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# Population ageing, labour productivity and economic welfare in the European Union

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## ABSTRACT

This paper examines the impact of the ageing dimensions and other economic and social variables on labour productivity and poverty risk within the European Union (EU). Taking into account the sizable dissimilarities among the EU Member States, our research is configured on four specific panels, according to the UNECE/European Commission mapping of EU countries, based on the Active Ageing Index data and methodology for 2018. We have compiled a complex dataset with official data to measure the ageing features, labour market dimensions and poverty, along with other economic and social representative variables, during 1995–2017. The methodological endeavour is critical and analytical, grounded on an extensive quantitative research. Two multi-factorial macro-econometric models are applied in order to evaluate the direct implications of the ageing dimensions and other utter credentials on labour productivity, respectively on poverty levels. Structural equation modelling further entails an integrative examination of the total, indirect and bidirectional connections between the ageing phenomenon, several socio-economic indicators and the labour market performance, with a final impact on poverty. Results show different yet extremely significant labour market and poverty impacts for the ageing representative groups of EU countries, which require specific policy interventions and tailored strategies.

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## 1. Introduction

In the last decades, population ageing has received a special attention from researchers who render global its importance owing to the magnitude of the effects induced

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by this phenomenon on affected economies and especially on the labour markets (Prskawetz et al., 2005), capital markets (Börsch-Supan, 2005), pension systems (Cristea & Mitrică, 2016), health and social security (Cristea et al., 2020; Pânzaru, 2015; Sharpe, 2011).

Due to the major medical breakthroughs, life expectancy has rapidly risen over recent years, triggering a strain on social security systems. In contrast, fertility and birth rates have sharply fallen, the share of young population in the total population and even the absolute numbers are decreasing. Therefore, population ageing is the result of the two demographic forces (birth rate and life expectancy) that simultaneously evolve, but in different directions and intensity, which heightens the old dependency ratio (the percentage of population 65+ to active population, 15-64 years) (Cristea & Mitrică, 2016; Phang, 2011).

The ageing phenomenon is a global one, but its speed and intensity are different from one state to another, for both developed and developing countries. Börsch-Supan (2005) emphasizes that Europe and Japan have a much older population than North America, while Germany, Italy and Spain have more pronounced rhythms of population ageing than France and the United Kingdom (UK). Within the European Union (EU), in 2018, almost 98 million people are aged 65 years and above, which accounts for some 19.2 per cent of the total population, according to the United Nations Economic Commission for Europe (UNECE)/European Commission (2019). As this share is expected to significantly rise over the next decades, ensuring active and healthy ageing becomes crucial to ensure a sustainable economic development. This means different effects on countries and inequalities that need to be managed wisely.

In front of these challenges and opportunities, the general objective of our research is to estimate the impacts of ageing and other economic and social variables on labour productivity (measured through the output per person employed) and poverty levels within the EU. As a new innovation brought by this paper in order to cope with the significant dissimilarities accounted among the EU Member States (MS) in terms of the ageing population, the research endeavour is rendered on four groups of EU MS, as mapped by UNECE/European Commission (2019), based on the Active Ageing Index (AAI).

These four panels of EU countries are clustered according to the untapped potential of older people for active and healthy ageing, as follows: (i) below the EU average score, comprising ten countries, mostly Central and East European (CEE) states; (ii) medium ranks above the EU average, enclosing six MS; (iii) upper medium values over the EU average, with seven MS; (iv) and the highest values, including five developed EU countries.

The research methodology is grounded on: (i) *multifactorial macro-econometric models*, comprising two econometric techniques - robust regression (RREG), and two-stage-least-squares, instrumental variables (2SLS(IV)), applied for each specific panel, in order to assess the direct impacts of ageing credentials and other economic and social factors upon labour productivity and poverty; and (ii) *Structural Equation Modelling (SEM)*, in order to assess overall inter-causalities (direct, indirect, bidirectional and total) among ageing representative indicators and other economic and

social selected variables, with a keen focus on labour productivity and poverty. The analysed period is 1995–2017 (constrained on the low availability of relevant data for longer time series).

