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# Do digital technologies affect the hiring and firing of older workers? Evidence from Russia

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## ABSTRACT

This study analyses the impact of digital technology adoption by enterprises on the hiring and firing of older workers. Data from the Russian Enterprise Survey for 2021–2022 are used for the analysis. Estimates are conducted for workers of retirement and pre-retirement age. The impact of enterprise digitalization on hiring and firing and the probability that firing will exceed hiring are estimated using Tobit and Probit models with an endogenous regressor. The results indicate that a high proportion of long-tenured workers hinders the hiring of older workers. At the same time, the digitalization of enterprises has a positive impact on the hiring of workers. However, highly digitalized enterprises also fire more workers than non-digitalized enterprises. At the same time, the higher the level of enterprises' digitalization, the greater is the excess of firing over hiring. Older workers need to improve digital literacy skills to remain employed and competitive in the labour market.

## KEYWORDS

Older workers; digitalisation; hiring, firing; employment

## JEL CLASSIFICATION

J14; J21; J63; M51; O33

## I. Introduction

Digitalization processes are taking place in most countries of the world. The growing use of digital technologies by enterprises requires employees to possess digital skills and increase the level of digital competencies. However, the level of digital literacy of older workers remains relatively low compared to younger workers in most European countries as well as in Russia (European Commission 2023; NAFI 2023). The absence of digital skills among older people can hinder their hiring and reduce their employment in the labour market.



Meanwhile, in many countries around the world, 'older workers – get-out' policies have been replaced by policies to 'promote longevity of working activity' (Taylor et al. 2016). In the context of an ageing population, many countries around the world have implemented pension reforms and raised the retirement age. In Russia, such a reform was carried out in 2018 (2019). This increased the duration of employment of the elderly population in the labour market.

Two simultaneous processes, the growing digitalization of enterprises and the increasing share of older workers with relatively low levels of digital literacy in the labour market, may reduce their


hiring and increase their firing. They can reduce the income level of this group and increase inequality and social tensions in society. However, whether the implementation of digital technologies at the firm level has an impact on the hiring and firing of elderly workers remains under-researched and is the subject of this study.

On the one hand, it has been observed that in the context of an ageing population, enterprises have increased their hiring of older workers (Busch, Fenge, and Ochsén 2021). Following pension reforms, enterprises in Europe have increased hiring and reduced firing of older workers (Dietz and Walwei 2011).

On the other hand, it has been found that while the turnover rate of older workers is relatively low, they have low opportunities to become new employees (Allen 2023). As older people age, their chances of re-employment decrease (Öylü, Motel-Klingebiel, and Kelfve 2024). With a relatively high proportion of older workers in enterprises, employers are not always inclined to hire them (Heywood, Jirjahn, and Tsertsvardze 2010). On-the-job training and seniority rewards increase the proportion of older workers in firms but

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discourage the hiring of new older workers (Daniel and Heywood 2007).

Much research assesses the effects of digitalization at the macro, cross-country, cross-industry or inter-professional levels (Allen 2023). The relevance of this study is to assess the effects of digital technologies at the enterprise level. There are few such studies in the world, and this is the only known study to be conducted in Russia.

We used for the analysis the data from the survey of enterprises in Russia for 2021–2022, which is representative for the country (RES 2022). The level of digitalization of enterprises was determined according to the methodology used in the European Union countries (European Commission 2020). The calculations took into account the self-selection of enterprises on the use of an elderly labour force. Women over 51 years of age and men over 56 years of age at the time of the survey of enterprises were classified as older workers.<sup>1</sup> Our methodological contribution lies in the application of IV methods to analyse the impact of digital technologies on the hiring and firing of older workers. Hiring (firing) equations were estimated for all workers and separately for elderly workers, controlling the endogeneity of the regressor ‘level of digitalisation of enterprises’ using ivtobit models. We estimated the impact of the level of digitalization of enterprises on the excess of firing over hiring using probit models with the endogenous regressor (ivprobit).

Currently, there are relatively few studies from transition economies on the impact of digitalization on the employment of older workers (Křížková, Pospíšilová, and Dudová 2024). This study fills this gap by focusing on the implications of digitalization for older workers in Russia. The case of Russia has similarities and differences with other European countries (Cirillo et al., 2022) and is of interest for a number of reasons.

