Firm Productivity and Early Retirement

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Abstract

Retirement behavior varies sharply with firm productivity. Using Hungarian administrative data, we show that workers at top-tertile productivity firms are 8 percentage points more likely to retire at the earliest eligibility age than those at bottom-tertile firms. About half of this gap is explained by higher firm-specific wages; most of the remaining gap reflects greater worker replaceability, higher part-time prevalence, and worse firm-level health outcomes. We reconcile these findings with evidence that lower voluntary separation rates at more productive firms during working ages are entirely pay-driven. Evidence from the Survey of Health, Ageing and Retirement in Europe confirms external validity.

Keywords: old-age employment; retirement; firm productivity; firm size; administrative data; SHARE data
JEL Codes: J21; J23; J26

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1 Introduction

According to population projections from Eurostat extending to 2100[1], the population of the European Union will continue to age. Population aging and the increasing old-age dependency ratio pose major challenges for societies and economies. In response, many governments seek to increase labor force participation at older ages to sustain tax revenues and alleviate pressure on social security systems. This objective is becoming even more pressing due to intensifying structural labor market shortages in most developed countries, which heighten the importance of mobilizing the labor potential of older individuals who have the capacity and willingness to work.

At the same time, increasing life expectancy extends the period people spend in good health, potentially raising the willingness to remain active in the labor market. Employment at older ages may also contribute positively to personal well-being by providing structure, social connection, and a sense of purpose.

In addition to pension system reforms, working lives may also lengthen if employers make efforts to retain older workers, and if workers are willing to work beyond their earliest possible retirement age. Therefore, it is important to understand the role of the workplace in retirement decisions. In this paper, our focus is on a key aspect of the workplace in retirement decisions: the productivity of the firm.

We show that workers tend to retire earlier from more productive firms both in Hungary and across Europe. As more productive firms are typically also higher payers, this finding is in stark contrast to the well known fact that higher paying firms tend to provide better amenities and have higher retention rates (Bronars and Famulari, 1997; Dale-Olsen, 2006; Clark et al., 2009; Lachowska et al., 2022; Sockin, 2022; Bana et al., 2023). We reconcile these findings by examining the role of earnings, working conditions, and the replaceability of workers in the productivity gradient of early retirement.

The productivity of the firm may be related both to the labor demand for older workers and to the retirement intentions (labor supply) of older workers. On the demand side, since more productive firms are typically larger, it may be easier to find a replacement for retiring workers. The age-wage profile may also differ by firm productivity, creating differential incentives to replace older workers with younger ones (Frimmel et al., 2018; Casas and Román, 2023). Based on the model of Chéron et al. (2011, 2013), the productivity of the firm can strongly affect its demand for older versus younger workers. The underlying mechanism is that the working horizon of older workers is shorter, making the productivity threshold of employment age-dependent. In this framework, if firms are subject to productivity shocks then such shocks have age-dependent impact on the demand for older workers. Consistent with this mechanism, Bello and Galasso (2020) provide causal

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing

evidence that trade liberalization – which improved Swiss firms' access to the EU market and induced relocation and innovation to raise productivity – increased early retirement among older workers in affected manufacturing industries, particularly in large exporting firms and in firms with pronounced wage gaps between younger and older employees. Age-varying skills (Lovász and Rigó, 2013) can further contribute to differential demand for older vs. younger workers by firm productivity. At the same time, differences in working conditions across firms of varying productivity may also influence labor supply decisions at older ages.

From a labor supply perspective, early models of retirement focus on the financial incentives of the worker. In their seminal work, Stock and Wise (1990) develop a model in which the retirement decision is based on the comparison of utility derived from immediate retirement versus the utility derived from continued work and retaining the option to retire later. Other, not necessarily economic models of retirement decision that consider the aspects of the workplace include the person-environment fit theory, which models the match between the characteristics of the individual worker and of the work environment (Feldman and Beehr, 2011), and the push/pull model of retirement (Shultz et al., 1998), which suggests that some workers leave the workforce because they are pushed out of the work role (demand side), while others are pulled towards retirement by its desirable aspects, including non-work reasons (Fisher et al., 2016).

Albeit there is a rich empirical literature on the individual- and workplace-level determinants of retirement, there is a gap regarding the impact of firm productivity – one of the basic characteristics of the employer. Fisher et al. (2016) provide a literature review of the explanatory factors of retirement timing, which they group into the following categories: individual factors (physical and mental health, demographic characteristics, economic status); family factors (marital status, caregiving); work-related factors (human relations practices, training opportunities, workplace age and retirement norms, age discrimination, job characteristics); person-job factors (work ability, work attitudes); macroeconomic factors (labor market opportunities). Although they discuss a range of work-related factors, the aspect of firm productivity (and firm size) is missing from this overview. In a related study, Hudomiet et al. (2021) investigate the role of job characteristics on retirement intentions – including working hours, commuting time, and job-related stress, without focusing on firm productivity (or firm size). The similar holds for other studies in the literature that consider the role of various working conditions in retirement decisions (Filer and Petri, 1988; Robroek et al., 2013; Schnalzenberger et al., 2014; Dal Bianco et al., 2015; Carr et al., 2016; Sonnega et al., 2018; Ameriks et al., 2020; Böckerman and Ilmakunnas, 2020; Virtanen et al., 2022; El Khawli et al., 2024, among others). Among the few notable exceptions, Røed and Haugen (2003) and Dorn and Sousa-Poza (2005), respectively, find that early retirement is more common at larger firms in Switzerland and Norway due to the variation in the availability of early retirement

options by firm size in these countries. Considering that firm size and productivity are closely related (Pozzi and Schivardi, 2016; Bartelsman and Doms, 2000), these findings are also suggestive about heterogeneities by firm productivity. Hofäcker et al. (2016) also find that workers retire earlier from larger firms than from smaller firms in Germany as well as in Japan, but can count on formalized early retirement schemes in Germany, and have higher chances of being redeployed/rehired in Japan. In our paper we show that firm size (and firm productivity) heterogeneity in early retirement also holds in countries where there are no firm-specific retirement options.

We contribute to the literature by providing broad evidence on the role of the productivity of the employer in retirement intentions and decisions. Our results show that workers employed at more productive firms are more likely to retire earlier. The robustness of our results is demonstrated by the fact that both Hungarian administrative data and European survey data from multiple other countries reveal the same pattern, indicating that the phenomenon is widespread and not driven by country-specific institutions or pension rules. In the European survey data, where direct measures of firm-level productivity are unavailable, we proxy productivity using firm size.

Based on a uniquely rich linked employer-employee administrative data set from Hungary, we find that workers at top-tertile productivity firms are 8 percentage points more likely to retire at the earliest retirement age than workers at bottom-tertile productivity firms. Firm-specific wages explain about half of this gap, and of the remaining gap, about a fifth is explained by within-firm replaceability of workers, about a third by the prevalence of part-time work among older workers at the firm, and around 4% by the firm-specific use of antiinfectives, a proxy for the prevalence of infectious diseases at the firm. Firm-specific measures of mental health, musculo-skeletal health and total prescription drug spending have no explanatory power on the productivity gradient in early retirement, neither has the age profile of wages at the firm.

In contrast, during prime working ages, separation rates are lower at more productive firms; however, these differences disappear once wages are controlled for. Moreover, among relatively older workers, the relationship reverses – conditional on wages, voluntary separation rates are slightly higher at more productive firms. This pattern suggests that wage premia at more productive firms promote longer retention throughout workers' active careers, yet the same wage premia contribute to earlier retirement once workers reach eligibility. Higher lifetime earnings make immediate retirement financially feasible upon reaching retirement age.

We complement the administrative data-based analysis with survey-based cross-country evidence from Europe. Consistent with our findings for Hungarian firms, the Survey of Health, Ageing and Retirement (SHARE) data indicate that although workers in larger firms are less likely to separate from their employer during active ages, they tend to retire earlier. Using the SHARE, we find that on average, workers are 15 percentage points

more likely to retire before the statutory retirement age from firms with 200+ workers than from firms with 1–24 workers. In contrast, among employees in active ages, jobs in large firms are significantly more stable. Workers at large firms are 11 percentage points less likely to quit and 3 percentage points less likely to change jobs within two years, their average tenure is about 7 years longer than in small firms, and the differences remain substantial after controlling for other factors. At the same time, workers at larger firms are also more likely to report intentions to retire early: the gap between the largest and smallest firm size categories is 8 percentage points and is largely unchanged after controlling for observable characteristics. The fact that both stated intentions and actual retirement ages point to earlier retirement in larger firms highlights the importance of supply-side factors in retirement behavior.

Overall, our results demonstrate that workers at more productive firms are less likely to separate during their active years mainly because these firms pay higher wages. Beyond higher pay, however, these firms do not appear to offer better working conditions or greater flexibility. In fact, they provide fewer part-time opportunities and employ workers in more easily replaceable positions. Consequently, once employees at these firms reach pension eligibility, they are more likely to retire fully, probably reflecting both demand- and supply-side forces. Their higher lifetime earnings make early retirement financially affordable, and the less flexible or more substitutable nature of their jobs provides little reason to remain employed.

The remainder of the paper is structured as follows. Section 2 outlines the institutional background. Section 3 describes the administrative and survey data sources. Section 4 details the empirical methodology. Section 5 presents the results based on the administrative data, while Section 6 reports the findings from the survey data. Section 7 concludes.

2 Institutional Background

In the first part of our empirical analysis, we examine retirement in Hungary. The country has a mandatory pay-as-you-go system, where pension benefits are based on lifetime earnings before retirement and on total years of service. The government sets the standard retirement age, which has been gradually increasing in recent times (from 62 years for the cohort born in 1951 to 65 years for the 1957 cohort). Until 2011, an early retirement age existed (60 years for men and 57 or 59 years for women, depending on their year of birth). People could receive full pension benefits under the early retirement scheme if they had accumulated at least 40 years of service, but this possibility was abolished in January 2012. However, as a result of another policy change, since 2011, women can retire after 40 years of service irrespective of age (this is called the "Women40" policy). Therefore, since 2011, the standard retirement age is not applicable for the majority of women. Table 1

provides an overview of the standard and early retirement ages.[2]

Focusing on the private sector, the employment rules in conjunction with retirement are the following.[3] Retirement can be deferred beyond the standard retirement age, when the pension benefit increases by 0.5% for each month of deferral. It is also possible to remain employed while receiving pension benefits, however, from January 2008, pensioners who worked before reaching the standard retirement age had to give up their pension above a certain annual earnings limit (12 times the monthly minimum wage in 2008–2009 and 18 times from 2010). In contrast, pensioners who had already reached the standard retirement age could take up work without restrictions. Finally, in the private sector, there are no firm-specific regulatory differences in retirement options, and occupational pension schemes do not exist in Hungary.