The versatility and complexity of the ageing phenomenon were subject to profound and continuous investigations made by researchers, oriented towards the implications on the labour market and poverty levels. However, this paper provides new insights and empirical evidence through an updated integrative approach that captures direct, indirect, bidirectional and total connections/interplay between workforce ageing, labour market performance and poverty, for the four distinctive panels of EU countries, which, to the best of our knowledge, has not been considered in literature.

The paper briefly introduces the amplex of the ageing phenomenon through the impacts upon manifold economic and social dimensions. Then the paper develops a synthesized literature review capturing the diverse strands of thought amended over the years. Subsequently, data/indicators included in the empirical study are detailed, along with the scientific research methods and work hypotheses. The results obtained throughout the methodological strain, jointly with discussions for each panel, follow onward. Concluding remarks and [supplementary data](#) for the econometric models (enclosed in the Appendix) complete the paper in its final sections.

## 2. Literature review

A number of economic and social consequences of population ageing are underlined in the literature, such as the increased need for social services (Hank, 2011), health services (Aiyar & Ebeke, 2016; Cristea et al., 2020; Sharpe, 2011; Taylor, 2006), pensions (Cristea & Mitrică, 2016), drop in labour supply (Maestas et al., 2016), the increase of age retirement (Pânzaru, 2015) and, implicitly, lower unemployment rates of young population (Grzenda, 2019). All of these implications can be summarized in a common denominator linked to the labour market performance.

A major important consequence of ageing, which we will focus on in this study, is the entanglement on labour productivity and poverty, which drew the attention of many researchers. Thus, within a certain perspective, there will be a drag in labour productivity for the businesses where physical attributes of jobs are relevant, due to the decrease of physical attributes with age, “such as physical strength, energy, and dexterity” (Sharpe, 2011, p. 86), as well as flexibility and adaptability (Smith, 1996; Verhaeghen & Salthouse, 1997), along with a significant increase of the share of working aged group (55–64 years) compared to the younger working force, due to the reduction of the birth rate (Kuhn et al., 2018). On the other hand, senior workers embed significant knowledge, cognitive skills and expertise and can benefit from their work experience, gaining managerial abilities with age (Ericsson & Lehmann, 1996; Ilmakunnas et al., 2004; Kuhn et al., 2018; Salthouse, 1984). Therefore, in professions for which these skills are essential, “such as judges, university presidents, top performing individuals” (Lehman, 1953, in Sharpe, 2011, p. 87), it will lead to a higher productivity. On the same thought, Káčerová and Mládek (2012, p. 275) underlined the significance of searching for the “opportunities for further utilization of the capabilities and knowledge of the elderly population”.

Maestas et al. (2016) highlighted that population ageing is responsible for a two-thirds reduction in labour productivity growth, and one-third is driven by the slowdown in labour growth in the United States of America (USA), which will sharpen in the following years.

Aiyar and Ebeke (2016), based on the facts that Europe's population is rapidly ageing, and the proportion of workers above the age of 55 is substantially increasing (especially in Italy, Spain, Ireland, Portugal and Greece), pointed out that the workforce ageing reduces productivity, especially through its negative effect on total factor productivity growth, on average, by 0.2% annually over the next two decades. In order to counteract this unfavourable impact, it is being underlined "the crucial role played by labour market reforms such as increases in active labour market policies on training or increase in the availability of medical inputs" over productivity (Aiyar & Ebeke, 2016, p. 18). At the same time, Kuhn et al. (2018, p. 50) drove into attention the need for policies mixture targeted towards old-age poverty control, jointly with „the capabilities to keep up with the pace of innovation and transformation in the labour market" for the old-age cohorts, and lifelong learning enrolment. The authors appreciated that "targeted efforts to encourage older workers' participation in training and skills updating schemes would benefit an expanding ageing share of the workforce".