Firstly, Russia, like many European countries, is facing the challenge of a relatively growing share of an ageing population. Unlike many European countries, Russia has a relatively low level of unemployment among the elderly population, despite the general shortage of labour force. Pre-retirement workers with higher education and women of retirement

age have, on average, higher employment chances than workers aged 25–64 (Agranovich 2019).

Secondly, Russia has a relatively high index of digitalization of the economic and social sectors. In 2020, Russia was among the top three transition economies in terms of the level of digitalization of enterprises, and the share of enterprises with a high level of digitalization in Russia was higher than in some European countries (e.g. France) (Fig. A.1).

Thirdly, Russia has a relatively cheap labour force compared to developed countries. Furthermore, Russia exhibits an atypical wage profile. Economic literature has a stylized notion that wages increase with age, albeit at a declining rate. This pattern is not observed in Russia: earnings peak early and then decline rapidly. By the time workers reach pre-retirement age, they are already on a downward earnings trajectory. The labour substitution effect of labour-saving digital technologies is most likely in countries with high labour costs (Bachmann et al. 2024). At the same time, it is less likely in countries with a relatively cheap labour force, which includes Russia. As a result, enterprises in Russia may be more willing to hire older workers and less likely to fire them.

By incorporating these specific factors, this study is unique and enables us to expand our scientific understanding of the impact of digital technologies on the hiring and firing of workers, particularly older individuals.

The results of this work are presented in five sections. Section II provides a literature review of the study topic. Section III describes the data and variables and outlines the methodology of the analysis. Section IV presents the results describing the hiring (firing) of all workers and elderly workers in enterprises with different levels of digitalization and interprets them. Section V discusses the main findings and makes recommendations for economic policy and future studies.

## II. Literature review

The implementation of digital technologies at the company level can lead to reductions in

<sup>1</sup>According to the pension reform in the Russian Federation, the retirement age is being raised gradually. It will reach its maximum in 2028, amounting to 65 years for men and 60 years for women.

employment and increased worker dismissals, as machines can replace workers when performing certain tasks (Acemoglu and Restrepo 2022; Bessen et al. 2025). However, digital technologies can also stimulate employment by generating economies of scale. By boosting business activity and increasing the demand for labour, they have the potential to increase hiring and reduce firing rates (Gregory, Salomons, and Zierahn 2022).

By reducing the share of routine tasks, digital technologies increase job polarization (Guidetti and Leoncini 2023; Martins-Neto et al. 2024). As a result of digitalization, there is an increasing demand for new good matches between digital jobs and employees. At the enterprise level, this can manifest itself in increasing labour turnover (hiring and firing).

Companies can select workers based on their ability to adapt to change (Allen 2023), including by testing the digital adaptability of both young and older workers. On the one hand, there is no evidence that the productivity of older workers is lower than that of their young counterparts (Börsch-Supan, Hunkler, and Weiss 2021). On the other hand, automation and robots, as distinct forms of digitalization, can increase the productivity of older workers (Acemoglu and Restrepo 2022). In addition, companies often do not differentiate between young and older workers in their HR policies (Hudomiet et al. 2021; Mekhtiev 2024). When the search for a suitable match for digital jobs includes both young and older workers, companies tend to exhibit relatively high hiring and firing rates in both age groups. It is assumed that, all other things being equal, enterprises with a higher level of digitalization will have higher hiring and firing (labour turnover) than enterprises without digital technologies (with a relatively low level of digitalization) (Hypothesis 1).

There are several reasons why the impact of digital technologies on workers may differ according to their age. Firstly, elderly people tend to have lower levels of digital literacy and poorer information and computer technology (ICT) skills than younger workers (Albinowski and Lewandowski 2024). In most countries – including those with transition economies – older workers tend to have lower levels of digital literacy compared to their younger counterparts. Conversely, in many developed and some

transition countries, companies have a relatively high level of digitalization (Smirnykh 2020; Stojanović, Veličković, and Arsić 2025).