Table 1: Standard retirement ages in Hungary

Year of birth	Standard retirement age	Early retirement age	
	Women & Men	Women	Men
-1951	62.0	57.0	60.0
1952	62.5	59.0	-
1953	63.0	-	-
1954	63.5	-	-
1955	64.0	-	-
1956	64.5	-	-
1957+	65.0	-	-

In the second part of our empirical analysis, we examine retirement in European countries. In each country, pensions based on social security contributions are available above a given age, depending on employment history. In 2010, the statutory retirement age varied between 57 and 65 in the 11 European countries we include in our analysis. It is beyond the scope of our paper to provide details of the pension system of the individual countries, see OECD (2019) for details on the pension systems corresponding to year 2010, which is roughly in the middle of the analysis period covered by the European data.

Apart from retirement at the statutory retirement age, specific groups may be eligible for early retirement in many countries. Among the countries covered by our empirical analysis, occupational pensions, which may be firm-specific, are available in France, the Netherlands, Sweden and Switzerland. Importantly, our estimation strategy does

[2]Between 1996 and 2011, employees could also retire even before the early retirement age if they reached an agreement with their employer. This system was designed to prevent older workers from becoming unemployed after being laid off. Instead, they could retire early, with the employer paying a lump-sum pension contribution in advance. This option was available until the end of 2008 for workers within five years of the official retirement age. From 2009 on, it was offered to people who were at least 57 years old with some further restrictions. In addition, workers in physically demanding or harmful jobs could receive different levels of early retirement benefits.

[3]Different rules may apply in the public sector (see e.g., Bíró et al., 2022), which is outside the scope of the current study.

not depend on the specific institutional settings as our focus is on the individual-level and employer-level explanatory factors of retirement intentions and retirement decisions. Nevertheless, we show in Section 6 that people generally retire earlier from larger firms also in those European countries where there are no occupational pensions.

3 Data Sources

3.1 Administrative Data From Hungary

In the first part of the empirical analysis, we use linked employer-employee administrative data, complemented with health-related variables, for a 50% random sample of the entire population of Hungary on the monthly level.[4] The dataset contains individual-level labor market information (employment, occupation, wages, pensions and other benefits). Employees and employers are linked, and, for double-bookkeeping firms, we have yearly data on firm size, revenue, costs, and value of capital from the tax records of the firm. Details on the specific control variables used in our analysis are given in Section 5, here we only focus on the dependent variables and the main explanatory variable. In the main analysis, we use data for the years 2007–2016, and analyze the retirement decisions of full time workers.[5]

Retirement Variable. Because of the given sample period and the changes in the retirement ages and policies during this time, we can only focus on the retirement of specific cohorts. For women, we examine cohorts born in 1950 and 1951, for whom the early retirement age of 57 and the standard retirement age of 62 applied. Younger female cohorts cannot be analyzed because of the introduction of the "Women40" policy. For men, we examine cohorts born in 1950, 1951, and 1953. For the former two cohorts, the early retirement age of 60 and the standard retirement age of 62 were in force, while men born in 1953 could retire only at age 63. (We exclude the "transition" cohort of 1952 because the increase of the retirement age was then in progress.) Younger male cohorts cannot be examined because of the end of the sample period.

Our focal variable is *full retirement*, which we define as receiving pension benefits (including old-age pensions and early pensions but excluding spousal pensions or disability

[4]The administrative database used in this paper is owned by the National Health Insurance Fund Administration, the Central Administration of National Pension Insurance, the National Tax and Customs Administration, the National Employment Service and the Educational Authority of Hungary. The data was processed by the Databank of the ELTE Centre for Economic and Regional Studies.

[5]The sample for the administrative data was drawn in 2003 and the same people were followed until 2017. Since retirement records in the data are not complete in 2017, we exclude that year from the analysis. Employment and wage records in the data are based on social security contributions payable after wages. Until 2006, employees who received pension benefits were exempt from such contributions, so we cannot use data before 2007.

pensions) without being employed. The binary variable for employment status equals one if the individual is employed on the 15$^{\text{th}}$ of the given month and zero otherwise.

Voluntary Separation Variable. For the analysis of the retention rate of workers at active ages, we aggregate observations to the quarterly level (based on the first month of each quarter) and set the binary indicator of voluntary separation to one if the current and next-quarter employer are different, zero otherwise. Here we use observations from the entire time horizon of the administrative data (years 2003–2017), and focus on workers aged 30–56. Using employer-to-employer transitions as proxy for voluntary separations is in line with the literature showing that such transitions are mostly voluntary, generally reflecting moves to jobs that pay more and last longer (Bjelland et al., 2011; Hyatt, 2015; Moscarini and Postel-Vinay, 2018).

Total Factor Productivity. Our main explanatory variable is total factor productivity (TFP). We estimate the value-added-based TFP of firms using the *prodest* Stata module of Rovigatti and Mollisi (2020) and applying the estimation procedure of Wooldridge (2009). In a system GMM (generalized method of moments) framework, we regress the logarithm of value added (gross revenue minus the cost of goods sold) on year effects, the logarithm of firm size (variable input) and the logarithm of subscribed capital (state variable). Unobserved productivity is assumed to be a function of the state variable and proxy variables (material and service costs), and follows a first-order Markov chain. The TFP is the residual estimated from this regression, which is a year- and firm-specific measure. The variables based on which we calculate the TFP are observed only for private sector firms. Due to measurement errors at the smallest firms, we restrict the analysis to firms with at least 20 workers. In addition, we exclude from the analysis nine firms which have more than 10,000 workers – very large and unique firms in the Hungarian context – to avoid outliers driving the results.[6]

[6]Our results are robust to keeping firms with 10–19 and above 10,000 workers in the sample. We repeat our main results based on this broader sample in Appendix Tables A2 and A3.

3.2 SHARE Data From Europe

In the second part of the empirical analysis, we use SHARE data.[7] This is a bi-annual representative panel survey of individuals aged 50 and above in Europe. The first survey wave was collected in 2004, and the ninth (and so far the last available) wave was collected in 2022. Although the country coverage of SHARE expanded throughout the survey waves, we restrict our analysis to countries (and individuals) included in the first wave because our key explanatory variable, firm size, is recorded only in that wave.[8] We use firm size as a proxy for firm productivity, and restrict the sample to private sector workers.

Retirement Variables. We use various dependent variables to examine actual retirement decisions and retirement intentions. First, we track individuals across subsequent waves and determine their actual retirement age by calculating the difference between their reported year and month of retirement (as provided by respondents who are already retired in response to the question "In what year and month did you retire?") and their year and month of birth.[9] Second, since these retrospective answers are subject to truncation bias (high actual retirement ages are observed less often than lower ones), we examine the probability that a person retired before the country- and sex-specific statutory retirement age, which we calculate from the SHARE Job Episodes Panel. This probability can be evaluated for everyone who has already passed this age. Third, we analyze the answers to the question "Thinking about your present job, would you like to retire as early as you can from this job?" raised in the first wave.

Variables for Job Separation. We also examine variables that measure job separation for reasons other than retirement in the SHARE survey. First, we define quitting the firm

[7]This paper uses data from SHARE Waves 1 through 9, and from the Job Episodes Panel (DOIs: 10.6103/SHARE.w1.900, 10.6103/SHARE.w2.900, 10.6103/SHARE.w3.900, 10.6103/SHARE.w4.900, 10.6103/SHARE.w5.900, 10.6103/SHARE.w6.900, 10.6103/SHARE.w6.DBS.100, 10.6103/SHARE.w7.900, 10.6103/SHARE.w8.900, 10.6103/SHARE.w8ca.900, 10.6103/SHARE.w9.900, 10.6103/SHARE.w9ca900, 10.6103/SHARE.jep.900) see Börsch-Supan et al. (2013); Antonova et al. (2014); Brugiavini et al. (2019) for methodological details. The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA N°211909, SHARE-LEAP: GA N°227822, SHARE M4: GA N°261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N°676536, SHARE-COHESION: GA N°870628, SERISS: GA N°654221, SSHOC: GA N°823782, SHARE-COVID19: GA N°101015924) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, VS 2020/0313, SHARE-EUCOV: GA N°101052589 and EUCOVII: GA N°101102412. Additional funding from the German Federal Ministry of Education and Research (01UW1301, 01UW1801, 01UW2202), the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, BSR12-04, R01_AG052527-02, R01_AG056329-02, R01_AG063944, HHSN271201300071C, RAG052527A) and from various national funding sources is gratefully acknowledged (see www.share-eric.eu).

[8]These countries are: Austria, Belgium, Denmark, France, Germany, Greece, Italy, Spain, Sweden, Switzerland, and the Netherlands. Israel is excluded from the analysis.

[9]We also make some data cleaning based on the self-reported current job situation of the respondent in various waves. If these are not consistent with the retrospectively reported retirement age, then the observation is not taken into account.

during the two years between wave 1 and 2 among workers who did not retire during this time. This way, we examine separation from the firm for any reason other than retirement. Second, we define a employer-to-employer transition between wave 1 and 2 among workers who were continuously employed during this time if the respondent reported a change of employer during the two years between the waves.[10] Third, as a separate, cross-sectional measure, we examine the length of tenure already spent within the same firm in wave 1.

4 Methods

We examine retirement outcomes of the particular cohorts in the Hungarian analysis and of respondents of the first wave of SHARE in the European analysis. We regress the retirement outcomes of employees working at different-productivity (Hungary) or different-sized (Europe) firms with controlling for a growing set of (pre-determined) explanatory variables, and examine how the firm productivity or size parameters change after the inclusion of the controls. We extend the analysis also to voluntary separations among active-age workers.

To examine productivity differences, we analyze relationships across tertiles of TFP. While the number of categories is ultimately a pragmatic choice, tertiles provide a natural compromise that avoids arbitrary functional form assumptions, limits the impact of noisy TFP estimates, and preserves adequate sample sizes for decomposition analysis. In the analysis by firm size, we classify firms into three groups: 1–24, 25–199, and 200 or more employees.