Similarly, the unfavourable impacts of ageing upon labour productivity were evidenced for the EU developing countries, such as Bulgaria (Rangelova & Sariiski, 2013) or Poland (Grzenda, 2019). Moreover, Skibiński (2018) showed the presence of age discrimination on the labour market in Poland and Slovakia. Employers are reluctant to hiring individuals aged over 50 years due to the high employment costs, high probability of illness, work absence and pre-retirement protection. The author underlines the importance of human development capital and proper health services and support, as coping strategies for social problems and economic difficulties in a rapidly ageing society. On this thought, Taylor (2006, p. 24) suggested the following recommendations for employers in order to enhance labour market integration of workers aged 55-64 years: "Learning, training and development, flexible working practices and the modernization of work, workplace design and health promotion, changing attitudes within the organization".

Dostie (2011) show a concave age-wage and age-productivity curves, and disparities between wages and labour productivity in Canada for some labour categories, such as older workers with at least an undergraduate diploma. The author (Dostie, 2011) emphasizes that this class of workers has lower productivity than their wages and concluded that productivity fluctuations are still too imprecise to draw clear findings.

Dufek and Minařík (2009, p. 270) pointed out the need for automatic adjustment between the number of young population (that is decreasing, due to the ageing phenomenon) and "the technological progress, the increased level of human capital i.e. the better education of population and the development of skills and knowledge".

In order to promote the favourable impact of healthy and active ageing on labour productivity, Sharpe (2011, pp. 90-91) suggested the following measures: increased health expenditure dedicated to improve the health conditions and active

participation of the population aged 55–64 on the labour market; upward trend in the educational attainment of workers aged 55–64 years, which would lead to better performances, since “more educated workers are better able to adapt to offset any negative effect of aging on productivity”; and flexible working arrangements, which would also meet the needs of some older workers, by creating “opportunities for part-time work, contract work, and telecommuting”.

Further, the literature entails the important interplay between labour productivity growth and poverty alleviation (International Labour Organization [ILO], 2019; Ivanic & Martin, 2018; Majid, 2004; Thath, 2016). It is being underlined that improved employment opportunities and life trajectories of workers, particularly older workers aged 65+, represent successful interventions that lead to increases in outputs per person employed and poverty reduction. At the same time, as innovations become more widely adopted, new challenges and opportunities arise for workers that are turndown on productivity and poverty levels. Environmental factors, such as education and health conditions, are also essential for increased productivity and downsized poverty risk (Cristea et al., 2020).

Consequently, after reviewing the scientific literature, we can attest that the relationship between population ageing, labour productivity and poverty is still open to debate, whereas for the EU the evidence needs to be strengthened with comprehensive assessments and representative inquiries. We summarize that: there are various approaches regarding the economic and social consequences of population ageing, particularly upon the labour market performance; fewer studies have investigated the distinct groups of countries within the EU; the main findings on the interlinkages between the ageing dimensions and labour market outcomes suggested that there are unfavourable consequences on the long term if the skills of the workforce aged 55–64 years would not be correlated with suitable jobs for them; essential predictors to be comprised by policies and strategies for older working group (55–64 years) as recommended by several authors were towards education and lifelong learning, innovation support, higher health expenditures along with supportive health services and poverty reduction.

### 3. Data and methodology

In order to achieve the main purpose of our research endeavour, and as a result of the literature review, we have included the following two major categories of variables in the empirical analysis: ageing relevant credentials; and representative socio-economic variables. These specific indicators are detailed as follows:

- *Ageing specific dimensions*: Old dependency ratio (population 65+ to population 15–64 years, %) (*OD\_65*); Employment rate, 55–64 years aged group or workforce ageing (% of total population) (*ER\_55\_64*);
- *Economic and social representative indicators*: Labour productivity per person employed (% of the EU-28 average) (*LP*); Annual net earnings for „two-earner married couple, with two children” (European Commission, 2019) (Purchasing Power Standard, PPS) (*ANE*); Research and Development (R&D) expenditures (%)

of GDP) (*GERD*); Tertiary education level for the 30-34 age group (% of the population aged 30-34) (*Tert\_ED*); Educational attainment (levels 3-8) (% of the population aged 15-64 years) (*ED*); Health government expenditure (% of GDP) (*HGE*); Hospital services (% of GDP) (*HS*); At-risk-of-poverty rate (% of total population) (*POV*).

