firm effects respond to labour market shocks by exploiting establishment closures. A vast literature agrees that job loss leads to substantial and persistent penalties in employment and wages (Lachowska et al., 2020; Athey et al., 2022; Schmieder et al., 2023; Bertheau et al., 2023; Gulyas and Pytka, 2025; Fackler et al., 2021; Helm et al., 2023), against the predictions of models assuming frictionless labour markets. We use our wage model in equation (1) to test the extent to which job loss affects individual productivity versus employer average pay. Our extension allowing person effects to vary as a worker ages turns out to be crucial to tell employer premium and individual productivity losses apart.

Empirical strategy

We identify closing plants in firm data («data cessazione») and exploit closing events following the literature on job loss (e.g., Bertheau et al., 2023). To the aim of this exercise, we select a treatment group of "stable" workers, with at least 3 years of consecutive tenure, aged 25-60, and hit by one plant closure. Moreover, to avoid picking up different events such as mergers and acquisitions, we exclude workers who are re-employed after closure at the same plant of more than 20% of their co-workers.

We compare workers losing their jobs to a matched control group of observationally similar workers. We extend the tenure requirement to the control group and select one suitable control peer for each treated worker through a $1:1$ matching algorithm without replacement. Specifically, we exactly match on gender, birth cohort, job loss year, and industry. Moreover, conditional on the latter variables, we miniimse the distance in demographics and pre-displacement labour market outcomes (citizenship, age at first job, employment, weekly wage, permanent contract, full-time employment, occupation level, earnings ability, firm effect). Our final estimating sample includes 288,724 workers, evenly divided by treatment and control individuals.

We estimate event study models around the age bracket when job loss occurs, denoted as b^*:

$$Y_{ib} = \gamma_i + \delta_b + \sum_k \theta_k \mathbb{1}[b = b^* + k] + \sum_k \pi_k \mathbb{1}[b = b^* + k] \times T_i + u_{ib}, \qquad (2)$$

where Y_{ib} is a labor market outcome for worker i in age bracket b, and T_i is an indicator equal to one for treated workers. In this formulation, coefficients π_k estimate k age brackets from the job loss event. A key distinctive feature of our exercise is to work at the individual-age-bracket level, at which firm effects and earnings ability are estimated, rather than the individual-year level. Our panel is defined at the level of worker i and age bracket b, and the control group is constructed by matching average characteristics observed in an age bracket. As a consequence, event study graphs plotting estimated π_k show average outcome differences for displaced workers in each age bracket with respect to control peers and to the age bracket before job loss. In particular, estimated impacts at $b = b^*$, i.e., π_0, pool pre- and post-job loss years depending on which exact year within b^* the establishment closure hits. We estimate equation (2) separately by age bracket at establishment closure.

Older workers at the time of job loss experience heavier wage losses conditional on employment. In the first age bracket after establishment closure, i.e., 3-8 years after job loss, workers aged 56-60 at job loss have 12% lower wages, compared to 5% for workers ages 31-35 (Figure 11, Panel A). These results are in line with age being among the main predictors of wage penalties following job loss (Salvanes et al., 2023; Athey et al., 2022).

Most of the wage loss is accounted for by individual earnings ability. About two-thirds of losses in Panel A reflect drops in earnings ability, ranging from 3.5% for younger workers to 7% for older workers (Panel B). The remaining penalty is accounted for by the decrease in employer pay, ranging from 1 to 4% (Panel C). Firm effects seem to account for a larger part of the wage loss as workers age. The relatively small role played by employer premia aligns with findings in Lachowska et al. (2020) and Athey et al. (2022) but contrasts with findings in Fackler et al. (2021); Schmieder et al. (2023); Helm et al. (2023). One potential reconciliation is that the relative role of employer premia is heterogeneous, with low-wage workers being the most affected group from employer premium loss (Gulyas and Pytka, 2025). We find similar heterogeneity below. Moreover, another potential source of inflation in the role of employer premia is the model used to estimate firm productivity. We show in Figure 12 that the loss in employer premium appears substantially more pronounced when estimating firm pay using a canonical AKM model rather than our extended model that allows person effects to vary as a worker ages.

Even more pronounced losses are observed at the extensive margin, with labour market participation dropping for displaced workers. The likelihood of being out of the private-sector labour market increase by 20 to 30 p.p. 3-8 years after job loss, generally more for older workers (Figure 13, Panel A), When imputing zero earnings to non-employment spells, earnings drop by 150-200 euros per week on average with more pronounced losses for older workers (Panel B). Most of these penalties are accounted for by drops in unconditional earning ability rather than firm effects conditional on working (Panel C).

Wage penalties following job loss are larger for workers with above-median earning ability before closure. Figure 14 presents heterogeneity analyses by pre-displacement earnings ability. While for younger workers the relatively milder wage losses are mostly homogeneous, high-productivity older workers exhibit substantially larger penalties than low-productivity ones, possibly reflecting a higher match value destroyed by closure (Panel A). A notable pattern emerges when decomposing these losses into earnings ability (Panel B) and firm effect (Panel C). While earnings ability decreases much more markedly for high-productivity workers, employer pay declines particularly for low-productivity ones. While high-productivity younger workers are able to find jobs in even higher-paying firms than the one from which they are displaced, low-productivity workers face a substantial decline in firm productivity, especially if they are relatively older at the time of job loss.

V. Conclusion

Assessing how individual productivity evolves over the life cycle is a crucial question in an aging society. Answering this question faces substantial challenges stemming from the measurement of individual productivity. Our approach extends the canonical AKM model of wage determination to allow person effects to vary as a worker's age.

Age-varying measures of earnings ability unveil heterogeneous career trajectories, with highly productive workers sorting to higher-paying employers in the starting stage of their career and moving to different firms to a lesser extent thereafter. Individual productivity is at least partly match-specific, since it is significantly decreased by labour market shocks such as job loss. This result is particularly pronounced for high-productivity workers, despite their ability to minimise the penalties in employer pay after job loss.

In next steps, we plan to employ supervised and unsupervised machine learning techniques to summarise heterogeneous career trajectories.