We also examine the explanatory factors behind the firm productivity differences in retirement using the Blinder–Oaxaca decomposition (Blinder, 1973; Oaxaca, 1973).[11] This method decomposes the difference in the outcome into an "explained" and "unexplained" part, where the "explained" part originates from group differences in observed characteristics.

More formally, building on the methodological overview of Jann (2008), let us denote with R the difference of the mean retirement outcome (r) between firm group l and s:

$$R = E(r_l) - E(r_s), \tag{1}$$

where r is specified with a linear model:

$$r_i = X_i'\beta_i + \epsilon_i, \text{ for } i \in (l, s). \tag{2}$$

[10] These definitions are due to the peculiarities of the survey – a job separation cannot be detected precisely if the respondent did not work continuously between the waves.

[11] For this exercise, we use the *oaxaca* Stata command of Jann (2008).

The mean outcome difference then can be rewritten as:

$$R = \underbrace{\{E(X_l) - E(X_s)\}'\beta^*}_{Q} + \underbrace{\{E(X_l)'(\beta_l - \beta^*) + E(X_s)'(\beta^* - \beta_s)\}}_{U}, \tag{3}$$

where β^* is a nondiscriminatory coefficient vector lying between β_l and β_s. The term denoted by Q is the part of the mean outcome differences that is explained by group differences in the explanatory variables. In the following, we replace β^* with a single β estimated from equation (2) on the pooled observations.

Since this method is available only for the comparison of two groups, we make three separate comparisons among productivity tertiles: (1) the two smaller productivity categories vs. the highest category; (2) the smallest vs. the two larger productivity categories; (3) the smallest vs. the largest productivity category.

5 Results Based on Hungarian Administrative Data

Here we provide evidence on the heterogeneity in retirement timing by firm productivity based on administrative data from Hungary, and relate the results to heterogeneity in separation rates by firm productivity at active ages.

5.1 Retirement Rate and Voluntary Separation Rate by TFP

We first look at the descriptive patterns of full retirement over age by firm productivity. To account for potential lags between the last month of employment and the first month of observed receipt of pensions in the administrative data, we measure firm productivity six months before the measurement of retirement rates. Figure 1 shows that – as expected – the retirement rate of the examined cohorts (women born in 1950-1951, and men born in 1950, 1951 or 1953) jumps at the early and standard retirement ages. Notably, the transition rate from private sector employment to retirement at the early retirement age (panel (a) and (b)) and, after the cessation of early retirement, at the standard retirement age (panel (c)) is remarkably higher at more productive firms.[12] Accordingly, Figure 2 shows that the decile of the productivity (TFP) of the employer drops upon reaching the minimum retirement age, i.e., those who continue to work do so on average at less productive firms. Note that the deciles are defined yearly on the sample of the entire working population.

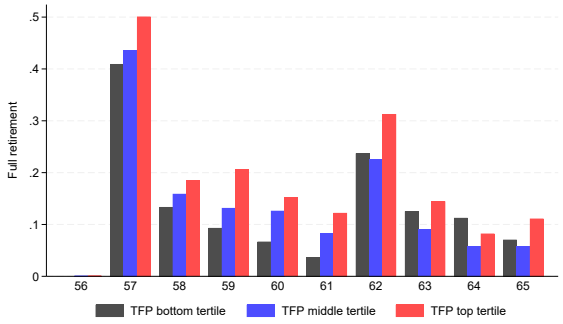
This pattern is in stark contrast to the differences in voluntary separation (quarterly employer-to-employer transition) rates at active ages by firm productivity, as presented in

[12]Note that the transition (hazard) rates are calculated on the sample of people who were employed at a private sector firm six months prior to reaching the age shown on the x-axis. As such, they represent conditional probabilities and therefore do not sum to one.

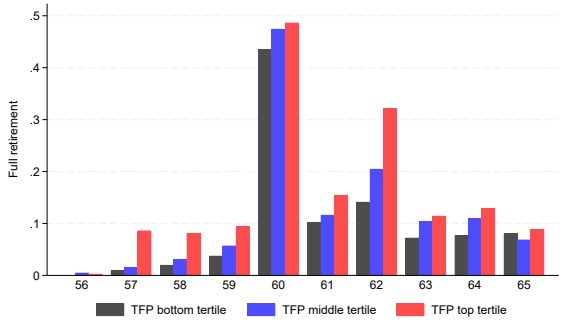
Figure 3. The probability of voluntary separation decreases with firm productivity across all age groups 30 to 56.

Figure 1: Transition rate from private sector employment to full retirement by age (Hungary)

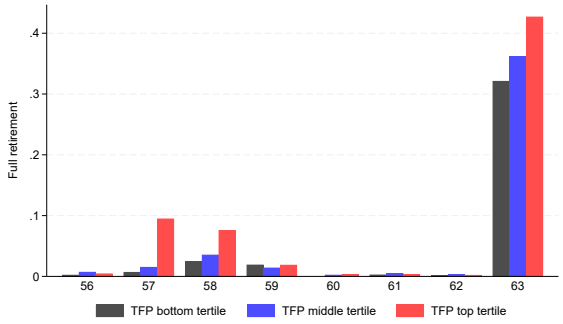
(a) Cohort 1950-1951, women (early ret. age: 57, standard ret. age: 62)



(b) Cohort 1950-1951, men (early ret. age: 60, standard ret. age: 62)



(c) Cohort 1953, men (early ret. age: -, standard ret. age: 63)



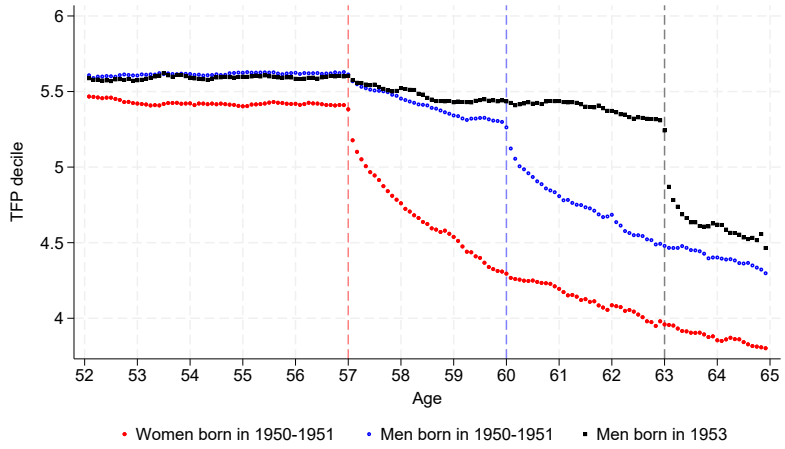
Notes: Figure shows age-yearly transition rate from private sector employment to full retirement in 2007–2016, using Hungarian administrative data. The monthly transition variable is defined for people who had not received early or old age pensions earlier, and were employed at a private sector firm six months before. The variable is set to one if the person retired in the given month. We then take the age-yearly maximum of this binary variable for each person, and the figure plots its average values. In panels (b) and (c), retirement before the early (b) and standard (c) retirement ages is based on agreements with the employers, which was possible until 2011, as we explain in Section 2, footnote 2.

5.2 Explanatory Factors of Productivity Gradient in Retirement

5.2.1 Explanatory Variables

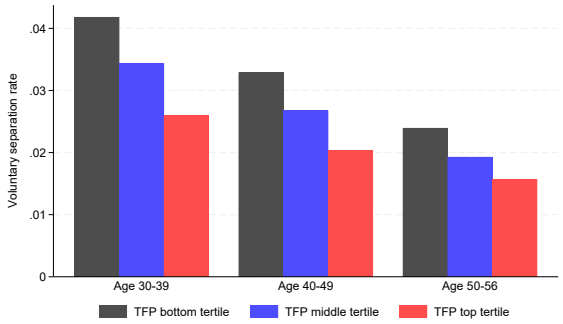
To uncover the mechanisms underlying the relationship between productivity and retirement timing, we examine to what extent the raw TFP gradient can be explained by factors that influence retirement decisions (either through worker preferences or firm incentives), which may systematically vary with firm productivity, as suggested by the literature. Beyond some baseline variables, these factors include earnings, seniority wage profile of the firm, part-time work prevalence at the firm, worker replaceability, and firm-specific health measures. We provide descriptive statistics of the control variables by TFP tertiles

Figure 2: Employer productivity by cohorts (Hungary)



Notes: Figure shows the decile of the productivity (TFP) of the employer of the cohorts included in the analysis. The deciles are defined yearly on the sample of the entire working population. The vertical dashed lines indicate the standard retirement age for each cohort-group.

Figure 3: Voluntary separation rate by age groups (Hungary)



Notes: Figure shows quarterly employer-to-employer transition rates. Sample: Hungarian administrative data, 2003–2017, private sector employees not receiving pension-type benefits.

in Table A1.

Baseline Regressors. Baseline regressors, which we control for in all specifications, include sex, cohort effects, one-digit industry and one-digit occupation categories. Industry and occupation refer to six months before reaching the analyzed age.

Earnings. Workers may face different financial incentives to retire earlier or later depending on the productivity of their employer. This can be the case if average wages or years of service – the two basic determinants of pension benefits in Hungary – differ by TFP. Note that the benefit level is determined by a discounted sum of lifetime earnings (see Section 2 for institutional details); therefore, wages prior to retirement can only serve as a proxy for the underlying financial incentives.

Firstly, as we report in the first column of Table 2, wages tend to be substantially higher at more productive firms. The implications of higher wages for retirement timing

are theoretically ambiguous, as earnings generate both income and substitution effects that work in opposite direction. On the one hand, higher earners receive higher pensions. Although we do not observe wealth directly in our data, higher earnings suggest that workers at higher-TFP firms are likely to have accumulated greater savings. Consequently, these workers may be better positioned to retire earlier, as they can rely both on their accumulated savings and on the higher pension benefits they receive after retirement.

Table 2: Wage and years of service at earliest retirement age, by TFP (Hungary)

	Wage (HUF)			Years of service		
	mean	median	std.dev.	mean	median	std.dev.
Bottom TFP tertile	157,904	125,843	106,949	40.22	41	4.66
Middle TFP tertile	199,062	157,860	132,968	40.92	41	4.77
Top TFP tertile	297,859	233,608	189,519	40.76	41	4.68

Notes: Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level. Wage is the 12-month lag of mean wage in Hungarian forints (HUF), deflated by CPI to 2016 values. In 2011, the average value of 1 EUR was 311 HUF. The years of service is conditional on retirement in the analyzed age.