Moreover, taking into account the heterogeneity of the EU MS and, particularly, the approach of UNECE/European Commission (2019) for 2018, which clusters the EU countries on four groups, according to the intensity of the ageing phenomenon measured through the levels of the AAI, we have performed the analysis on four distinct panels:

- *1<sup>st</sup> panel* comprises ten countries ranking AAI below the EU average score (namely, Greece, Croatia, Romania, Hungary, Slovenia, Poland, Bulgaria, Slovakia, Italy and Spain);
- *2<sup>nd</sup> panel* encloses six countries with medium values of AAI, up to the EU average (Luxembourg, Malta, Cyprus, Austria, Belgium and France);
- *3<sup>rd</sup> panel* grasps seven EU MS, ranking upper medium values over the EU average (Lithuania, Portugal, Latvia, the Czech Republic, Estonia, Ireland and Germany);
- *4<sup>th</sup> panel* encompasses five developed countries, ranking the highest values over the EU average (Finland, the UK, the Netherlands, Denmark and Sweden).

The dataset covers the 1995–2017 lapse of time, and includes numerous indicators extracted from the official database, relying on their availability - Eurostat (European Commission, 2019). Summary statistics are detailed in Appendix, [Table A1a](#), and unit-root test results are presented in Appendix, [Table A1b](#).

Within the EU, there are significant differences among the EU-28 MS in terms of labour productivity and, moreover, as regards the poverty levels ([Figure 1](#)).

In 2017, the Nordic states (Sweden and Denmark) registered some of the highest levels of labour productivity within the EU, along with France, Austria, Belgium and Ireland ([Figure 1a](#)). On the opposite side, CEE countries, new EU MS, have low labour productivity and the highest levels of poverty ([Figure 1a and 1b](#)). Spain, Italy and Greece also struggle with the same issues.

At the same time, as regards the ageing specific dimensions, it can be noticed that Germany, the UK, Netherlands, Denmark, Sweden and the Baltic States have managed to properly integrate the people aged 55-64 years into the labour market ([Figure 2a](#)). These countries are coping also with increased old dependency ratios, along with Italy, Portugal, Greece, Finland and Bulgaria ([Figure 2b](#)).

Germany and the UK accounted the highest levels of annual net earnings in 2017 (while facing important labour immigration challenges), along with Austria, Netherlands and Sweden ([Figure 3a](#)). As regards the tertiary educational attainment of the population aged between 30-34 years (indicator targeted by Europe 2020 Strategy), the large enrolment is in Sweden, Denmark, Ireland and Baltic countries ([Figure 3b](#)). Health government expenditures (*HGE*), as share of GDP, were at the highest level in 2017 in the UK, France, Denmark, Netherlands, Belgium and Austria,

but also in the Czech Republic (Figure 3c). Moreover, the most considerable public hospital services (*HS*) are assigned to the same countries as in the case of *HGE*, but also Estonia from the CEE group (European Commission, 2019).

In order to provide an adequate comparability across selection, we have used the logarithm procedure to control for the stationarity of the variables (unit root test results are presented in the Appendix, Table A1b). Furthermore, by applying the logarithm procedure, we cope with the various measurement units of the variables used in the empirical analysis (elasticity coefficients).

The research methodology entails two main econometric procedures, respectively: (1) *multifactorial macro-econometric models*, built up on two econometric techniques, namely - robust regression (RREG) and two-stage-least-squares, instrumental variables (2SLS(IV)); and (2) *Structural Equation Modelling (SEM)*, in order to assess the overall interlinkages (inter-causality) (direct, indirect, bidirectional and total) among the ageing representative indicators and other economic and social selected indicators on labour productivity and poverty.