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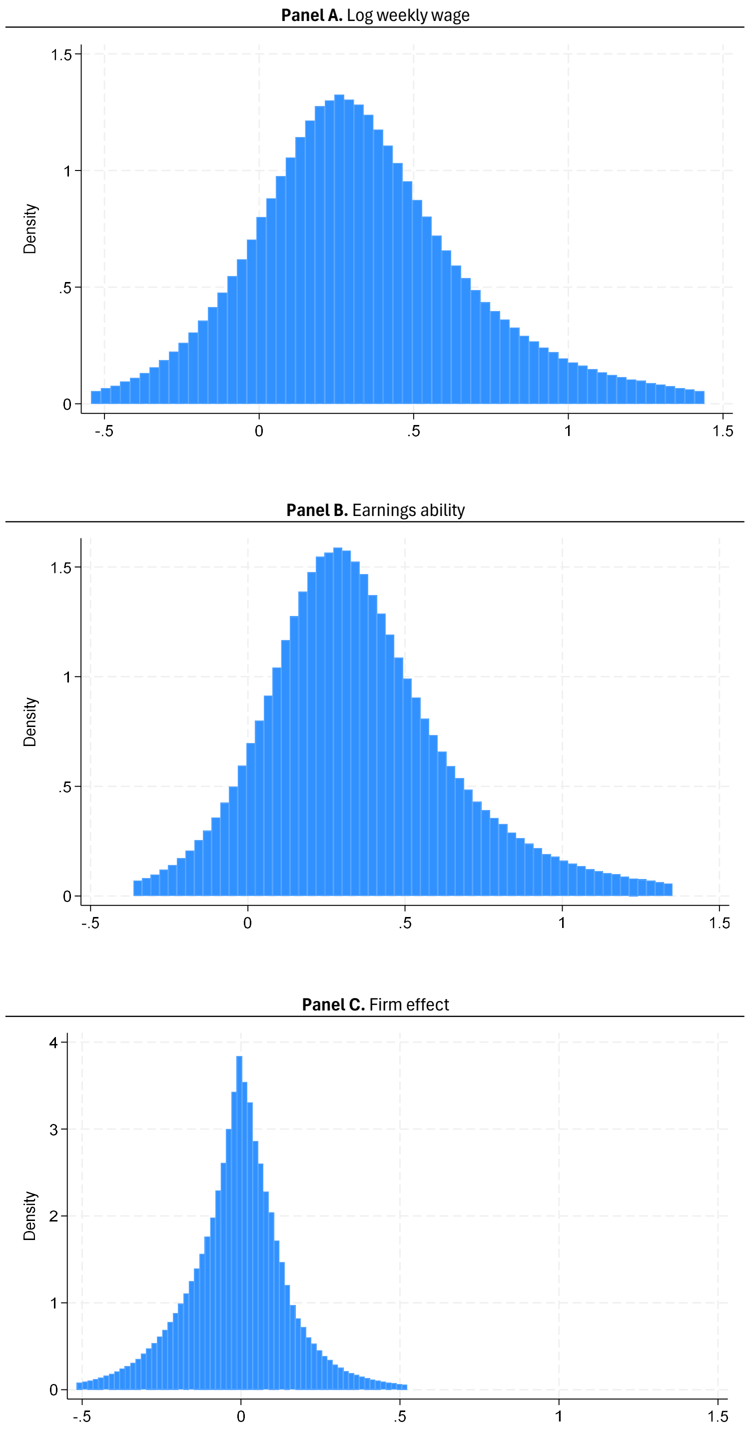