It is thought that some of the parameters of the latest technologies may pose challenges for elderly workers (Allen 2023). As people age, their memory declines, they are more likely to fall ill, and they need more time to cope with stress. As a consequence, the psychophysiological characteristics of an elderly workforce have a negative impact on their productivity. In this regard, businesses implementing digital technologies may consider elderly workers to be less productive (d'Albis 2023). Digital technologies are reshaping existing job tasks and creating entirely new tasks (Autor et al. 2024). Older workers may lack the digital skills that employers require in modern workplaces (Lipowski, Salomons, and Zierahn 2024).

In addition, employers have little incentive to invest in new digital skills for elderly workers, as the period of return on this investment decreases with age (Becker 2009). A negative relationship between training costs and age at hire has been found in US data (Hu 2003). Daniel and Heywood, using UK data, confirmed that long-term training reduces the likelihood of businesses hiring older workers (Daniel and Heywood 2007).

However, other productive characteristics of workers may improve with age. Older workers have more experience and specific human capital than younger workers (Thijssen and Rocco 2010). Business managers believe that workers become more reliable and stable as they age, which reduces transaction costs (Allen 2023).

As recent developments in computer programs have a simplified interface and their use does not require programming skills, they can be handled by older workers (Lee, Kwak, and Song 2022). With higher levels of occupational knowledge combined with information and computer technology (ICT), older workers may be more productive than younger workers (Barth et al. 2023). It is argued that older adults are active agents. They make sense of the digitalizing world and take action to cope with it (Pirhonen et al. 2020). Skills-based hiring can reduce age-related bias in hiring and help older workers retain their employment in the labour market (Butrica and Mudrazija 2022).

With data from South Korea, it was found that well-educated older workers may achieve greater productivity gains through the acquisition of ICT skills and their application compared to younger workers. In addition, new technologies can compensate some of the productivity limitations caused by the ageing process. For example, robots reduce the physical demands of jobs and search engines increase human memory (Allen 2023). There has been evidence that robots and older workers over the age of fifty are more likely to be mutually complementary, and robots and younger workers are more likely to be mutually substitutable (Battisti and Gravina 2021).

In Russia, older workers have a relatively high level of education compared to younger workers (Kolosnizyna and Gerasimenko 2014). In conditions of labour shortage, older workers are in demand in the labour market. The increase in the retirement age in 2018 as a result of the pension reform did not lead to an increase in unemployment among older persons. In 2019, unemployment among persons above working age amounted to 2.4%. In 2022, it decreased to 2.2% (Rosstat 2023). At the same time, the employment of older workers in Russia is normatively protected by the state (Kolosnizyna and Gerasimenko 2014). The Russian Labour Code establishes additional employment guarantees for persons of pre-retirement age. In particular, employers are prohibited from refusing to hire and/or fire persons of pre-retirement age on the grounds that they have reached pre-retirement age (2019).

The second reason for the impact of digital technologies on the hiring (firing) of older workers at the firm level is the size of labour costs (wages). Increasing wages through years of service in the same job make older workers relatively expensive and motivate businesses to hire younger workers to minimize costs (Cirillo, Mina, and Ricci 2022). According to Adams and Heywood, Australian data shows that steep seniority-dependent wage profiles lead to a decrease in the age of hired workers (Adams and Heywood 2007). Thus, enterprises with significant investment in specific human capital and long on-the-job training have, on average, longer worker tenure and a relatively high proportion of older workers but relatively low levels of

their hiring (Heywood, Jirjahn, and Tsertsvardze 2010).

However, researchers have noted that at enterprises that invest in digitalization, employees have shorter employment durations than at enterprises without digitalization (Genz and Schnabel 2021). As a consequence, enterprises with high levels of digitalization have a lower proportion of workers with long tenure. On this basis, it is assumed that enterprises with a high level of digitalization will have a higher level of hiring of older workers than enterprises without digital technologies (with a relatively low level of digitalization) (Hypothesis 2).