The basic configuration of the *multifactorial macro-econometric models* is presented in Equations (1) and (2).

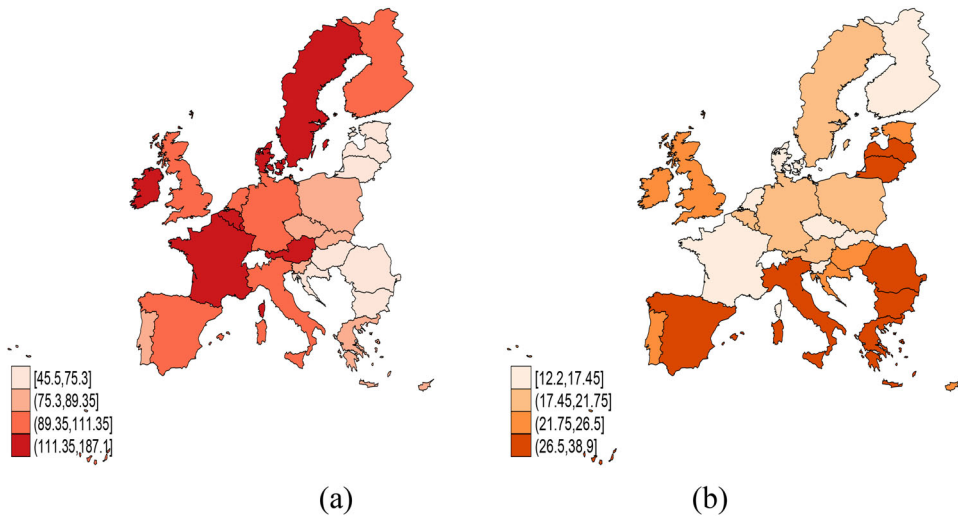
$$\log LP_{it} = \alpha_0 + \alpha_1 ER_{564_{it}} + \alpha_2 \log_H GE_{it} + \alpha_3 \log_H S_{it} + \alpha_4 \log_A NE_{it} + \alpha_5 \log_E D_{it} + \alpha_6 \log_{Tert} ED_{it} + \alpha_7 \log_{GER} D_{it} + \alpha_8 \log_{OD65_{it}} + \varepsilon_{it} \quad (1)$$

$$\log POV_{it} = \alpha_0 + \alpha_1 LP_{it} + \alpha_2 ER_{564_{it}} + \alpha_3 \log_H GE_{it} + \alpha_4 \log_H S_{it} + \alpha_5 \log_A NE_{it} + \alpha_6 \log_E D_{it} + \alpha_7 \log_{Tert} ED_{it} + \alpha_8 \log_{GER} D_{it} + \alpha_9 \log_{OD65_{it}} + \varepsilon_{it} \quad (2)$$

where: labour productivity (*LP*) and poverty (*POV*) are the dependent variables, placed under the influence of numerous credentials previously detailed,  $\alpha$  encompasses the coefficients, and  $\varepsilon$  is the error term.

By summarizing the theoretical groundings and own motivation for selecting the explanatory variables of the designed macroeconometric models, we highlight that: *ER\_55\_64* captures the proper insertion and active participation of people aged 55-64 years on the labour market. *HGE* and *HS* grasp the healthy ageing side, namely the public financial allocations dedicated to improve health conditions and hospital services that support a lifetime care system essential for workers' wellbeing (Sharpe, 2011). Increased productivity leads to higher wages, but, at the same time, higher wages act as an incentive for workers to become more productive, hence *ANE* is introduced as explanatory variable in the logic of "efficiency wages" (Fisman & Luca, 2018), namely paying wages that are above the market rate in order to motivate employees and spur productivity. *ED* and *Tert\_ED* entail the role played by education, particularly higher education, in shaping an active and healthy life style, acquiring new skills and knowledge throughout the lifetime and increasing productivity (Dostie, 2011; Sharpe, 2011). *GERD* accounts for the crucial role played by research and development in finding new medical breakthroughs, workplace innovations and other key credentials that lead to output increases (Dufek & Minařík, 2009). Ultimately, *OD\_65* captures the ageing population features through the