FIGURE 1. Individual and firm productivity growth between 26-30 and 56-60

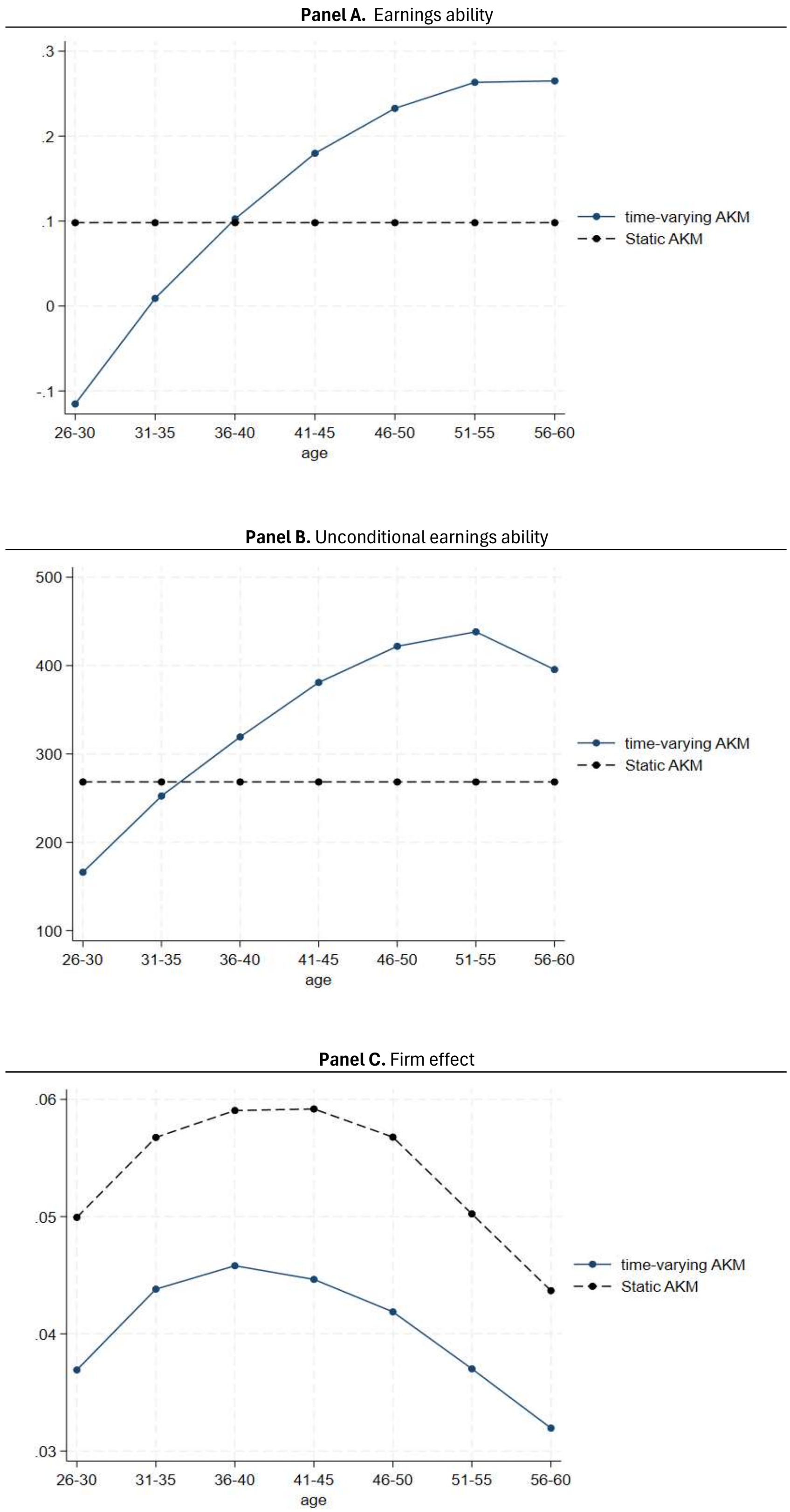


FIGURE 2. Age-varying VS canonical AKM model

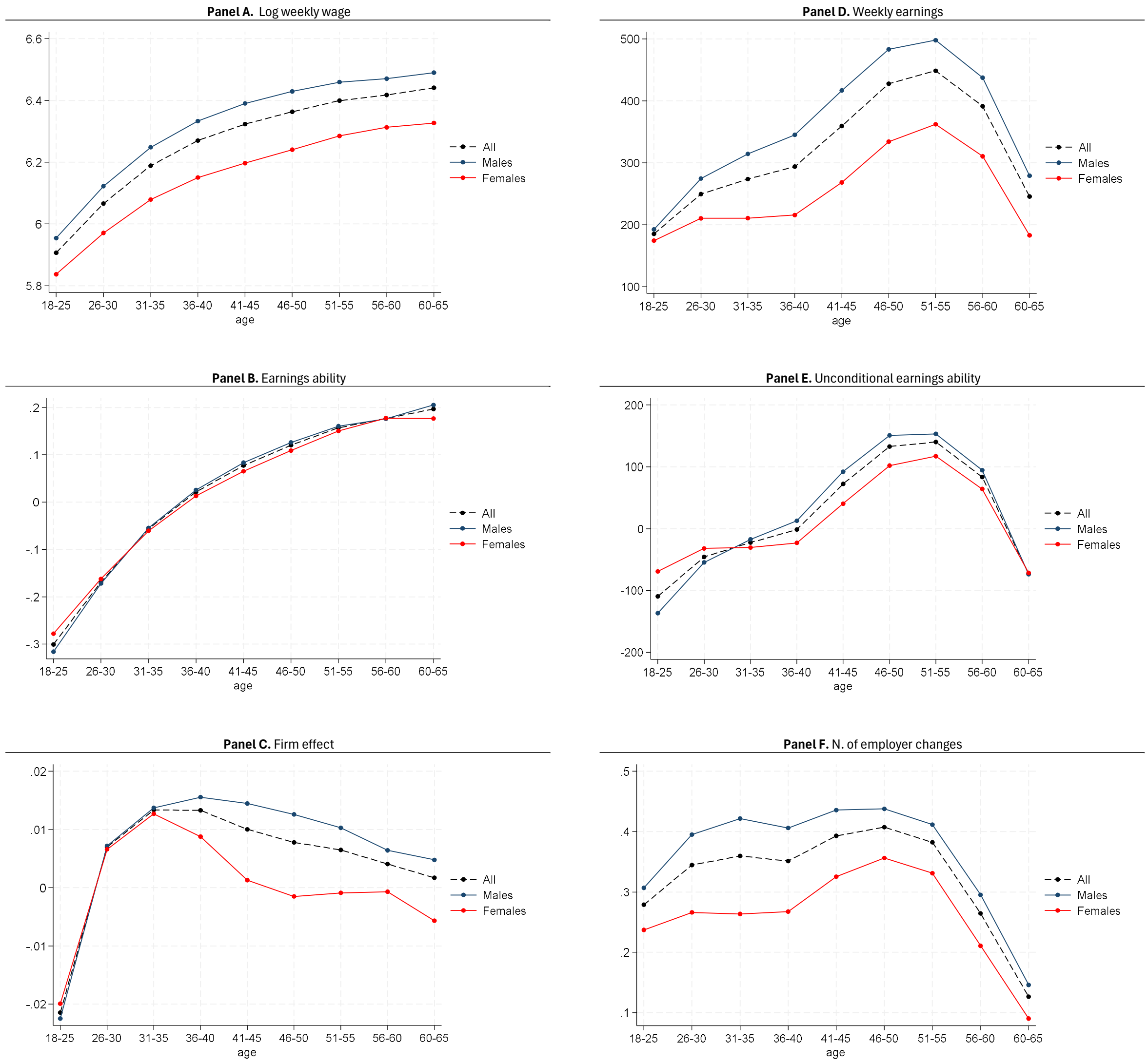


FIGURE 3. Individual and firm productivity over the life cycle

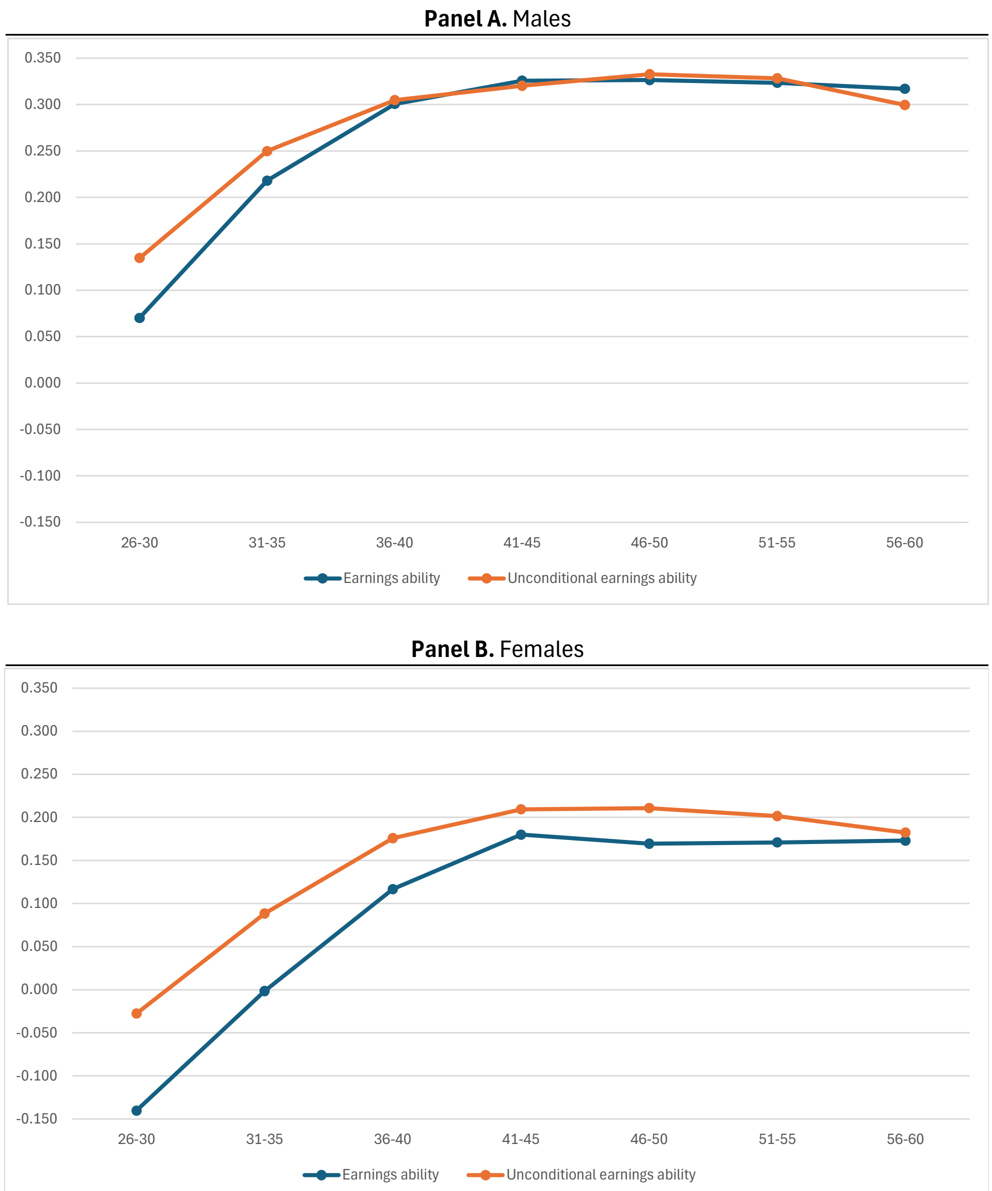
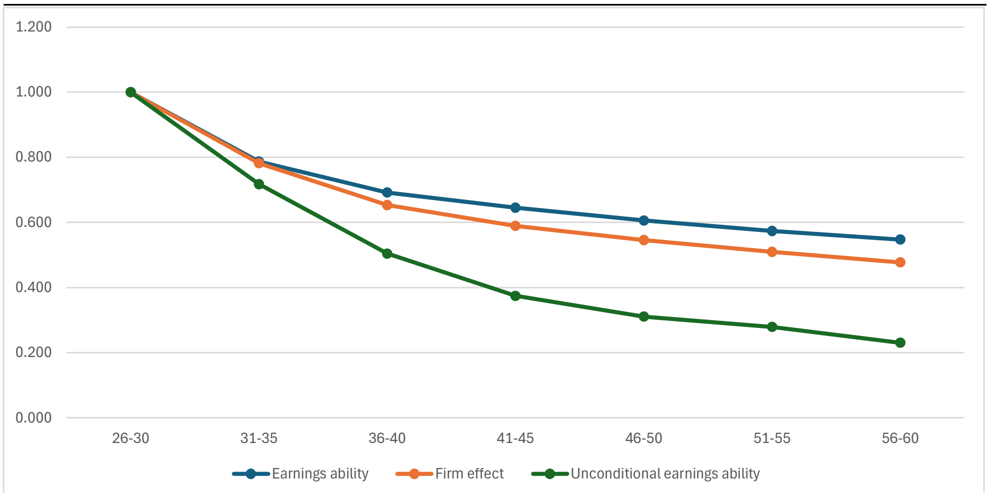