On the other hand, these income effects are in contrast to the substitution effect – that is, the incentives stemming from the pension replacement rate. Due to the progressive benefit system, higher pre-retirement wages enter the pension base with a decreasing weight. As the wage level and the TFP are positively correlated, retirees from higher-TFP firms are more likely to face lower replacement rates, even though the mean and median years of service are similar across TFP groups (as reported in the last three columns of Table 2). In Table 3, we report the replacement rate of pension benefits by tertiles of wage and service years. We calculate the replacement rate as the ratio between the regular pension benefit six months after retirement (deflated to 2016 values) and the full-time equivalent wage 12 months before retirement (also deflated to 2016 values). The replacement rate varies moderately with the observed years of service, but decreases substantially over the wage tertiles, implying that higher earners face weaker financial incentives to retire early. Taken together, this pattern suggests that the higher propensity to retire at the earliest possible age from more productive firms is unlikely to be driven by pension replacement rates.

Individual wages six months before the retirement age may be endogeneous with respect to the retirement decision. To tackle this issue, in addition to individual wages, we also examine a firm-level measure of wage premium. We perform an Abowd-Kramarz-Margolis (AKM) style decomposition of logarithmic wages (Abowd et al., 1999) and compute worker-level and firm-level wage premia (fixed effects, FE) by exploiting moves between firms. That is, on the largest connected set of the employers and employees, we regress log wages on individual and firm fixed effects, controlling for year effects, age squared, age cubed (in line with, e.g., Card et al., 2013). We take the estimated firm fixed effects and call them the firm-level wage premium or *AKM firm wage FE*. Not surprisingly, according

Table 3: Pension benefit replacement rate (Hungary)

Replacement rate	*Wage (1,000 HUF)*			
	1–136	136–211	211+	all
Years of service				
19–41	0.95	0.62	0.46	0.70
42–44	0.93	0.66	0.47	0.71
45–50	1.16	0.73	0.56	0.75
all	0.98	0.67	0.50	0.72

Notes: Table shows pension benefit replacement rates for women born in 1950 and 1951 retiring at age 57, men born in 1950 and 1951 retiring at age 60, and men born in 1953 retiring at age 63, based on the Hungarian administrative data. Average replacement rates are displayed for tertiles of wage (measured 12 months before retirement) and tertiles of service years (at retirement).

to Table A1, AKM firm wage FE (which is measured on the logarithmic scale) is 0.32 higher in the top-tertile TFP firms than in the bottom-tertile ones.

Seniority Wage Profile. Building on Frimmel et al. (2018), firms may have strong incentives to encourage the retirement of older, more expensive workers when seniority wage profiles are steep, as such profiles increase the relative cost of retaining older employees. If seniority wage profiles are steeper in more productive firms, this demand-side mechanism could help explain the positive relationship between firm productivity and full retirement at the earliest eligible age. To estimate firm-specific seniority wage profiles, we follow the approach of Frimmel et al. (2018). Restricting the administrative data to full-time workers aged 30–56 in years 2007–2016, we take the difference between the monthly wage and the average industry-age-year-specific wage (Δw).[13] Then, we regress Δw on (linear) age interacted with the firm identifiers. We define the estimated firm-specific slope of this relationship as the seniority wage profile.

The resulting estimated average seniority wage profiles at firms with bottom-, middle-, and top-tertile TFP are, respectively, 1.1, 1.4, and 1.2 thousand HUF / age year. Thus, there is a non-monotonic relationship between seniority wage profile and firm productivity. We show in Figure A1 the age-wage profiles by TFP categories, net of one-digit industry and year effects. The figure shows a humped-shaped pattern at more productive firms.

Replaceability. Another potential explanation for heterogeneity in demand for workers beyond the early retirement age across firms with different productivity levels is variation in worker replaceability. At more productive firms, workers are easier to be replaced internally by co-workers because more productive firms are typically also larger (see the descriptive statistics in Table A1). Greater internal substitutability lowers the cost of separation for the employer and may increase the firm's willingness to allow older workers

[13]We exclude workers below age 30 from this calculation because the transitory steep age-wage gradient for them (as presented in in Figure A1) is unlikely to affect the retention of older workers. Indeed, in our regressions, the explanatory power of the age gradient of wages is even lower if we calculate that on the sample of workers aged 20 to 56.

to retire once they become eligible. To examine this mechanism, we construct a binary indicator of replaceability that equals one if, at the time TFP is measured, we observe at least three workers in our sample with the same four-digit occupation code within the same firm, and zero otherwise. This measure captures whether a worker's tasks are performed by multiple employees in the same occupation, indicating the potential ease of internal replacement. We find that the rate of replaceability rises markedly with firm productivity: at firms with bottom-, middle-, and top-tertile TFP its average values are, respectively, 0.59, 0.67, and 0.81.

Part-Time Work Prevalence. In contrast to seniority wage profiles and replaceability – which primarily affect the demand for older workers – working conditions are likely to influence the supply side, that is, workers' willingness to remain employed at older ages. Although our administrative data do not include direct measures of working conditions, we can proxy an important dimension: the availability of part-time work options. Ameriks et al. (2020) show that the option of flexible working hours has major influence on retirement decisions – older workers are more willing to work at jobs with flexible working hours. In our administrative data, we observe the contractual working hours, based on which we can analyze if the prevalence of part-time work at the firm level contributes to the firm size gradient in the propensity of full retirement at the earliest age.

We define the binary indicator of part-time work as employment with fewer than the standard 40 weekly hours of work. For each firm, using observations between 2007 and 2016 but excluding the cohorts for which we analyze the retirement decisions, we calculate the share of workers aged 55 and above (i.e., close to or above the retirement age) who work part-time. We use this measure to proxy for firm-specific availability of part-time work among older workers. A limitation of this measure is that it is subject to selectivity – people preferring part-time work may sort to firms with better such options. Moreover, we do not observe the preferred hours of work in the data. Nevertheless, we assume that a higher share of part-time workers generally indicates better access to part-time working arrangements at a firm, which in turn may reduce the willingness of older employees to exit the labor market at the earliest possible retirement age.

Consistent with this interpretation, we find important differences in the prevalence of part-time work by firm productivity. The share of part-time work among older workers is 26%, 16% and 9% at firms with bottom-, middle-, and top-tertile TFP, respectively.

Firm-Specific Use of Prescription Drugs. Using the mover-based AKM-style decomposition method (see above the definition of the AKM firm wage FE), we also create firm specific measures of healthcare use, focusing on the binary indicators of the quarterly consumption of specific drug categories: (1) antiinfectives for systemic use (Anatomical Therapeutic Chemical, ATC group J); (2) drugs of the musculo-skeletal system (ATC M); (3) nervous system drugs (ATC N); as well as (4) the monthly total prescription drug

spending as outcome variables. Note, that in the administrative data, the health measures are available only for 2009–2017, but we can use the estimated firm specific FEs also in earlier years.

In addition to the prevalence of part-time work at the firm, we use the above listed firm-specific measures of prescription drug consumption as further proxies for adverse working conditions – or, more broadly, for (negative) workplace amenities. Rather than relying on individual-specific health measures, we use the estimated AKM firm fixed effects to capture firm characteristics independently of workforce composition. There are important differences in the use of prescription drugs by firm productivity (see Table A1). Firm-specific total drug spending and the use of nervous system drugs decrease, whereas the firm-specific use of antiinfectives and musculo-skeletal drugs increases with firm productivity. These patterns suggest that firm productivity and health outcomes have complex, disease-specific relations, in line with the findings of Bíró and Elek (2025).

5.2.2 Regression Estimates

In the regression analysis, we regress the binary indicator of full retirement at the earliest age (57 for women born in 1950-1951, 60 for men born in 1950-1951, 63 for men born in 1953) on TFP categories and an expanding set of other explanatory variables, all measured six months prior to reaching the relevant age. We aggregate the data to yearly age-level and set the outcome to one if the individual retires at any point during that age-year.

The parameter estimates for the TFP categories in the different models are shown in the top panel of Table 4. In the middle and bottom panels we repeat the regressions estimated by sex. There are no major differences in the estimated retirement patterns and in the role of the analyzed explanatory variables between men and women, so, in what follows, we focus on the full sample containing both sexes. The parameter estimates for the whole set of explanatory variables in the full model are displayed in Table A4.

In line with Figure 1, the raw differences reported in column (1) of Table 4 (i.e., the regression results without control variables) indicate that people employed at firms with middle- and top-tertile TFP are, respectively, 3.5 and 8.2 percentage points more likely to retire at the earliest occasion than people employed at bottom-tertile TFP firms. Considering that the average rate of retirement at the earliest occasion is 44.9%, the difference between the largest and smallest firm productivity groups is substantial.

In column (2) of Table 4, we net out the effect of the baseline regressors (sex, cohort effects, one-digit industry and one-digit occupation categories). The inclusion of these controls in the model does not reduce but even increases the TFP gradient in retirement rates: relative to people who were employed at bottom-tertile TFP firms, people employed at middle- and top-tertile TFP firms are ceteris paribus 4.6, and 11.1 percentage points more likely to retire at the earliest occasion, respectively. This indicates that differences

Table 4: Relation between firm productivity and early retirement, role of regressor-groups (Hungary)

Dependent variable: full retirement at earliest age					
	(1)	(2)	(3)	(4)	(5)
Sample: women and men					
Middle tertile TFP	0.035***	0.046***	0.026**	0.027**	0.016
	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]
Top tertile TFP	0.082***	0.111***	0.044***	0.048***	0.025*
	[0.013]	[0.013]	[0.015]	[0.015]	[0.015]
Observations	22,939	22,939	22,939	22,939	22,939
Sample: women					
Middle tertile TFP	0.036*	0.031*	0.016	0.017	0.005
	[0.019]	[0.018]	[0.018]	[0.018]	[0.019]
Top tertile TFP	0.106***	0.106***	0.050**	0.052**	0.028
	[0.020]	[0.021]	[0.022]	[0.022]	[0.023]
Observations	9,221	9,221	9,221	9,221	9,221
Sample: men					
Middle tertile TFP	0.037***	0.053***	0.033**	0.035**	0.024*
	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]
Top tertile TFP	0.069***	0.108***	0.045**	0.049***	0.026
	[0.017]	[0.015]	[0.019]	[0.019]	[0.018]
Observations	13,718	13,718	13,718	13,718	13,718
Control variables					
Baseline	no	yes	yes	yes	yes
AKM firm wage FE	no	no	yes	yes	yes
Log wage	no	no	no	yes	yes
Seniority wage profile	no	no	no	no	yes
Replaceability	no	no	no	no	yes
Part-time work prevalence	no	no	no	no	yes
AKM firm drug FEs	no	no	no	no	yes

Notes: Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age. Firm characteristics, occupation and age are measured 6 months before reaching the analyzed age. *Baseline control variables:* sex, cohort effects, one-digit industry and one-digit occupation categories. *AKM firm drug FEs:* firm fixed effects for the use of anti-infectives (ATC J), musculo-skeletal drugs (ATC M), nervous system drugs (ATC N), and for the total spending on prescription drugs. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

in the occupational and industry structure of more productive firms do not explain the earlier retirement.