A peculiarity of the Russian labour market model is the 'non-standard' age profile of wages. With the start of market reforms in the 1990s, the knowledge and experience accumulated by workers during the Soviet era proved to be unclaimed in the market economy. As workers' human capital accumulations depreciated with age, they approached retirement age on a declining earnings trajectory (Gimpelson 2019; Gimpelson and Zinchenko 2019). In Russia, for almost thirty recent years, the wages of older workers in many occupations have been inferior to those of younger workers. In addition, older workers in Russia often find themselves employed under non-standard conditions (Bobkov 2019) or in the informal sector of the economy (Zudina 2021) with relatively low wages. The relatively low earnings of older workers make them, other things being equal, more attractive to employers, increasing the likelihood of hiring.

The third reason for the differential impact of digital technologies on the hiring (firing) of workers depending on their age is the differences in internal markets of enterprises. Internal markets of enterprises may be open to a greater or lesser extent. When internal markets are closed, workers from the labour market outside the enterprise are hired for low positions, and jobs in higher positions are filled by the internal promotion of workers. In such markets, older workers are often needed by younger workers as mentors to transfer experience and knowledge. In this case, older and younger workers are highly likely to complement each other. If internal labour markets are more open and there is no obvious promotion from low to

high positions, older and younger workers will compete and, rather, substitute each other (Bechichi et al. 2017; Benešová and Tupa 2017). Thus, if the complementation effect of younger and older workers dominates, the hiring and firing of older and younger workers will be in the same direction at enterprises. If the substitution effect dominates, the direction of hiring and firing of younger and older workers will be different.

At digitalized enterprises, internal markets are likely to be more open than at non-digitalized enterprises. It is unlikely that at enterprises with a high level of digitalization, older workers with relatively low levels of digital literacy will find themselves mentoring younger workers. In this regard, it is expected that at enterprises with a high level of digitalization, younger and older workers will complement each other rather than substitute for each other. Supporting this, recent studies on Poland's labour market, which is a transition economy, show that younger and older workers complement rather than replace each other (Broniatowska and Strawiński 2025). In the Russian labour market, younger and older workers often complement each other (Lyashok and Roshchin 2017). It is also noted that the sectoral structure of employment of older workers in Russia is changing in the same directions as in other age groups (Lukyanova and Kapelyushnikov 2019). On this basis, it is assumed that at enterprises with a high level of digitalization, the hiring and firing of older workers and workers of relatively young age groups will, other things being equal occur in the same direction (Hypothesis 3).

### III. Methodology and data

#### Data

The study was carried out on the data of enterprises survey that are representative in Russia and cover the following types of activities: mining, industry, construction, trade, transport and communications, finance, and business services (RES 2022).<sup>2</sup> The peculiarity of the data is that for a significant list of indicators, they contain information for the current (2022) and previous (2021) years. The

sample includes 1206 enterprises. It is dominated by small private Russian enterprises with the number of employees being from 30 to 100 persons (57%), which corresponds to the structure of enterprises in the Russian economy as a whole. The sample excludes sectors such as education and healthcare, which have a relatively high level of digitalization and proportion of older workers. This can lead to an underestimation of both digitalization levels and hiring and firing rates for older workers. We acknowledge and accept these limitations in our analysis.

The group of older workers was considered heterogeneous. It included pre-retirees, who are workers employed by enterprises with no more than five years left before the old-age pension is granted (2023), and retirees, who are workers employed by enterprises who have been granted an old-age pension. In 2022 in Russia, women aged from 51 to 56 and men aged from 56 to 61 were considered to be pre-retirees, and women over 56 and men over 61 were considered to be retirees. Older workers were defined as pre-retirees (women aged from 51 to 56 and men aged from 56 to 61) and retirees (women over 56 and men over 61). In this study, older workers were defined as those of pre-retirement age (women aged 51 to 56 years and men aged 56 to 61 years) and retirees (women over 56 years and men over 61 years).

According to the Federal Service of State Statistics in Russia, in 2022, the average share of older workers in the economy amounted to 6% (Rosstat 2022). In our sample, which covers only the formal off-budget sector of the economy, it was 5.12%. The differences are explained by the fact that the sample of enterprises does not include organizations in the budget sector (education and health care), which traditionally have a relatively high proportion of older workers in Russia.