FIGURE 4. Sorting correlations with firm effect

Panel A. Males



Panel B. Females

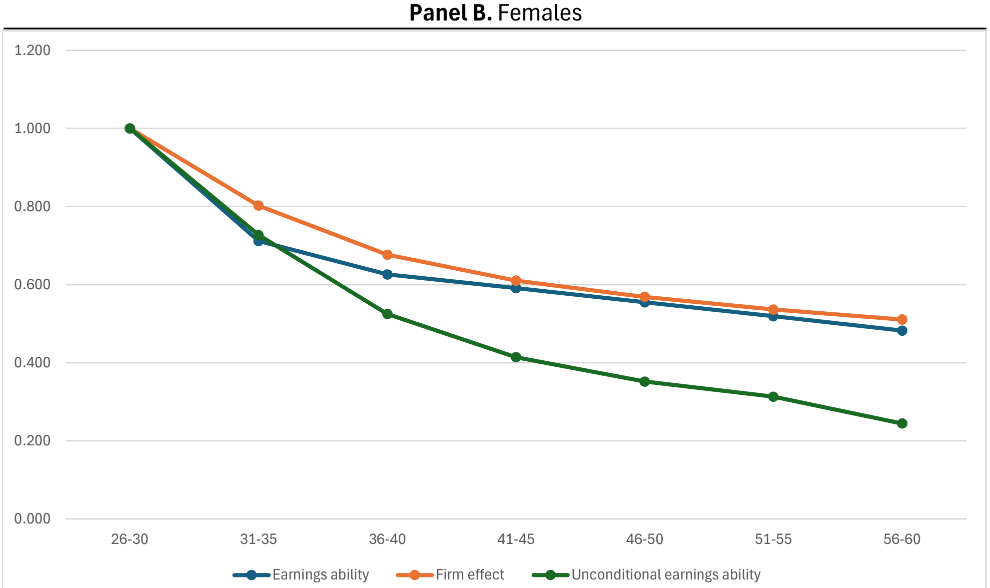


FIGURE 5. Persistence of individual and firm productivity

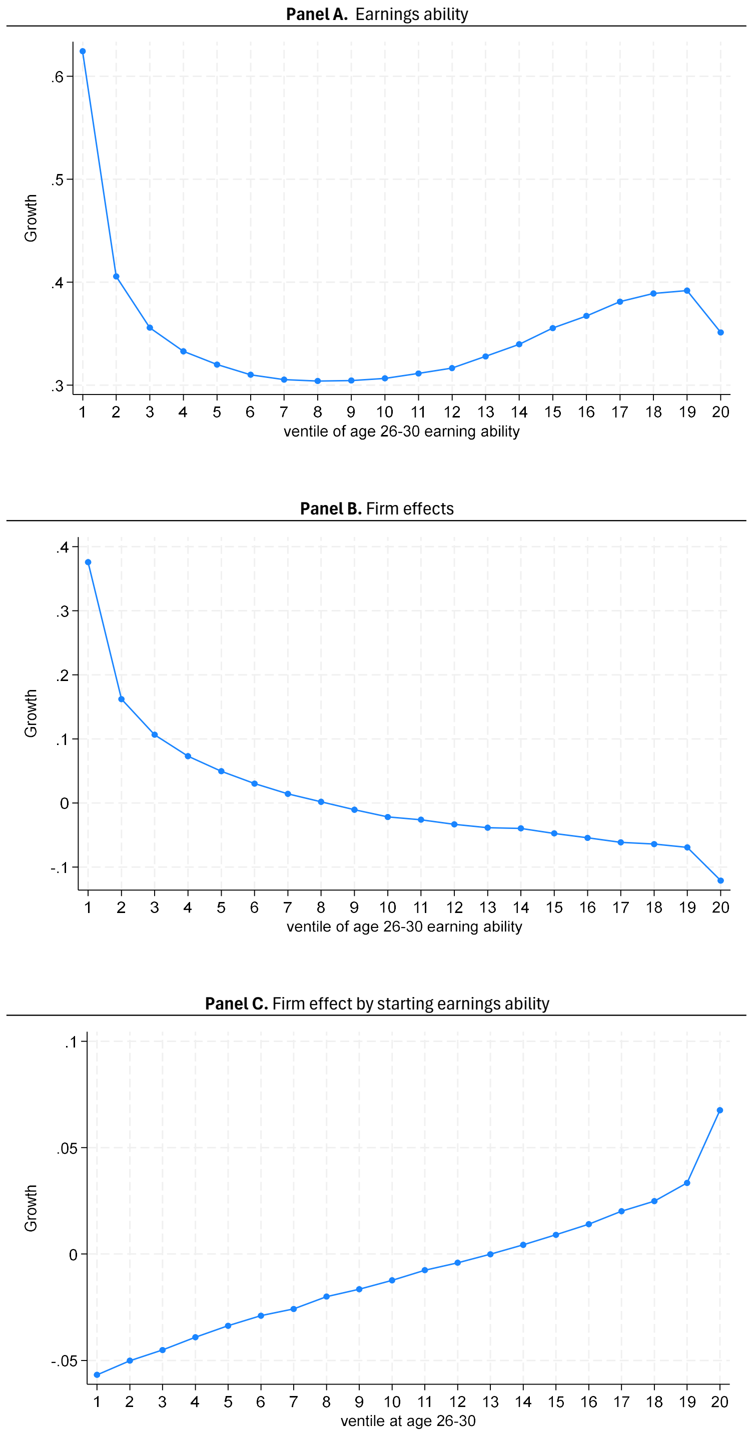


FIGURE 6. Individual and firm productivity growth by ventile of initial earnings ability