To assess the contribution of the explanatory factors to the TFP gradient in the probability of retirement at the earliest eligible age, we progressively extend the set of regressors. We first add the AKM firm wage fixed effects. As shown in column (3) of Table 4, controlling for firm-specific wage components reduces the productivity gradient in early retirement by roughly half. This finding suggests that part of the higher propensity to retire early at more productive firms can be attributed to higher firm-specific wages. These higher wages may increase accumulated savings and, in turn, strengthen the income effect of higher earnings. However, as shown in column (4), adding the individual-specific wage components (log wage) does not further reduce the gradient, suggesting that differences in individual pay levels within firms do not play a major role once firm effects are accounted

for. This finding is consistent with the full regression results reported in Table A4, which show that higher firm-specific wages are strongly associated with early retirement. Yet, conditional on the firm-level wage component, individual wages are not significantly related to retirement timing.

Finally, in column (5) of Table 4, we augment the model with additional firm-level characteristics: firm-specific seniority wage profile, replaceability, firm-specific prevalence of part-time work among older workers, and the use of prescription drugs. The results indicate that these additional control variables explain around half of the wage-controlled TFP gradient in retirement rates at the earliest age (reported in column (4)). The remaining productivity gradient is statistically significant at most at the 10% level.

5.2.3 Explained Variation of Residual Differences in Retirement Timing by TFP

Next, we assess the separate explanatory shares of seniority wage profile, replaceability, part-time work prevalence, and the firm-specific health measures in the TFP gradient of the probability of retirement at the earliest age, after netting out the role of sex, cohort, industry, occupation, AKM firm wage FE, and log wage. We apply the Blinder–Oaxaca decomposition (Blinder, 1973; Oaxaca, 1973), as introduced in Section 4.

We report the results of the decomposition exercises in Table 5. Irrespective of the exact classification of firms into larger- and smaller-TFP groups, the control variables explain more than half (55–65%) of the residual differences in the probability of retirement at the earliest retirement age between the more and less productive firms. Among the explanatory components, the prevalence of part-time work emerges as the most important factor, explaining between 35% and 39% of the residual productivity gradient across the three comparisons. This highlights the central role of flexible working arrangements in shaping older workers' retirement decisions: firms that provide more part-time opportunities tend to retain employees longer, thereby reducing early full retirement.

The replaceability measure also makes a substantial contribution, explaining 15–24% of the residual variation. This finding supports the notion that at more productive – and typically larger – firms, older workers are easier to be substituted internally, which increases the likelihood of full retirement once eligibility is reached.

By contrast, the seniority wage profile contributes little (–2% to +3%), suggesting that, conditional on other controls, the variation of the steepness of the wage profiles by firm productivity does not explain the variation in retirement rates.

The health-related firm measures explain only a small share (around 2–3%) of the residual variation, implying that differences in workplace health or physical strain, as proxied by prescription drug use, play a secondary role relative to flexibility and replaceability.[14]

[14]Note that our health measures cannot capture such work-related health problems that do not result in prescription drug use. Indeed, the 2015 wave of the European Working Conditions Survey indicates that

Taken together, these decompositions highlight that firm-level flexibility and worker replaceability are important channels linking productivity to early retirement. In Appendix Table A5, we perform the decomposition separately by sex and cohort. The results show that the explanatory contributions of replaceability and part-time work prevalence to retirement timing were larger for cohorts with access to early retirement options.

Table 5: Explanatory shares of control variables in the residual TFP differences in early retirement (Hungary)

Dependent variable: full retirement at earliest age	(1) TFP tertile 1–2 vs. 3	(2) TFP tertile 1 vs. 2–3	(3) TFP tertile 1 vs. 3
Seniority wage profile	3.1%	-1.8%	0.0%
Replaceability	23.8%	17.1%	14.7%
Part-time work prevalence	34.8%	36.5%	38.9%
AKM firm antiinfectives FE	3.9%	4.9%	3.5%
AKM firm muscle drugs FE	0.1%	0.0%	0.0%
AKM firm nervous system drugs FE	-0.4%	-1.1%	-0.6%
AKM firm drug spending FE	0.0%	-0.5%	-0.3%
All controls	65.3%	55.2%	56.3%
Average residual difference (larger vs. smaller firms)	0.032	0.041	0.057

Notes: Table shows explanatory shares of control variable groups in the firm productivity differences in the probability of retirement at the earliest retirement age, after netting out the role of sex, cohort effects, industry, occupation, AKM firm wage FE, and log wage. Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age.

5.2.4 Relation Between Productivity and Retirement on Longer Horizons

So far, we have focused on the relationship between employer productivity six months prior to reaching the earliest retirement age and the probability of retiring exactly at that age. Although retirement rates increase gradually with age, Appendix Table A6 shows that the positive association between firm productivity and retirement probability persists one and two years after individuals reach the earliest retirement age. Specifically, we estimate regressions analogous to those reported in Table 4, replacing the dependent variable with binary indicators for being fully retired one or two years after the earliest retirement age. The results indicate that the explanatory variables considered account for most of the productivity gradient even over these longer horizons. Note that because our data end in 2016, these longer-horizon analyses can be conducted only for the 1950–1951 cohorts.

In our main analysis, we examine the productivity gradient of early retirement among individuals who were employed in the private sector six months before reaching the earliest

workplace stress is less prevalent at smaller (and typically less productive) firms, both among younger and older workers. Looking at the responses of workers aged 50 and above, among those who work at firms with 2 to 9 workers, 43% report that they rarely or never experience stress at work. The same ratio is 37% and 31% at firms with 10 to 249, and 250+ workers, respectively.

retirement age. This sample is inherently selective, as some workers may exit employment earlier by becoming unemployed, applying for disability benefits, or remaining inactive until they reach retirement age. To assess the sensitivity of our results to this sample selection, we re-estimate our baseline regressions using alternative samples consisting of individuals who were employed 12 or 24 months before reaching the earliest retirement age. In these specifications, firm productivity and other employer and job characteristics are measured at those time points, rather than using the baseline six-month lag.

The results reported in Appendix Table A7 indicate that the productivity gradient in early retirement persists when employer productivity is measured at earlier points in time. However, the gradient becomes less steep as the time gap exceeds one year, and the explanatory power of the included covariates also declines. These attenuated effects are expected, as worker mobility across firms implies that the retirement decision may be made at a different employer than the one used for calculating firm characteristics.

5.2.5 Firm Productivity and Firm Size

The previous sections demonstrated that early retirement is more prevalent in more productive firms. To examine whether these findings hold when using firm size as a proxy for productivity, we replicate the analysis using firm size – the only available productivity proxy in the SHARE data discussed later in Section 6. As shown in Table A1, firms with higher productivity are generally larger. The correlation between TFP and firm size is 0.45, which suggests that firm size can serve as a reasonable proxy for productivity in datasets where direct productivity measures are not available.[15]

The results presented in Table 6 show that indeed, workers are more likely to retire early from larger firms. The raw probability of full retirement is 6.6 percentage points higher in medium-sized firms (25–199 employees) and 16.7 percentage points higher in large firms (200+ employees) relative to small firms (5–24 employees). Including the full set of control variables – sex, cohort, industry, occupation, AKM firm wage fixed effects, log wage, and firm-level indicators of seniority wage profile, replaceability, flexibility, and health – reduces these differences substantially. The estimated coefficients in column (5) imply that more than half of the raw firm-size gradient in early retirement is explained by these observable factors. Note that, for this exercise, we include firms with at least 5 workers in the sample (instead of the lower bound of 20 that we use in the case of firm productivity, which is noisily measured for the smallest firms).

[15]Note that more productive firms are also more likely to have higher firm-level wage premia, to be foreign owned and to have exporting activities. These differences are reinforced by the statistics reported in the bottom part of Table A1, where foreign ownership is defined as at least 50% of the firm's capital being owned by foreign owners.

Table 6: Relation between firm size and early retirement, role of regressor-groups (Hungary)

Dependent variable: full retirement at earliest age					
	(1)	(2)	(3)	(4)	(5)
Firm size 25–199	0.066***	0.051***	0.031**	0.031**	0.019
	[0.012]	[0.012]	[0.013]	[0.013]	[0.013]
Firm size 200+	0.167***	0.148***	0.102***	0.103***	0.077***
	[0.014]	[0.014]	[0.015]	[0.015]	[0.015]
Observations	24,768	24,768	24,768	24,768	24,768
Control variables					
Baseline	no	yes	yes	yes	yes
AKM firm wage FE	no	no	yes	yes	yes
Log wage	no	no	no	yes	yes
Seniority wage profile	no	no	no	no	yes
Replaceability	no	no	no	no	yes
Part-time work prevalence	no	no	no	no	yes
AKM firm drug FEs	no	no	no	no	yes

Notes: Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age. Firm characteristics, occupation and wage are measured 6 months before reaching the analyzed age. *Baseline control variables:* sex, cohort effects, one-digit industry and one-digit occupation categories. *AKM firm drug FEs:* firm fixed effects for the use of anti-infectives (ATC J), musculo-skeletal drugs (ATC M), nervous system drugs (ATC N), and for the total spending on prescription drugs. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

5.3 Separation Rate by TFP at Active Ages

The gradient in early retirement by firm productivity is in contrast to the widespread evidence that better-paying (and more productive) firms are also "better" in the sense of providing better amenities (Clark et al., 2009; Lachowska et al., 2022; Sockin, 2022; Bana et al., 2023; Bíró and Elek, 2025). In this section we show that this apparent contradiction can be resolved by the finding that, once we net out the role of earnings, more productive firms no longer appear to be "better" in terms of employee retention.