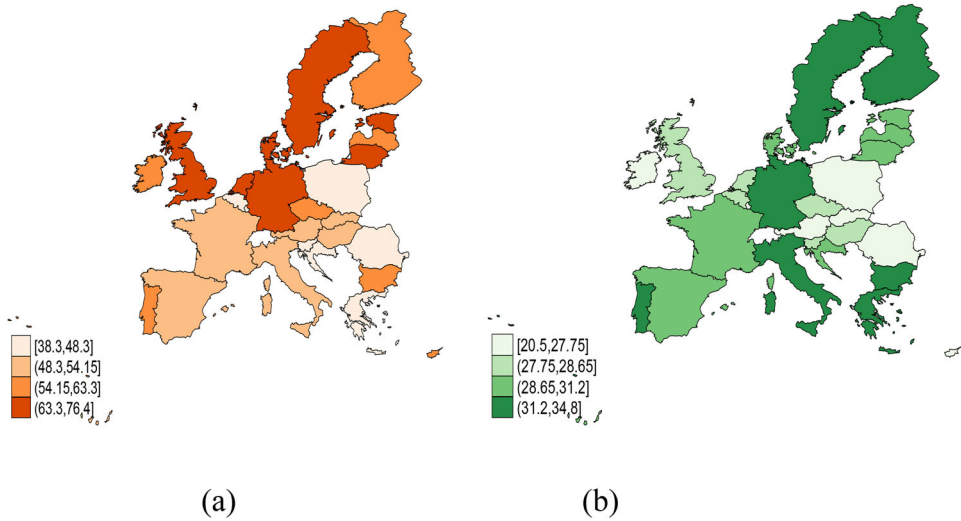
**Figure 1.** Labour productivity and poverty, in the EU-28, 2017: a – LP; b – POV.  
 Source: authors' processing in Stata based on data provided by the European Commission (2019)

number of retired persons (above 65 years, old age) that a potential worker (aged 15 to 64 years) has to sustain.

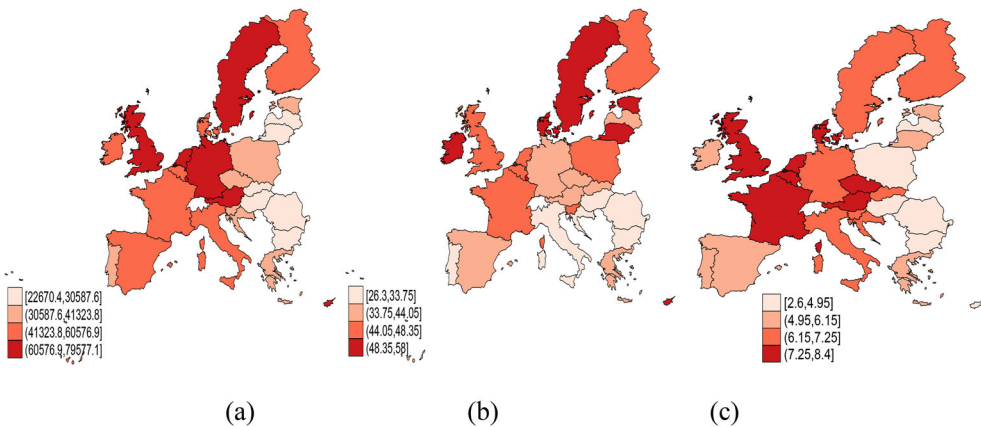
In order to ensure robustness and accuracy of the estimations, to avoid spurious regressions and overcome the limitations of traditional methods, we went beyond the classical widely used Ordinary Least Squares (OLS) method, to enhance robust regression (RREG), along with the two-stage-least-squares, instrumental variables (2SLS(IV)) methods. The estimation methods are also selected to avoid that larger economies (e.g. Germany, France) drive the entire panel and affect the results. Hence, we have firstly applied robust regression, which weights each observation differently, rather than treating them equally as in the case of an OLS regression. Based on Cook's distance, the iteration process in robust regression relies on Huber and biweights to get the final efficient estimates. Further, we've applied the 2SLS technique, since we have also processed Structural Equation Models (SEM) to get the path coefficients in our endeavour, anchored to assess the interlinkages between ageing, labour productivity and poverty, mediated through various economic and social credentials. Thus, we have a double check of the empirical results since two-stage least squares regression is an alternative technique in SEM modelling. In addition, SEM allowed us to evaluate a complex model, comprising a multitude of variables and relationships, including bidirectional connections, and to test its compatibility with the data in its entirety.