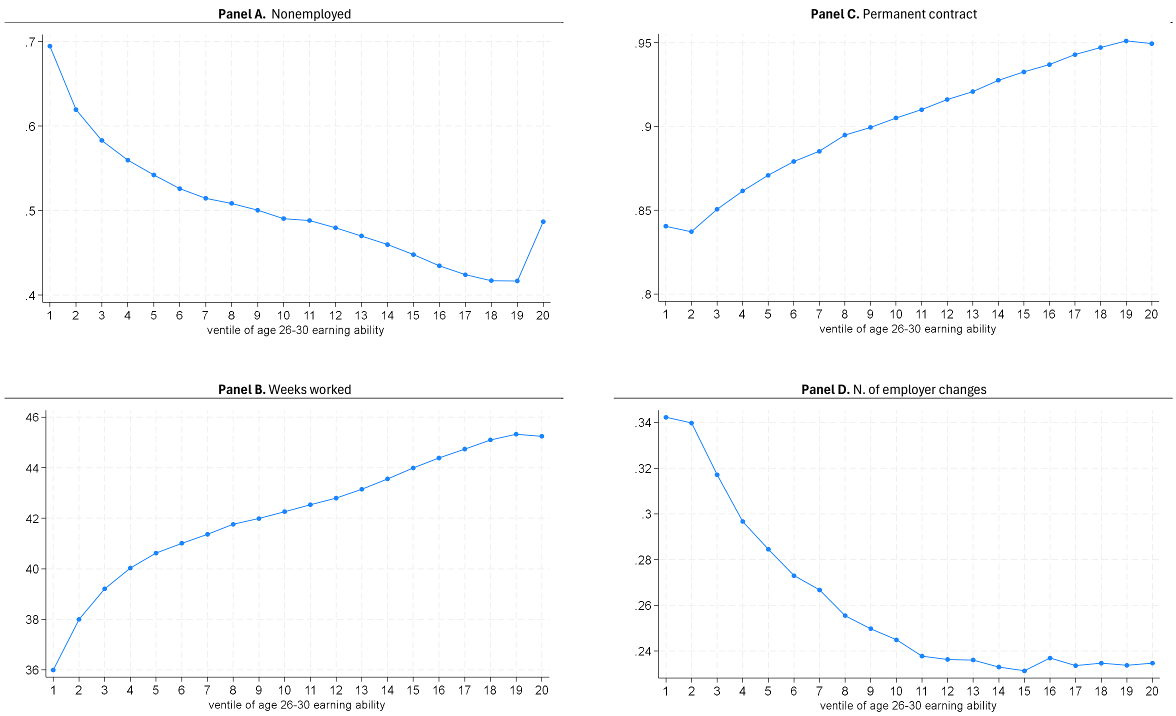


FIGURE 7. Labour market outcomes at age 56-60 by ventile of starting earnings ability