We capture the revealed preferences for a firm by the rate of voluntary separations (employer-to-employer transitions), with higher separation rates indicating lower preferences for remaining at the firm. As outlined in section 3.1, we set the binary indicator of voluntary separation to one if the current and next-quarter employer are different, and zero otherwise. Then, we regress this binary indicator on the year-specific tertiles of TFP and on the expanding set of control variables that we used in the analysis of retirement: baseline controls (calendar year, sex, age effects, one-digit industry and one-digit occupation categories), AKM firm wage FE, log wage, seniority wage profile, replaceability, part-time work prevalence at older ages, and firm-specific measures of prescription drug use.[16] We estimate these regressions separately for two age groups (30–49 and 50–56) because the average separation rate decreases substantially with age (0.03 in the younger age group, 0.02 in the older age group), and also because this way we can relate the results for the oldest age group to the results we estimated for retirement decisions.

[16]Instead of the cohort effects in the retirement regressions, here we use calendar year and age effects because of the setup of the data.

The results reported in Table 7 reveal a clear pattern. For both age groups, the raw differences and the estimates with baseline controls (columns 1–2) show that voluntary separations are significantly less frequent at more productive firms: for example, in the 30–49 age group, the separation rate is about 0.9 percentage point lower at top-tertile TFP firms compared to the least productive ones, relative to a base rate of 3%. This confirms the conventional finding that high-productivity firms retain their workers more effectively (see, e.g., Ilmakunnas et al., 2005; Yanadori and Kato, 2007), likely reflecting better pay and career prospects.

Table 7: Voluntary separation rate at active ages

Dependent variable: voluntary separation					
	(1)	(2)	(3)	(4)	(5)
Age 30–49					
Middle third TFP	-0.004***	-0.004***	0.001	0.001	0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Top third TFP	-0.009***	-0.009***	0.000	0.002	0.001
	[0.001]	[0.001]	[0.002]	[0.002]	[0.002]
Age 50–56					
Middle third TFP	-0.003***	-0.003***	0.000	0.001	0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Top third TFP	-0.005***	-0.005***	0.002*	0.003**	0.003**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Control variables					
Baseline	no	yes	yes	yes	yes
AKM firm wage FE	no	no	yes	yes	yes
Log wage	no	no	no	yes	yes
Seniority wage profile	no	no	no	no	yes
Replaceability	no	no	no	no	yes
Part-time work prevalence	no	no	no	no	yes
AKM firm drug FEs	no	no	no	no	yes

Notes: Sample: Hungarian administrative data, private sector employees not receiving pension-type benefits. *Baseline control variables:* calendar year, sex, age effects, one-digit industry and one-digit occupation categories. *AKM firm drug FEs:* firm fixed effects for the use of anti-infectives (ATC J), musculo-skeletal drugs (ATC M), nervous system drugs (ATC N), and for the total spending on prescription drugs. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1. Mean outcome at age 30–49 and 50–56, respectively, is 0.030 and 0.020. Number of observations at age 30–49: 12,180,334; at age 50–56: 3,702,338.

However, this gradient largely disappears once we control for AKM firm wage fixed effects (column (3)) and then to individual wages (column (4)). For the younger age group, the coefficients on top- and middle-tertile TFP firms fall from –0.009 and –0.004 to near zero. This suggests that the lower separation rates at high-TFP firms are largely explained by higher pay rather than by other non-wage workplace advantages.

For the older age group (50–56), the pattern becomes even more striking. Once wages are controlled for, the TFP gradient reverses sign: older workers in top TFP tertile firms are slightly (0.3 percentage points) more likely to separate voluntarily than workers in bottom tertile firms (columns 3–4). Hence, conditional on pay effects, older employees at high-productivity firms are more inclined to leave. The gradient remains essentially the same when further, firm-specific controls are added (column (5)).

This reversal among older workers mirrors the pattern observed in the retirement analysis. While raw data suggest that more productive firms provide better jobs with lower separation rates, once we net out the role of earnings, these firms no longer appear more attractive to older workers – in fact, they are associated with a higher likelihood of separation, including through early retirement.

Overall, the results on separation rates support the retirement-related findings of Table 4. Workers at more productive firms are less likely to separate during their active years mainly because these firms pay higher wages. Beyond higher pay, however, these firms do not appear to offer better working conditions or greater flexibility. In fact, they provide fewer part-time opportunities and employ workers in more easily replaceable positions. Consequently, once employees at these firms reach pension eligibility, they are more likely to retire fully. Their higher lifetime earnings make early retirement financially affordable, and the less flexible or more substitutable nature of their jobs provides little reason to remain employed.

6 Results Based on the SHARE Data

Consistent with our findings for Hungarian firms, the SHARE data indicate that although workers in larger firms are less likely to separate from their employer during active ages, they tend to retire promptly once they become eligible.

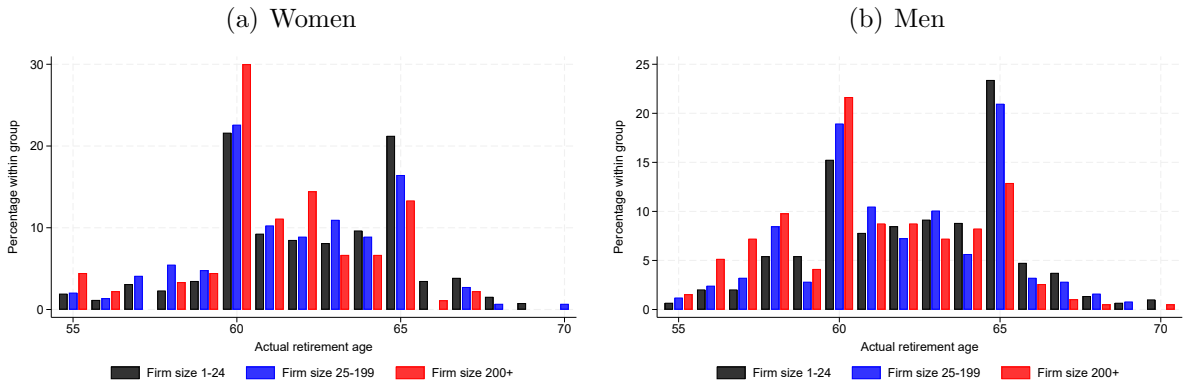
6.1 Retirement by Firm Size – SHARE Data

Figure 4 shows the histogram of the actual retirement age by sex and firm size for private sector employees aged 50–59 at the time of the first wave of SHARE (i.e., in 2004). For both sexes, the mode is 65 years for firms with 1–24 employees and 60 years for firms with 200+ employees, which suggests a negative association of firm size with the age of retirement.

Table 8 shows the association between firm size and the probability of retiring before the statutory retirement age, the actual retirement age, and early retirement intentions with and without controlling for explanatory variables.[17] Without controls, the probability of retirement before the statutory retirement age is 15 percentage points higher and the actual retirement age is 1.2 years lower in firms with 200+ employees than in firms with 1–24 employees. If we include sex and country dummies, age and age squared, one-digit occupation and industry categories as control variables in the regressions, the difference is substantially reduced to around 9 percentage points and 0.64 year, respectively, but remains statistically significant.

[17]We provide descriptive statistics by firm size in Table A8 and the full set of regression coefficients in Table A9.

Figure 4: Distribution of actual retirement age by sex and firm size (Europe)



Notes: Sample: SHARE data, private sector employees aged 50–59 in wave 1 are followed in later waves. Only retirement ages between 55 and 70 are shown.

Workers at larger firms are also more likely to report early retirement intentions. The difference is 8 percentage points between the largest and smallest firm size category, and the association is not substantially affected by the inclusion of the control variables. The consistency between stated retirement intentions and observed retirement ages – both indicating earlier exits in larger firms – underscores the substantial influence of supply-side factors on retirement behavior.

Table 8: Relation between firm size and retirement (Europe)

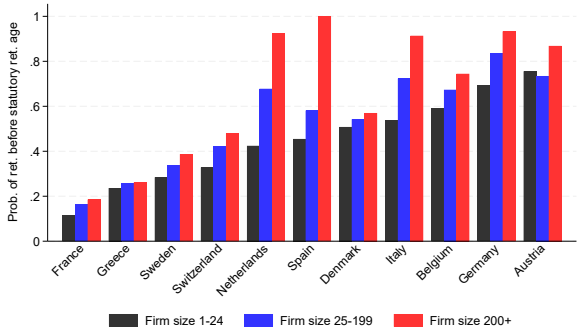
Dependent variable:	**Retirement before statutory age**		**Actual retirement age (years)**		**Early retirement intention**	
	(1)	(2)	(3)	(4)	(5)	(6)
Firm size 25–199	0.097***	0.065**	-0.56**	-0.32*	0.034	0.046*
	[0.035]	[0.030]	[0.22]	[0.19]	[0.027]	[0.027]
Firm size 200+	0.150***	0.090***	-1.20***	-0.64***	0.083***	0.083***
	[0.039]	[0.031]	[0.25]	[0.24]	[0.030]	[0.031]
Observations	2,290	2,290	1,880	1,880	3,889	3,889
Control variables	no	yes	no	yes	no	yes

Notes: Sample: SHARE data, private sector employees aged 50–59 at wave 1 are followed. Mean outcomes: 61.59 years (actual retirement age), 0.491 (retirement before statutory age), 0.515 (early retirement intention). Firm size and controls measured in wave 1. Reference category: 1–24 employees. *Controls:* sex, country dummies, age, age squared, occupation and industry categories. Cross-sectional weights used. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

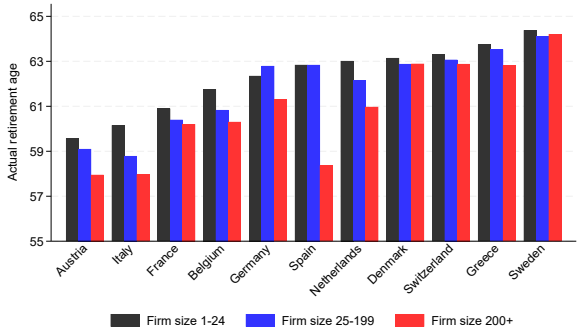
Figure 5 shows that firm size heterogeneities in retirement timing and early retirement intentions generally hold even within countries: people tend to and plan to retire earlier from larger firms. Importantly, the country-specific patterns show that the heterogeneities are not driven by countries with occupational pensions (France, the Netherlands, Sweden and Switzerland, see Section 2 for details).