The level of digitalization of enterprises was determined by taking into account the number of digital technologies used in them, following the methodology of the European Commission in 2020 (European Commission 2020). Four levels of digitalization were identified: very low or zero (0 digital technologies), low (1–3 technologies),

<sup>2</sup>Russian Enterprises Survey (RES). The representativeness of the survey sample is determined by two parameters – type of activity and size of enterprises. The sample includes companies from most of the Russian regions.

medium (4–6 technologies), and high (7 or more technologies). In 2022, the share of enterprises with a high level of digitalization was 29%, and the share of enterprises without any digital technologies was 6% (Table A.1, Appendix).

In 2022, the average hiring rate at the enterprises was 7.36%, and the average firing rate was 7.11%. Since the data on hiring (firing) of workers was obtained at the time of the survey of enterprises, it leads to their annual censoring. As a consequence, the indicators of hiring (firing) of workers based on the data of the survey of enterprises appear to be underestimated in comparison with similar indicators calculated on the basis of monthly measurements of hiring (firing) (for example, on the basis of the data of the Federal Service of State Statistics (Rosstat)). At the same time, the hiring (firing) rates on data that have similar censoring problems (e.g. the data of the Russian Longitudinal Monitoring Survey, RLMS-HSE) are practically the same. According to the RLMS-HSE data, the rate of inflow into employment in 2020 amounted to 6.7% (Gimpelson 2022). According to our data from the survey of enterprises for the same year, it was equal to 7%.

### **Econometric methodology**

The impact of the level of digitalization of enterprises on the hiring (firing) of workers was estimated based on the following equation:

$$h_{ji}(f_{ji}) = \beta_0 + \beta_1 X_{ji} + \beta_2 Y_{ji} + \beta_3 Z_{ji} + e_{ji}. \quad (1)$$

It was assumed that the level of digitalization ( $Y_{ji}$ ) in the equation (3) is the endogenous regressor that when correlated with the error ( $e_{ji}$ ), may lead to bias in the estimates. The instrumental equation was estimated to control the endogeneity:

$$Y_{ji} = \gamma_0 + \gamma' P_{ji} + \delta' Z_{ji} + u_{ji}, \quad (2)$$

where  $i = 1, \dots, N$  the number of enterprises;  $j$  – groups of workers (all workers, pre-retirees, retirees).  $h_{ji}$  – hiring rate,  $f_{ji}$  – firing rate of workers;  $X$  – share of older workers;  $Z$  – vector of enterprise characteristics;  $P$  – vector of instrumental variables;  $\gamma, \delta, \beta$  – are parameters to be assessed;  $e, u$  – is the error term random errors.

Since hiring (firing) did not occur at all enterprises, Equation (1) was estimated using a censored regression with an endogenous regressor (ivtobit). The reason for endogeneity could be the mutual influence effect of the dependent variable ( $h_{ji}(f_{ji})$ ) and the level of digitalisation of enterprises ( $Y_{ji}$ ). It was assumed that not only digitalisation may have an impact on the hiring (firing) of older workers (Hudomiet and Willis 2022), but also an increase of older workers in the labour market due to population ageing may create incentives for enterprises to use digital technologies (Jing and Li, 2024). In addition, factors such as company productivity simultaneously influence both the adoption of digital technologies and the hiring and firing of workers.

The choice of instruments took into account that they should correlate with the level of digitalization of enterprises but not correlate directly with the hiring (firing) of workers and with the error term ( $e_{ji}$ ) in Equation (1) (Wooldridge 2010). It was taken into account that Russia is specifically implementing the Federal Project ‘Demography’ to train and retrain older people in digital technologies. On this basis, training and/or retraining of employees (e.g. in new technologies and software products) and changes in organizational structure were tested as instruments. These instruments were justified on the grounds that while organizational changes and employee training are strongly linked to the adoption of digital technologies, they may not directly affect hiring or firing decisions. Labour turnover (hiring and firing) can also be driven by other external factors – such as fluctuations in demand for products (services) or demographic trends – that are not necessarily connected to the instruments. It was assumed that as the level of digitalization increases, the hiring and firing rates of enterprises may change by different amounts. As a result, there could be an excess of firing over hiring, resulting in a negative balance between the indicators. A binary probit model with an endogenous regressor (ivprobit) was used to estimate the probability of excess of firing over hiring depending on the level of digitalization of enterprises. The reason for endogeneity could be the presence of factors that simultaneously influenced both the endogenous regressor (the level of