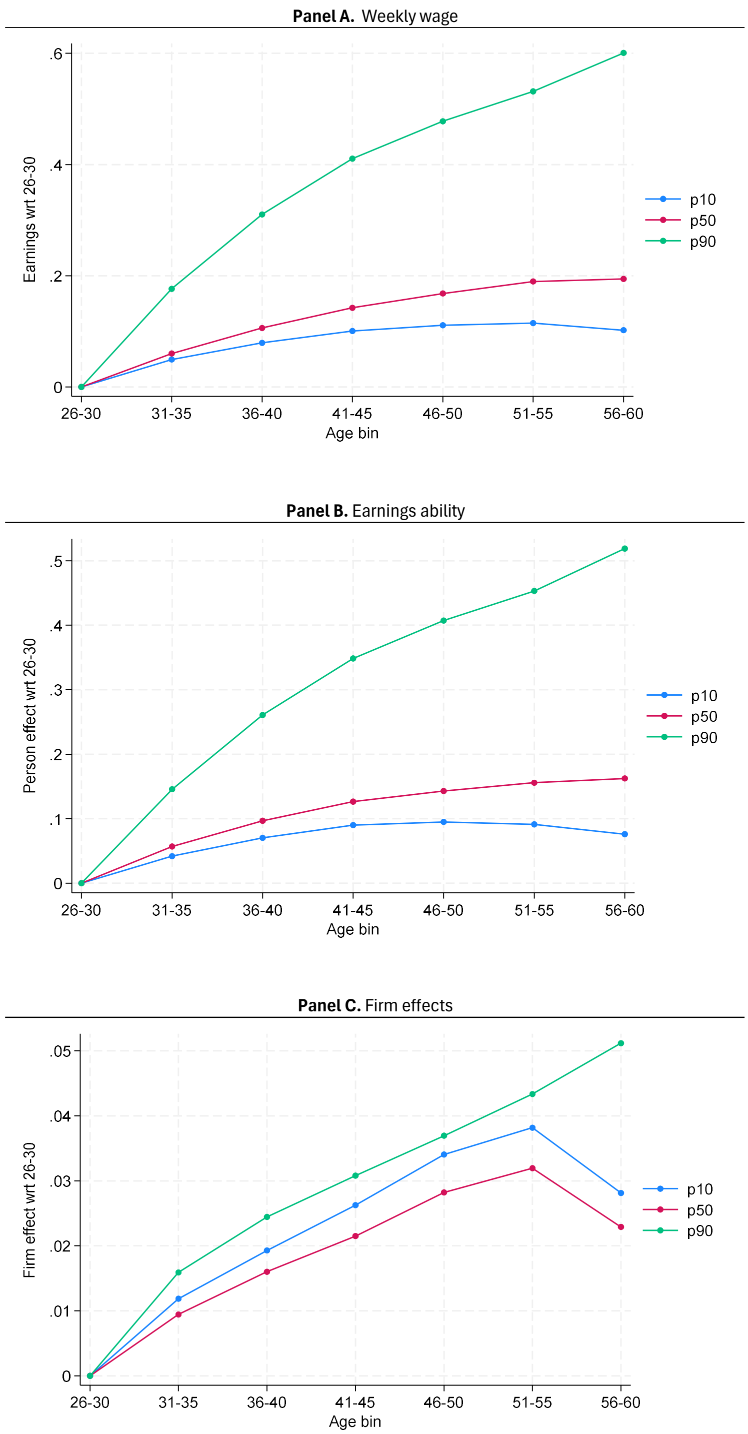


FIGURE 8. Selected percentile values by age bracket

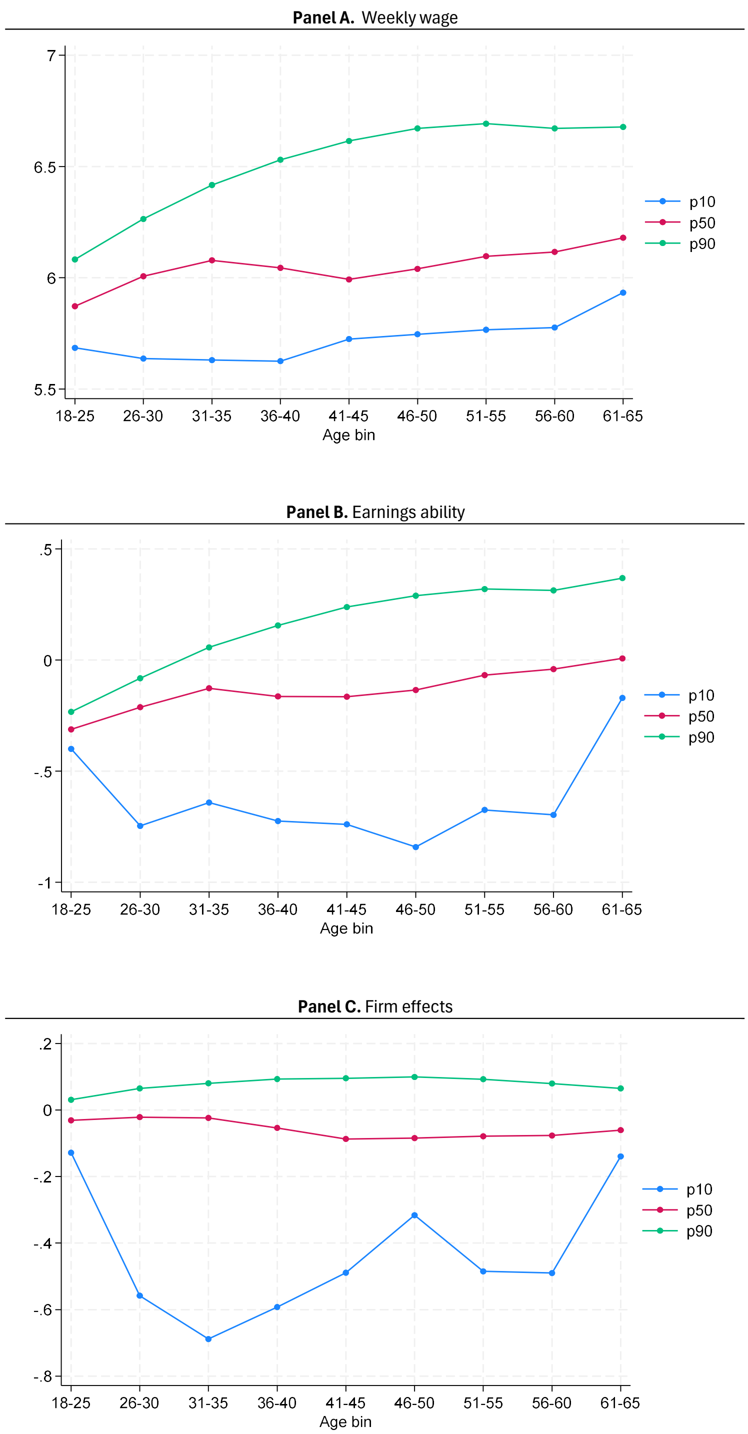


FIGURE 9. Workers' trajectories by percentile of lifetime earnings