Figure 5: Firm size heterogeneity in retirement timing within European countries

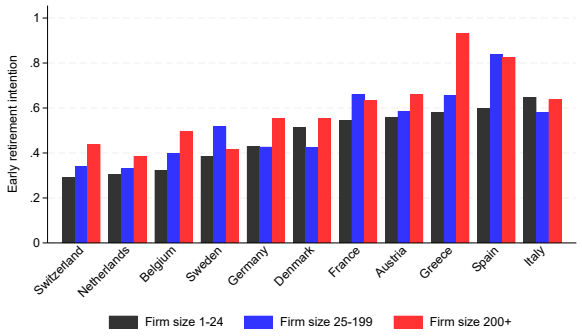
(a) Probability of retirement before the statutory retirement age



(b) Actual retirement age



(c) Early retirement intention (probability)



Notes: Sample: SHARE data, private sector employees aged 50–59 in wave 1 are followed in later waves. Cross-sectional weights from wave 1 are used.

6.2 Job Separation by Firm Size – SHARE Data

Table 9 displays results for job separation by firm size throughout Europe, estimated on the 50-59 years old population. According to the table, the probability of quitting the firm within two years among those who did not retire is 11 percentage points lower in the largest than in the smallest firm category (the mean quit rate is 24%). Similarly, the two-year employer-to-employer transition rate among the continuously employed population is 3.2 percentage points lower from firms with 200+ employees than from firms with 1-24 employees (the mean transition rate is 4.4%). These differences remain significant at least at the 10% level after including the control variables. Also, average tenure measured in wave 1 is by 6.8 years longer in the largest vs. the smallest firms, and 5.1 years longer if the control variables are adjusted for.

These results suggest that separation rates for reasons other than retirement are lower from the larger firms than from the smaller firms throughout Europe. Overall, the SHARE evidence for European countries supports the dual pattern observed in Hungary: lower job mobility but higher early retirement in larger (more productive) firms.

Table 9: Relation between firm size and measures of job separation (Europe)

Dependent variable:	**Probability of quitting within two years**		**Probability of employer-to-employer transition within two years**		**Tenure at current firm (wave 1)**	
	(1)	(2)	(3)	(4)	(5)	(6)
Firm size: 25–199	-0.030	-0.011	0.002	0.007	2.56***	1.67***
	[0.028]	[0.029]	[0.014]	[0.016]	[0.63]	[0.62]
Firm size: 200+	-0.110***	-0.064**	-0.032***	-0.022*	6.81***	5.10***
	[0.029]	[0.031]	[0.011]	[0.012]	[0.66]	[0.66]
Observations	2,671	2,671	2,167	2,167	3,915	3,915
Control variables	no	yes	no	yes	no	yes

Notes: Sample: SHARE data, private sector employees aged 50–59 at wave 1. Mean outcomes: 0.240 (quit within two years), 0.044 (employer-to-employer transition within two years), 19.1 years (tenure). Firm size and controls measured in wave 1. Reference category: 1–24 employees. *Controls:* sex, country dummies, age, age squared, occupation and industry categories. Cross-sectional weights used. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

7 Conclusions

Our results reveal a striking paradox that has received little attention: while more productive firms tend to retain employees longer during their working years – largely due to higher wages – these same firms experience earlier retirements once employees become eligible, compared to less productive firms. This result persists even after controlling for sex, age, occupation, and industry

This pattern appears to be partly explained by the characteristics of high-productivity firms: they often provide fewer opportunities for part-time or flexible work, their employees are easier to be replaced, and some aspects of the work environment may be more demanding. Moreover, unlike during prime working ages, higher-wage firms (which are generally more productive) are associated with earlier retirement. This likely reflects that greater earnings facilitate higher savings and pensions, making retirement more affordable, and offsetting the substitution effect that would act in the opposite direction. Combined, these factors help explain the earlier exits from the labor market.

The findings from Hungarian administrative data closely align with survey evidence from 11 other European countries (excluding Hungary), where firm size serves as a proxy for productivity. This consistency suggests that the phenomenon is not driven by country-specific institutions or pension rules, but reflects a broader pattern across labor markets.

Our results indicate that the main "attractiveness" of more productive firms for employees lies in the provision of higher wages. During prime working ages, separation rates are lower at more productive firms, but this advantage vanishes once firm-level wage premia are taken into account. This suggests that higher wages drive longer retention over the working life, whereas non-wage features – such as limited flexibility or greater worker replaceability – promote earlier exits once retirement eligibility is reached. Together,

these patterns reconcile the lower separation rates of prime-age workers with the higher retirement rates of older workers observed at more productive firms.

From a policy perspective, our findings imply that extending working lives requires more than wages to delay retirement. Further research is needed to examine how age-climate – that is, perceptions, practices and policies related to age – varies with firm productivity (and firm size), and whether stronger collegial connections or workplace conditions better aligned to older workers could increase labor supply at old ages at more productive firms. Promoting employment at older ages may require not only raising statutory retirement ages, but also strengthening labor demand for older workers – particularly in more productive, often larger firms. This could be achieved through targeted training programs, as well as carefully designed financial incentives. Because older employees in highly productive firms tend to generate greater value added, their early exit from the labor force represents a disproportionate loss to society. Complementing broad retirement-age reforms with firm-level incentives could therefore encourage high-productivity employers to retain experienced workers.

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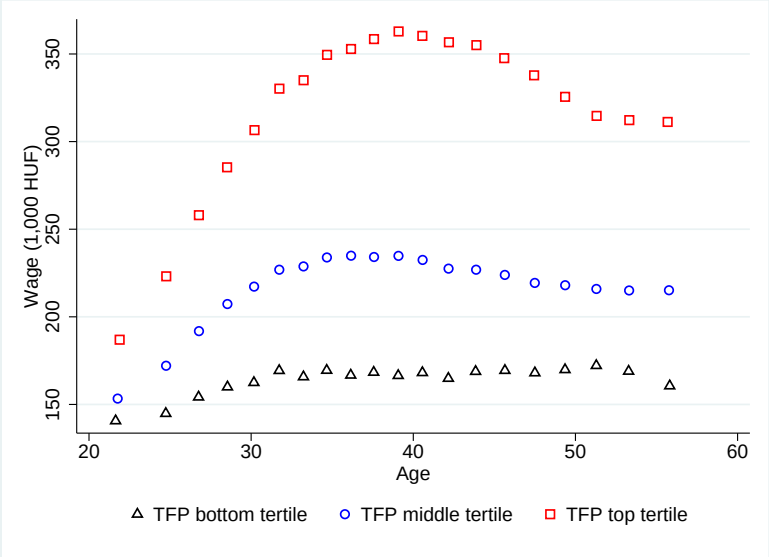
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Appendix

Appendix Figure A1: Age-wage profile (Hungary)



Notes: Figure shows binscatter plot of mean wage by 20 equally sized age groups, splitting the sample by TFP tertiles. Sample: Hungarian administrative data, 2007–2016. One-digit industry and year dummies are netted out.

Appendix Table A1: Descriptive statistics (Hungary)

	(1) TFP bottom tertile	(2) TFP middle tertile	(3) TFP top tertile	p-value of t-test of equal mean (1) & (2)	(1) & (3)	(2) & (3)
Men	0.539	0.612	0.596	0.000	0.000	0.019
Year of birth	1951.0	1951.1	1951.1	0.000	0.000	0.189
White collar job	0.287	0.311	0.434	0.000	0.000	0.000
Industry						
Manufacturing	0.337	0.411	0.419	0.000	0.000	0.314
Trade	0.108	0.121	0.078	0.034	0.000	0.000
Construction	0.040	0.054	0.075	0.001	0.000	0.000
Transportation, storage	0.014	0.065	0.098	0.000	0.000	0.000
Services	0.193	0.184	0.215	0.237	0.006	0.000
Other	0.308	0.165	0.115	0.000	0.000	0.000
AKM firm wage FE	-0.110	-0.015	0.212	0.000	0.000	0.000
Log wage	11.71	11.94	12.33	0.000	0.000	0.000
Seniority wage profile at age 30–56	1137.0	1446.3	1151.4	0.000	0.775	0.000
Replaceability	0.593	0.671	0.812	0.000	0.000	0.000
Part time work prevalence	0.259	0.164	0.092	0.000	0.000	0.000
AKM firm drug spending FE	161.4	32.9	55.7	0.001	0.000	0.307
AKM firm antiinfectives FE	0.001	0.006	0.009	0.000	0.000	0.000
AKM firm muscle drugs FE	0.000	0.003	0.006	0.000	0.000	0.000
AKM firm nervous sys. drugs FE	0.004	0.000	0.000	0.000	0.000	0.287
Firm size	210.9	283.6	1500.8	0.000	0.000	0.000
Foreign owned firm	0.075	0.191	0.503	0.000	0.000	0.000
Exporter firm	0.363	0.554	0.683	0.000	0.000	0.000

Notes: Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level. Firm characteristics, occupation and wage are measured 6 months before reaching the analyzed age. Number of individuals: 22,939.