digitalization of enterprises) and the dependent variable (the negative balance between hiring and firing). One such factor could be the policy of enterprises to optimize the number of employees by replacing labour with digital technologies in order to ‘survive’ in the competitive environment. The implementation of such a policy could be manifested not only in an increase in the level of digitalization of enterprises but also in the ‘washing out’ (reduced hiring and increased firing) of personnel who have a relatively low level of digital literacy. The policy of headcount optimization could be accompanied by the expansion of service areas through training (retraining) of workers already employed at enterprises, increasing the work intensity through optimization of the organizational structure (instruments).

#### IV. Empirical results and discussion

##### *Digitalization of enterprises and share of older workers in the labour market*

In 2022, Russia’s budget expenditures on the development of the digital economy amounted to 3.4% of the country’s GDP (Abdrakhmanova et al. 2023). At the same time, enterprises differed significantly in terms of the level of digitalization and the number of digital technologies they used (Table A.1, Appendix). At most enterprises (74.3%), more than 20% of employees used mobile devices, high-speed broadband internet was functioning (64.2%) and was used by the majority of employees (64.3%). However, only 25.1% of enterprises had online sales, and 25.2% of enterprises had connections to cloud services.

Enterprises used more digital technologies if they were located in Moscow or St. Petersburg, had a good financial position, had a relatively high technical and technological level and often trained their workers. They had made investments in the previous year and had undergone changes in their organizational structure (Table A.2, Appendix).

In 2022, the employment rate of workers aged 55 + in the Russian labour market was 34% (Rosstat 2022). This figure was lower than in Estonia (45%), the Czech Republic (40%), and Hungary (36%), but higher than in Poland (31%), Serbia (31%), and Romania (24%) (Eurostat 2024).

In 2022, the proportion of enterprises employing pre-retirees was 57%, and 43% of enterprises employed retirees. The average share of pre-retirees and retirees in the workforce of Russian enterprises was 6.30% and 3.94% (Table A.1, Appendix). The largest share of older workers was employed in industry (6.37%) and business services (5.79%).

The increase in the share of older workers at enterprises was favoured by their relatively good financial situation, the presence of trade unions and the older age of top managers. These enterprises were predominantly state-owned, had a relatively low technical and technological level and had a small share of workers with higher education. At the same time, they often provided training for their workers. Such enterprises did not consider the employment protection legislation in Russia to be too strict, and they often concluded fixed-term employment contracts with their workers (Table A.3, Appendix).

This increased the concentration of older workers in digitally enabled enterprises. While the average concentration of older workers at enterprises was 10.11%, it was 11.47% at enterprises with a high level of digitalization. The lowest concentration of older workers was at enterprises that did not apply any digital technologies (8.48%).

##### *Hiring and firing of workers*

Changes in the employment of the enterprises’ workers were due to their hiring and firing. While the average level of hiring of workers was 7.36%, it was lower for pre-retirees and retirees and was about 5%. The average level of firing at enterprises was almost equal to the level of hiring (7.11%). At the same time, older workers were more likely to leave (8%). The highest firing rate was observed among retirees (11.05%) (Table A.1, Appendix). Thus, on average, the enterprises hired older workers less often but fired them more often compared to other age groups of workers.

The enterprises with a high level of digitalization stood out against the general background. These enterprises were more likely to hire workers than enterprises without digitalization. As the level of digitalization at enterprises increased, not only did hiring increase, but also the firing of workers,

including older workers (Table 1; Tables A.4-A.5, Appendix). This could be related to the search for a ‘good’ match between workers and digital jobs. The matching process occurred from two sides – from companies and from employees. Employees understood that the conditions of employment at companies with a high level of digitalization did not suit them, and this could have pushed them to quit or retire. This is supported by the fact that at enterprises with a high level of digitalization, the firing of workers was predominantly voluntary (58%). In non-digitalized enterprises, voluntary firings were almost half as high (23%). At these enterprises, the firing of workers was mainly due to the termination of labour contracts or as a result of staff reductions.