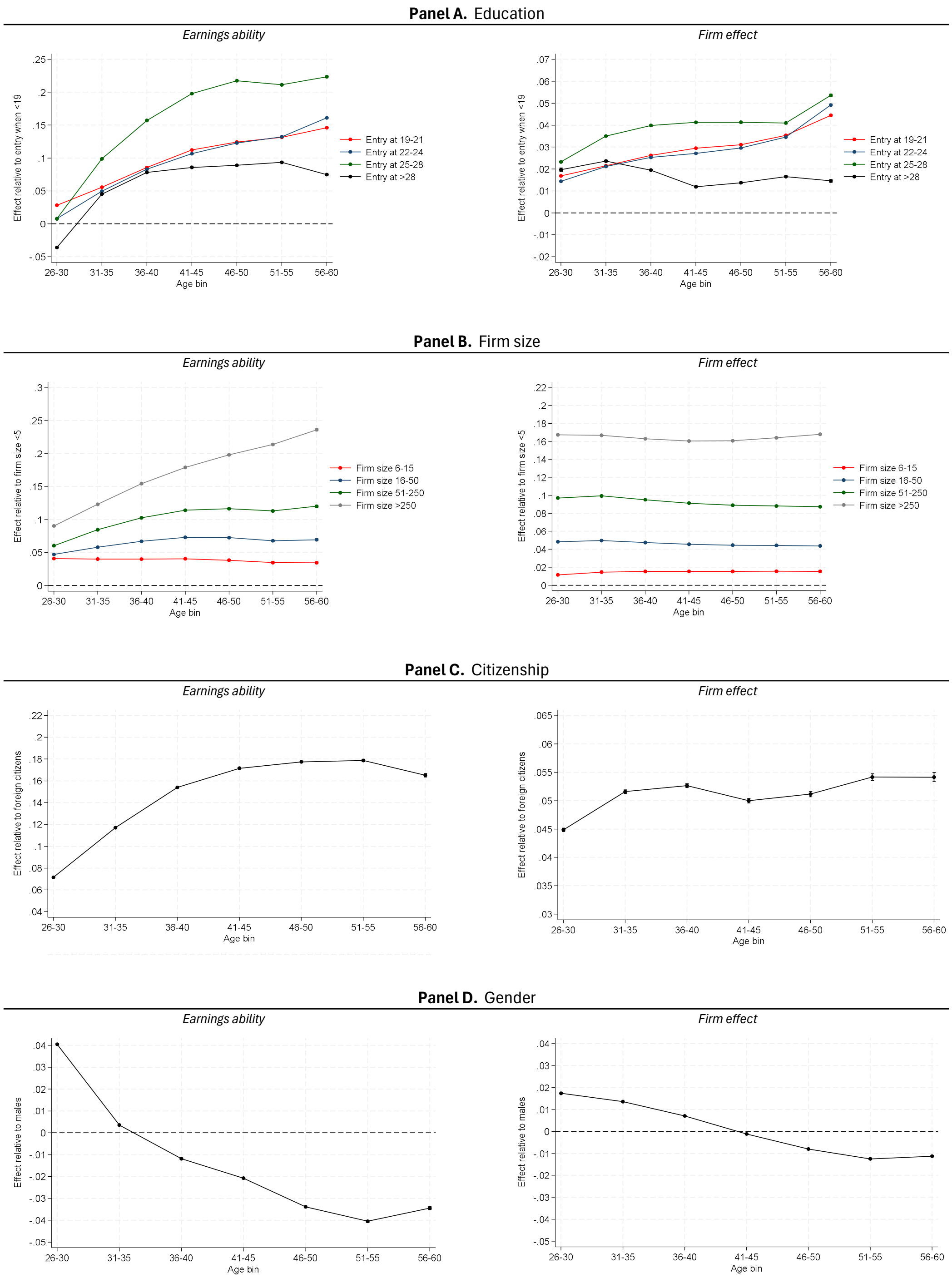


FIGURE 10. Individual and firm productivity and workers' characteristics

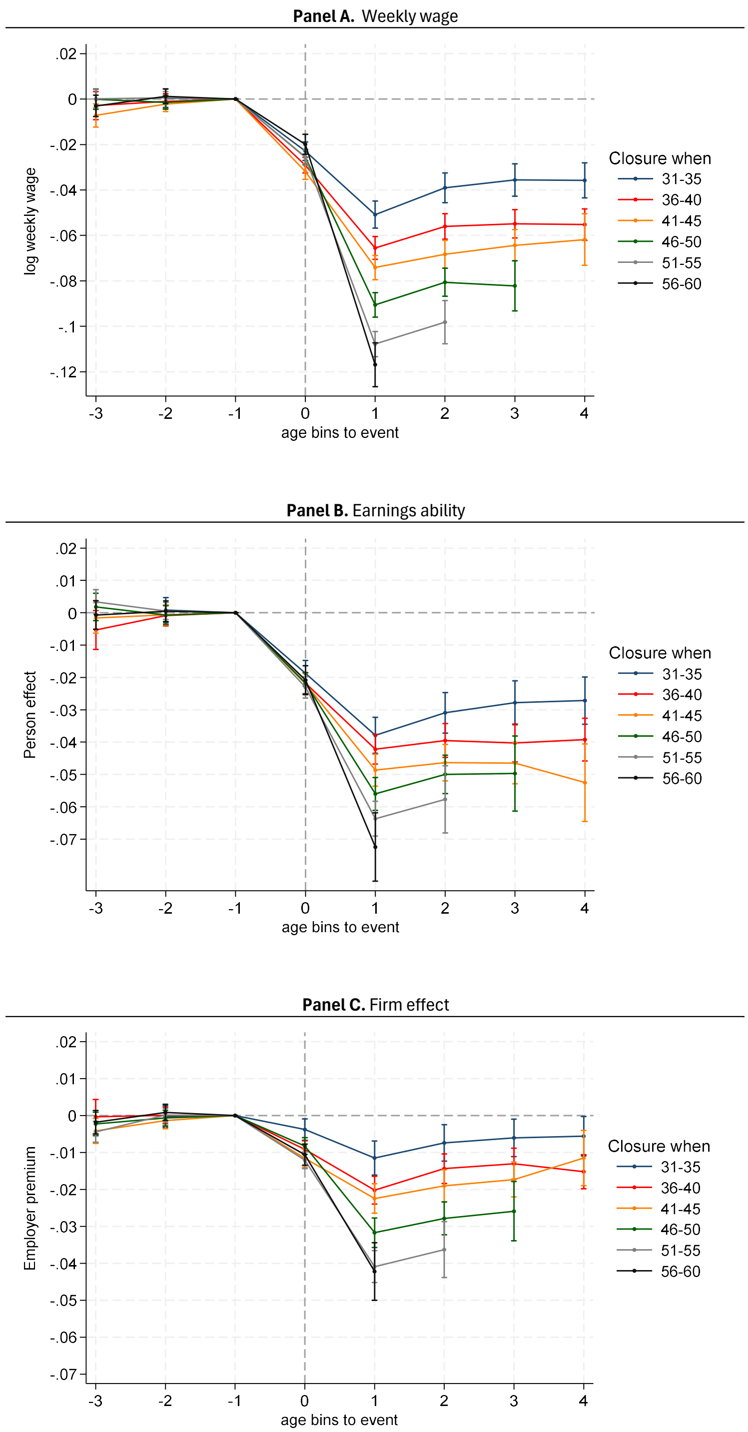
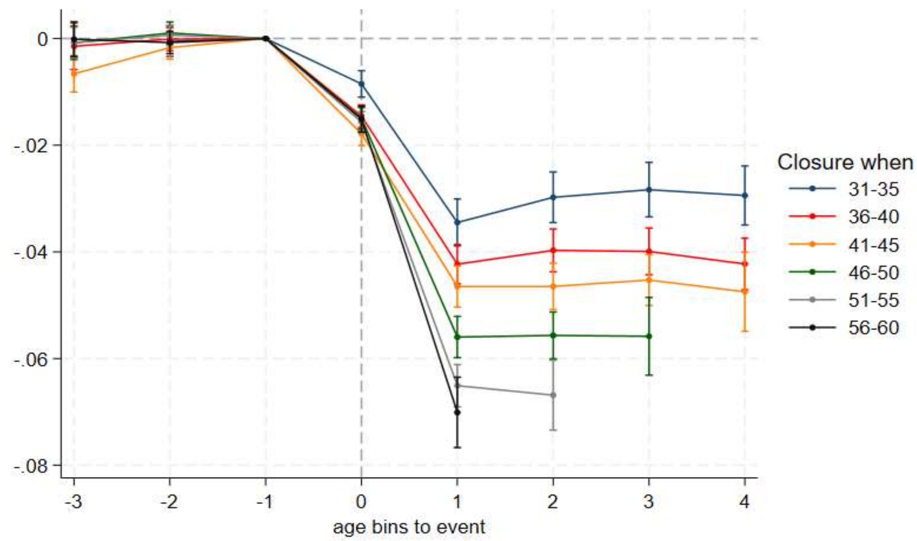