Appendix Table A2: Relation between firm productivity and early retirement, broader sample of firms, role of regressor-groups (Hungary)

Dependent variable: full retirement at earliest age					
	(1)	(2)	(3)	(4)	(5)
Middle tertile TFP	0.033***	0.042***	0.022**	0.024**	0.012
	[0.011]	[0.011]	[0.011]	[0.011]	[0.011]
Top tertile TFP	0.083***	0.109***	0.045***	0.048***	0.025*
	[0.013]	[0.012]	[0.015]	[0.014]	[0.014]
Observations	23,788	23,788	23,788	23,788	23,788
Control variables					
Baseline	no	yes	yes	yes	yes
AKM firm wage FE	no	no	yes	yes	yes
Log wage	no	no	no	yes	yes
Seniority wage profile	no	no	no	no	yes
Replaceability	no	no	no	no	yes
Part-time work prevalence	no	no	no	no	yes
AKM firm drug FEs	no	no	no	no	yes

Notes: Sample: Hungarian administrative data, workers at firs with 10+ workers, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age. Firm characteristics, occupation and age are measured 6 months before reaching the analyzed age. *Baseline control variables:* sex, cohort effects, one-digit industry and one-digit occupation categories. *AKM firm drug FEs:* firm fixed effects for the use of anti-infectives (ATC J), musculo-skeletal drugs (ATC M), nervous system drugs (ATC N), and for the total spending on prescription drugs. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table A3: Voluntary separation rate at active ages, broader sample of firms

	(1)	(2)	(3)	(4)	(5)
Dependent variable: voluntary separation					
Age 30–49					
Middle third TFP	-0.004***	-0.005***	0.000	0.001	0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Top third TFP	-0.010***	-0.010***	-0.000	0.001	0.001
	[0.001]	[0.001]	[0.002]	[0.002]	[0.002]
Age 50–56					
Middle third TFP	-0.003***	-0.004***	-0.000	0.000	0.000
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Top third TFP	-0.006***	-0.006***	0.002	0.003**	0.003*
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Control variables					
Baseline	no	yes	yes	yes	yes
AKM firm wage FE	no	no	yes	yes	yes
Log wage	no	no	no	yes	yes
Seniority wage profile	no	no	no	no	yes
Replaceability	no	no	no	no	yes
Part-time work prevalence	no	no	no	no	yes
AKM firm drug FEs	no	no	no	no	yes

Notes: Sample: Hungarian administrative data, private sector employees at firms with 10+ workers not receiving pension-type benefits. *Baseline control variables:* calendar year, sex, age effects, one-digit industry and one-digit occupation categories. *AKM firm drug FEs:* firm fixed effects for the use of anti-infectives (ATC J), musculo-skeletal drugs (ATC M), nervous system drugs (ATC N), and for the total spending on prescription drugs. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1. Mean outcome at age 30–49 and 50–56, respectively, is 0.031 and 0.020. Number of observations at age 30–49: 12,842,438; at age 50–56: 3,899,508 .

Appendix Table A4: Full regression table (Hungary)

Dependent variable: full retirement at earliest retirement age	
TFP middle tertile	0.016
	[0.012]
TFP top tertile	0.025*
	[0.015]
Men	-0.007
	[0.010]
Cohort 1951	0.009
	[0.008]
Cohort 1953	-0.089***
	[0.011]
Industry (ref.: manufacturing)	
trade	-0.030**
	[0.014]
construction	-0.062***
	[0.017]
transportation, storage	-0.033
	[0.027]
services	-0.082***
	[0.013]
other	0.017
	[0.013]
Occupation (ref.: manager)	
professional	-0.034**
	[0.017]
other white collar	0.134***
	[0.015]
skilled blue collar	0.215***
	[0.016]
assembler, machine operator	0.183***
	[0.017]
unskilled	0.131***
	[0.017]
AKM firm wage FE	0.204***
	[0.029]
Log wage	-0.017*
	[0.010]
Seniority wage profile	-0.000**
	[0.000]
Replaceable	0.047***
	[0.009]
Part-time work prevalence	-0.113***
	[0.019]
AKM firm drug spending FE	0.000
	[0.000]
AKM firm antiinfectives FE	0.323***
	[0.102]
AKM firm muscle drugs FE	0.003
	[0.132]
AKM firm nervous system drugs FE	0.097
	[0.168]
Constant	0.535***
	[0.122]
Observations	22,939

Notes: Sample: cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table A5: Explanatory shares of control variables in the residual TFP differences in early retirement by cohort groups (Hungary)

Dependent variable: full retirement at earliest age	(1)	(2)	(3)
	TFP tertile 1 vs. 3		
	Women born in 1950-1951	Men born in 1950-1951	Men born in 1953
Seniority wage profile	1.7%	-3.7%	0.2%
Replaceability	14.9%	32.5%	8.0%
Part-time work prevalence	64.3%	44.7%	23.3%
AKM firm antiinfectives FE	-1.2%	12.7%	4.3%
AKM firm muscle drugs FE	-1.4%	-2.6%	4.5%
AKM firm nervous system drugs FE	-3.6%	0.3%	-2.3%
AKM firm drug spending FE	1.5%	-1.2%	0.1%
All controls	76.4%	82.9%	38.2%
Average residual difference (larger vs. smaller firms)	0.038	0.040	0.113

Notes: Table shows explanatory shares of control variable groups in the firm productivity differences in the probability of retirement at the earliest retirement age, after netting out the role of sex, cohort effects, industry, occupation, AKM firm wage FE, and log wage. Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age.

Appendix Table A6: Relation between firm productivity and early retirement over longer time horizons (Hungary)

	(1)	(2)	(3)	(4)	(5)	(6)
	Full ret. at earliest age		Full ret. 1 yr after earliest age		Full ret. 2 yrs after earliest age	
Middle tertile TFP	0.035***	0.010	0.024**	-0.001	0.034***	0.008
	[0.013]	[0.013]	[0.012]	[0.012]	[0.013]	[0.013]
Top ertile TFP	0.077***	0.013	0.064***	0.003	0.086***	0.027*
	[0.015]	[0.017]	[0.014]	[0.016]	[0.013]	[0.016]
Observations	17,923	17,923	17,923	17,923	17,923	17,923
Control variables						
Baseline	no	yes	no	yes	no	yes
AKM firm wage FE	no	yes	no	yes	no	yes
Log wage	no	yes	no	yes	no	yes
Seniority wage profile	no	yes	no	yes	no	yes
Replaceability	no	yes	no	yes	no	yes
Part-time work prevalence	no	yes	no	yes	no	yes
AKM firm drug FEs	no	yes	no	yes	no	yes

Notes: Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age (columns (1) & (2), mean outcome 0.494), one year after the analyzed age (columns (3) & (4), mean outcome 0.604), or two years after the analyzed age (columns (5) & (6), mean outcome 0.664). Firm characteristics, occupation and age are measured 6 months before reaching the analyzed age. *Baseline control variables:* sex, cohort effects, one-digit industry and one-digit occupation categories. *AKM firm drug FEs:* firm fixed effects for the use of anti-infectives (ATC J), musculo-skeletal drugs (ATC M), nervous system drugs (ATC N), and for the total spending on prescription drugs. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table A7: Relation between firm productivity and early retirement when characteristics are measured at different points (Hungary)

Dependent variable: full retirement at earliest age						
	(1)	(2)	(3)	(4)	(5)	(6)
Middle tertile TFP	0.035***	0.016	0.045***	0.027**	0.053***	0.044***
	[0.012]	[0.012]	[0.012]	[0.012]	[0.014]	[0.013]
Top tertile TFP	0.082***	0.025*	0.080***	0.033**	0.059***	0.033**
	[0.013]	[0.015]	[0.013]	[0.015]	[0.015]	[0.016]
Observations	22,939	22,939	20,767	20,767	15,347	15,347
Lags in firm and job characteristics	6m	6m	12m	12m	24m	24m
Control variables						
Baseline	no	yes	no	yes	no	yes
AKM firm wage FE	no	yes	no	yes	no	yes
Log wage	no	yes	no	yes	no	yes
Seniority wage profile	no	yes	no	yes	no	yes
Replaceability	no	yes	no	yes	no	yes
Part-time work prevalence	no	yes	no	yes	no	yes
AKM firm drug FEs	no	yes	no	yes	no	yes

Notes: Sample: Hungarian administrative data, cohorts 1950 and 1951 of women at age 57, cohorts 1950 and 1951 of men at age 60, cohort 1953 of men at age 63. Monthly data are aggregated to the yearly age level, with the outcome set to one if the individual enters full retirement during the analyzed age. Firm characteristics, occupation and age are measured 6 (columns (1) & (2)), 12 (columns (3) & (4)), or 24 (columns (5) & (6)) months before reaching the analyzed age. *Baseline control variables:* sex, cohort effects, one-digit industry and one-digit occupation categories. *AKM firm drug FEs:* firm fixed effects for the use of anti-infectives (ATC J), musculo-skeletal drugs (ATC M), nervous system drugs (ATC N), and for the total spending on prescription drugs. Standard errors in brackets, clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table A8: Descriptive statistics (Europe)

	(1)	(2)	(3)	p-value of t-test of equal mean		
	Firm size 1-24	Firm size 25-199	Firm size 200+	(1) & (2)	(1) & (3)	(2) & (3)
Men	0.508	0.578	0.643	0.000	0.000	0.003
Age	53.921	53.889	53.863	0.744	0.609	0.820
White collar job	0.439	0.563	0.630	0.000	0.000	0.002
Early ret intention (0-no/1-yes)	0.486	0.520	0.568	0.061	0.000	0.028

Notes: Sample: SHARE data, private sector employees aged 50–59 at the time of wave 1 are followed. Cross-sectional weights from wave 1 are used.

Appendix Table A9: Full regression table (Europe)

	Retirement age	Prob ret before statutory ret age	Early ret intention
Firm size 25–199	-0.32*	0.065**	0.046*
	[0.19]	[0.030]	[0.027]
Firm size 200+	-0.64***	0.090***	0.083***
	[0.24]	[0.031]	[0.031]
Female	-0.44**	-0.071**	-0.023
	[0.20]	[0.029]	[0.028]
Age	-0.97	0.28	0.26
	[1.41]	[0.19]	[0.18]
Age squared	0.0097	-0.0026	-0.0023
	[0.013]	[0.0017]	[0.0017]
Country (reference: Austria)			
Germany	2.78***	0.033	-0.15***
	[0.32]	[0.053]	[0.046]
Sweden	4.55***	-0.40***	-0.15***
	[0.31]	[0.049]	[0.045]
Netherlands	2.86***	-0.18***	-0.27***
	[0.38]	[0.059]	[0.047]
Spain	3.14***	-0.25***	0.056
	[0.42]	[0.061]	[0.055]
Italy	0.16	-0.12**	0.0020
	[0.42]	[0.061]	[0.061]
France	1.19***	-0.60***	-0.011
	[0.31]	[0.047]	[0.046]
Denmark	3.29***	-0.21***	-0.12**
	[0.35]	[0.054]	[0.049]
Greece	3.94***	-0.47***	0.015
	[0.50]	[0.057]	[0.054]
Switzerland	3.73***	-0.34***	-0.22***
	[0.40]	[0.063]	[0.054]
Belgium	1.60***	-0.077	-0.22***
	[0.34]	[0.050]	[0.047]
Constant	83.4**	-6.47	-6.69
	[38.4]	[5.20]	[4.95]
Observations	1,880	2,290	3,889

Notes: Sample: SHARE data, private sector employees aged 50–59 at the time of wave 1 are followed. Further control variables: one-digit occupation and industry categories. Cross-sectional weights from wave 1 are used. Heteroskedasticity robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.