The study’s findings indicate that companies using digital technologies exhibit relatively high hiring and firing rates for both older and younger workers (Table 1; Tables A.4-A.5, Appendix). This suggests that enterprises search for suitable matches for digital jobs among both young and older workers. Such hiring and firing policies are employed by companies in both highly digitalized industries (finance, transport and communication) and industries with relatively low levels of digital technology use (mining, manufacturing, construction, trade, and business services).

As the level of digitalization increased, enterprises hired more workers who had not yet reached retirement age. In firms with a high level of digitalization, an increase in the share of younger workers was associated with a decline in the hiring of older workers (Table A.4, Models 4 and 6, Appendix). With each successive level of digitalization, they fired more workers who had already reached retirement age (Table 1; Table A.5, Appendix). This pattern likely reflects a prioritization of skills that were more commonly found among younger workers and which older workers are less likely to possess.

Enterprises with a high level of digitalization had the highest labour turnover (hiring and firing) of retirement-age workers. This could be due to heterogeneity in the productivity of people of retirement age relative to digital jobs. This finding is consistent with previous research that the digital divide exists not only between generations but also between different socioeconomic groups of older adults (Pirhonen et al. 2020).

The firing of workers was observed more often at small than at medium and large enterprises. Firing of pre-retirees occurred more often at state-owned than at private enterprises. At the same time, the presence of trade unions at enterprises did not provide protection from firing for older workers. Rather, the good financial situation of enterprises and investments in the previous year contributed to the decrease in firing. These enterprises were mainly located in Moscow or St Petersburg. They had a relatively large number of workers with a long tenure (more than 5 years) and with higher education. (Table A.5, Appendix). The more workers with more than five years of tenure were employed at the enterprises, the less they hired, but also the less they fired workers, including older workers (Tables A.4-A.5, Appendix).

### **Excess of firing over hiring**

A significant number of enterprises (40%) hired and fired workers at almost the same level, forming a zero balance. There were considerably fewer enterprises where hiring exceeded firing (28%). The share of enterprises at which firing exceeded hiring, forming a negative balance, was 32%. Such enterprises were most common in mining (39%) and business services (37%). The policy of negative balance could be related to the desire of enterprises to optimize the number of personnel through the use of digital technologies. It was implemented by

**Table 1.** Hiring and firing of workers by the enterprise’s digitalization level (ivtobit).

Variables	All workers		Pre-retirement workers		Retirement workers	
	dy/dx	Delta-method Std. err.	dy/dx	Delta-method Std. err.	dy/dx	Delta-method Std. err.
Hiring	15.79***	1.89	12.69***	2.17	6.62***	1.82
Firing	17.07***	1.97	11.46***	2.40	22.14***	3.84

Significance level \* $\leq 10\%$ , \*\* $\leq 5\%$ , \*\*\* $\leq 1\%$ . Marginal effects are calculated at the mean of the dependent variable.  
Source: Author’s calculations.

**Table 2.** Enterprises' digitalization level and the probability of a negative balance between hiring and firing of workers.

Groups of workers	dy/dx	Delta-method Std. err.
All workers	0.47***	0.08
Pre-retirement workers	0.28***	0.07
Retirement workers	0.43***	0.08

Significance Level \* $\leq 10\%$ , \*\* $\leq 5\%$ , \*\*\* $\leq 1\%$ .

Source: Author's calculations.

enterprises more often in relation to working retirees (27%) than to pre-retirees (12%).

The higher the level of enterprises' digitalization, the greater was the probability of an excess of firing over hiring. This pattern was observed for all age groups of workers. With each successive level of digitalization, the probability that firing exceeded hiring was higher for all workers (0.47) than for pre-retirees (0.28) and retirees (0.43) (Table 2; Table A.6, Appendix). The impact of digitalization was directionally the same for workers in all age groups. On this basis, we can conclude that younger and older workers at Russian enterprises complemented each other rather than competed with each other for digital jobs. The finding that an increase in the hiring of young workers in companies with a high level of digitalization leads to a reduction in the firing of older workers further supports this conclusion (Table A.5, Model 3 and Model 5, Appendix). This is consistent with earlier findings that younger and older workers are more likely to complement rather than substitute for each other in the Russian labour market (Lyashok and Roshchin 2017).