FIGURE 11. Individual and firm productivity around job loss

Panel A. Firm effect - classic AKM model



Panel B. Firm effect - extended AKM model

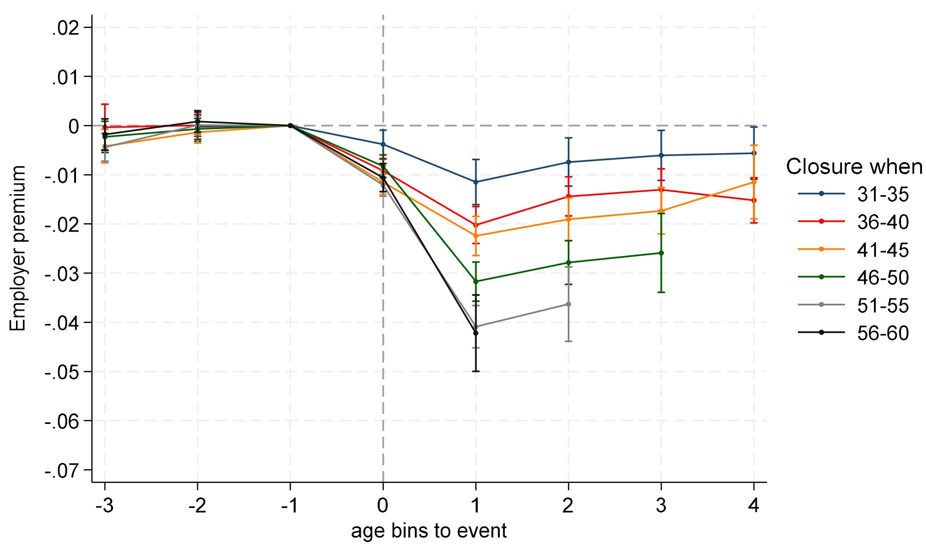


FIGURE 12. Firm productivity around job loss with different wage models

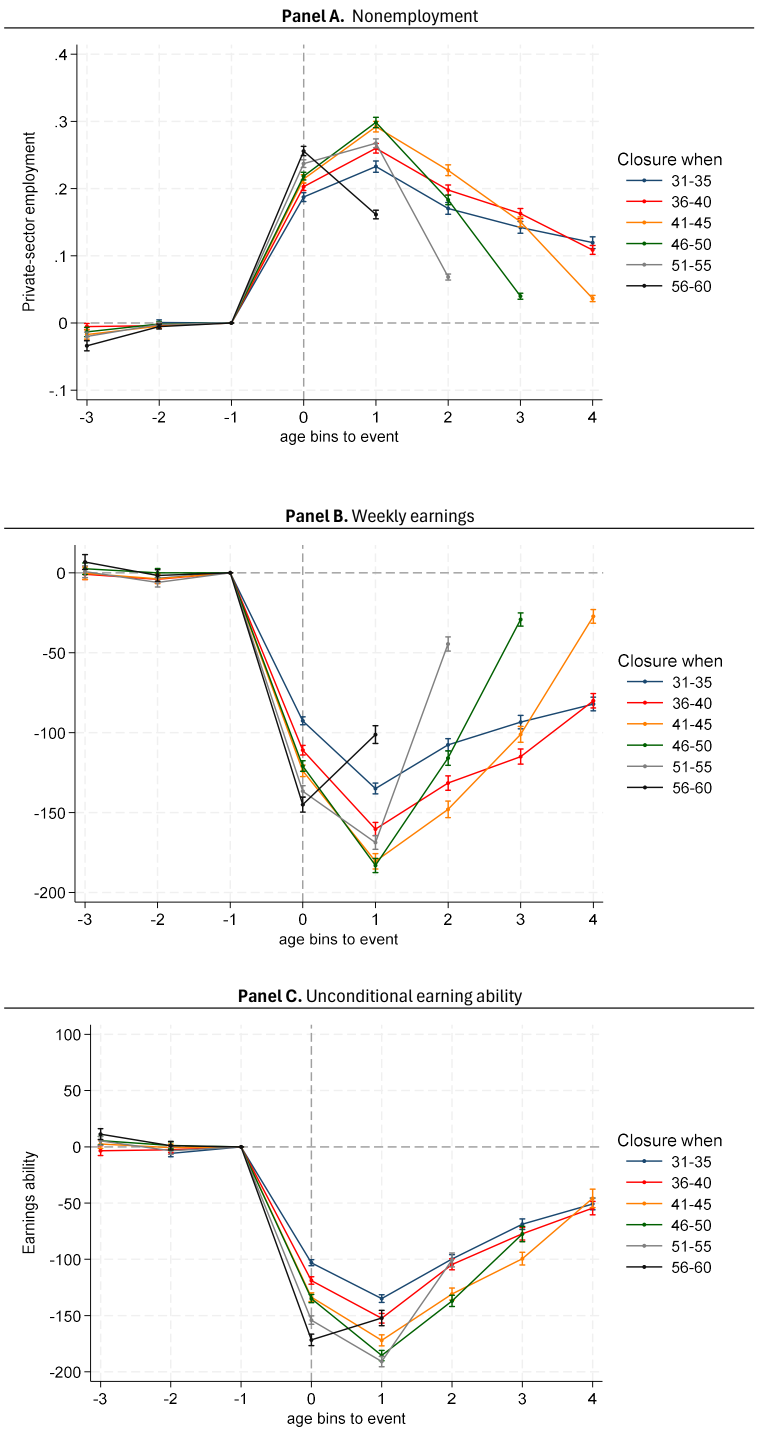


FIGURE 13. Individual and firm productivity around job loss – Extensive margin

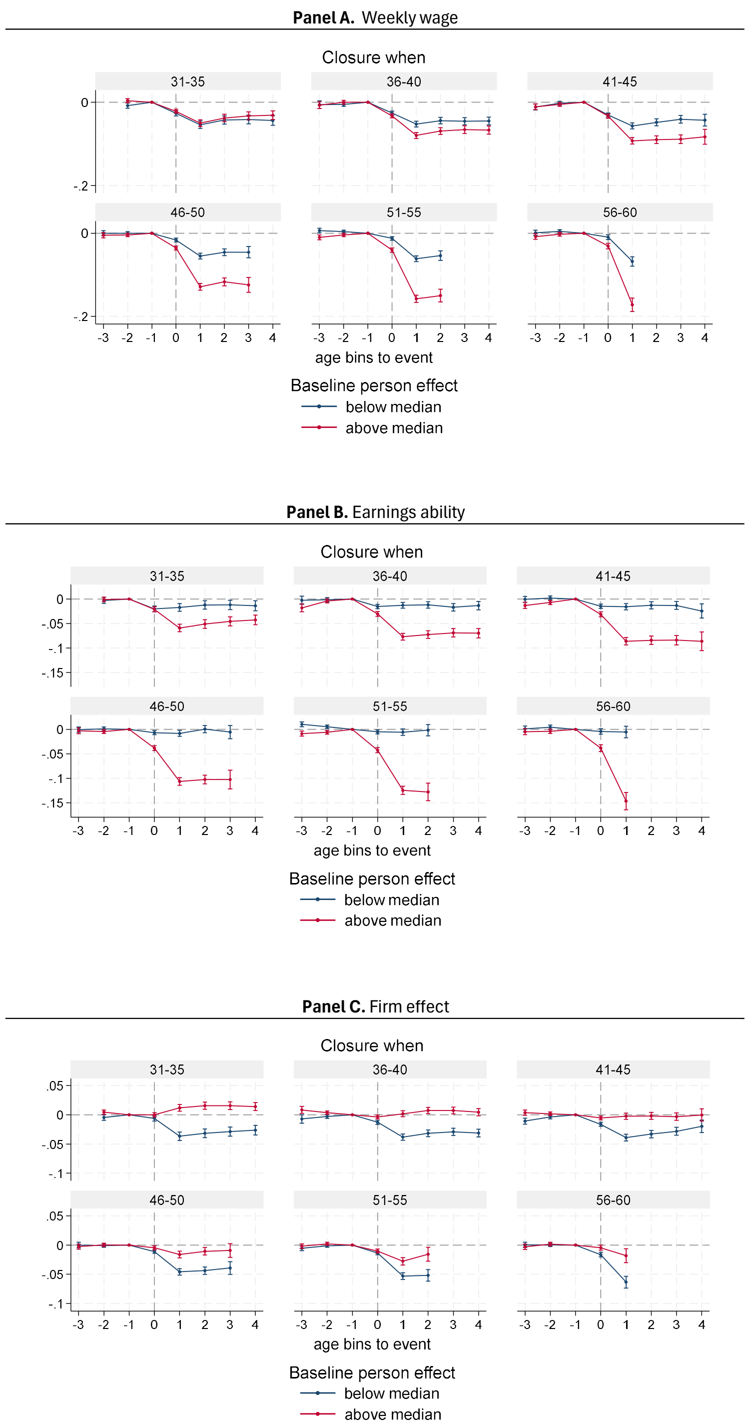


FIGURE 14. Individual and firm productivity around job loss – Heterogeneity

Panel A. Males

26-30	56-60 HW-HF	HW-LF	LW-HF	LW-LF	Unobserved	
HW-HF	0.446	0.110	0.038	0.048	0.359	1.000
HW-LF	0.121	0.230	0.039	0.118	0.491	1.000
LW-HF	0.168	0.099	0.101	0.138	0.494	1.000
LW-LF	0.056	0.136	0.059	0.211	0.538	1.000
Unobserved	0.098	0.059	0.052	0.123	0.668	1.000

Panel B. Females

26-30	56-60 HW-HF	HW-LF	LW-HF	LW-LF	Unobserved	
HW-HF	0.355	0.117	0.028	0.033	0.467	1.000
HW-LF	0.085	0.223	0.031	0.072	0.590	1.000
LW-HF	0.100	0.100	0.057	0.082	0.660	1.000
LW-LF	0.036	0.117	0.036	0.117	0.694	1.000
Unobserved	0.060	0.062	0.036	0.104	0.738	1.000

TABLE 1—Transitions across firm-worker groups

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