A competitive advantage for older workers in digitalized enterprises was their relatively low wages with relatively high professional qualifications. As a result, even with low levels of digital literacy, older workers with relatively low wages are still likely to be employed in digitalized enterprises. However, as the average wage level at a company increases, the likelihood of hiring older workers declines (Table A.4, Appendix).

### V. Concluding implications and future research direction

The presence in the economy of a segment of jobs that do not require digital skills and competencies and are not integrated into the digital space may be a reason for self-selection of older workers with

relatively low levels of digital literacy. However, in addition to the choices made by older workers themselves, the demand for them by businesses also matters. Enterprises can compare the benefits and costs of using younger and older workers, assess the productive and unproductive characteristics of the two groups, and decide whether to substitute or complement them.

How the digitalization of enterprises affects the hiring (firing) of older workers has remained poorly understood until recently. This study fills this gap. It uses data from the survey of enterprises for 2021–2022, which is representative for Russia, for analysis. They contain the necessary list of indicators and are suitable for analysis. Older workers were defined as pre-retirees (women aged from 51 to 56 and men aged from 56 to 61) and retirees (women over 56 and men over 61). Based on the methodology of the European Commission and the information from the questionnaire on the survey of enterprises on the number of digital technologies used by them, four levels of digitalization were identified. The impact of the level of digitalization of enterprises on hiring (firing) and on the probability that firing exceeds hiring was estimated using tobit and probit models with an endogenous regressor (digitalization level of enterprises). Estimations were performed for all workers and separately for workers of retirement and pre-retirement age.

The results of the study showed that the high proportion of workers with a long work tenure (more than 5 years) restrained the hiring of older workers at enterprises. At the same time, the digitalization of enterprises had a positive impact on the hiring of workers. In the Russian labour market, enterprises with a high level of digitalization hired older workers more than enterprises that did not use digital technologies. One explanation is the relatively low wages of older workers with relatively long professional experience.

However, enterprises with high levels of digitalization not only hired more workers but also fired more workers compared to enterprises without digitalization. This was true for all workers as well as for older workers. This higher worker turnover (hiring and firing) at companies likely reflects the search for the best match between employees and digital job requirements.

At the same time, the worker turnover that reached retirement age was the highest. This is probably because the productivity of this group of workers was the most heterogeneous in relation to digital jobs. At the same time, older workers at Russian enterprises are more likely to complement rather than compete directly with younger workers for digital jobs. As the level of digitalization increased, enterprises were more likely to optimize the number of employees, which could manifest itself in an excess of firing over hiring.

As the digitalization of enterprises continues to increase, older workers remain the most vulnerable group in the Russian labour market, who may lose hiring advantages, for example, due to rising wages. However, the wage profile of older workers in Russia remains persistently 'non-standard': earnings of older workers are significantly lower than those of middle-aged and younger workers. Expected future demographic shifts in the Russian labour market – namely, a decline in the youth population and an increase in the number of older workers – will reinforce this 'non-standard' wage profile. In order to maintain employment and strengthen their competitive position in the labour market, older people need to constantly improve their level of digital literacy.

However, given the relatively low returns (wages) to investment in human capital, older workers in Russia have limited incentives to learn digital skills. Consequently, companies are likely to bear the main responsibility for creating the conditions and incentives necessary to train older workers in digital skills. It is recommended that, in parallel with increasing investment in digitalization, enterprises should develop measures to train and integrate older workers into the digital environment. Companies should consider the specific needs of older workers by offering, for example, flexible work schedules for older workers, reducing their physical workload, and increasing access to training opportunities. This will help offset relatively low wages and provide incentives for older workers to learn digital skills. To encourage enterprises to train older workers in digital skills, the government could offer tax breaks, subsidies, and other incentives.

This study is one of the first of its kind and uses data from a relatively short period of time. At the

same time, the results of the study allow the academic community to broaden its understanding of the impact of enterprise digitalization on the hiring and firing of older workers. They can be used to evaluate the consequences of digital technology adoption by enterprises in countries with relatively low wages for older workers. Based on the results of the study, management decisions on personnel management at the enterprise level can be developed, and employment policy with respect to older workers can be improved.

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### Author contributions

CRedit: **Larisa Smirnykh**: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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