The general configuration of SEM is reflected in Equation (3).

$$\begin{cases} b_{11}y_{2t} + \dots + b_{1m}y_{mt} + c_{11}x_{1t} + \dots + c_{1n}x_{nt} = \varepsilon_{1t} \\ b_{21}y_{2t} + \dots + b_{2m}y_{mt} + c_{21}x_{1t} + \dots + c_{2n}x_{nt} = \varepsilon_{2t} \\ \dots\dots\dots \\ b_{m1}y_{2t} + \dots + b_{mm}y_{mt} + c_{m1}x_{nt} + \dots + c_{mn}x_{nt} = \varepsilon_{mt} \end{cases} \quad (3)$$



**Figure 2.** The ageing specific dimensions, in the EU-28, 2017: a – *ER\_55\_64*; b – *Old\_dep\_65*.  
 Source: authors' processing in Stata based on data provided by European Commission (2019)



**Figure 3.** The economic and social representative indicators, in the EU-28, 2017: a – *ANE*; b – *Tert\_ED*; c – *HGE*.  
 Source: authors' processing in Stata based on data provided by European Commission (2019)

where: “ $t$  is the number of observed time periods,  $b_{ij}$  represents the  $y_{ij}$  endogenous variable's parameters,  $c_{ij}$  are the  $x_{ij}$  exogenous variable's parameters,  $i = 1, \dots, m$ ,  $j = 1, \dots, n$ ;  $\varepsilon$  comprises the error term (residuals)” (Cristea & Noja, 2019, p. 115).

In the case of structural equation model designed (Figure 4), we have accounted for the direct implications of the following factors on labour productivity (*LP*): ageing workers (55-64 years, *ER\_55\_64*), under the cumulative influences of health government expenditure (*HGE*), hospital services (*HS*), earnings (*ANE*), educational attainment (levels 3-8 for 15-64 years) (*ED*), tertiary education for 30-34 years (*Tert\_ED*) and R&D implications (*GERD*); but also the impact of the old dependency ratio (*OD\_65*). We have placed a correlation in the SEM models between the old dependency ratio (*OD\_65*) with public health expenditure (*HGE*) and hospital services (*HS*),

entailed through the bidirectional (curved) paths, under the assumption that the number of retired people that a potential worker has to sustain is strongly related to the long-term care services and health support provided for the population, that significantly increases the life expectancy, with additional pressures on the sustainability of the social welfare systems and labour productivity. Ultimately, we have appraised the jointly impact of all considered variables on poverty reduction.

Grounded on the literature review and tightly connected with our methodological approach, we set out to assess the following hypotheses (*H*):

- H1: There are significant direct implications of ageing dimensions and other social and economic variables upon labour productivity (H1a), respectively poverty (H1b), with tangible disparities across the four groups of EU MS;
- H2: There are overall (direct indirect, bidirectional and total) significant implications of ageing dimensions jointly with relevant economic and social factors upon labour productivity (H2a), with cumulative cascade effects on poverty (H2b).

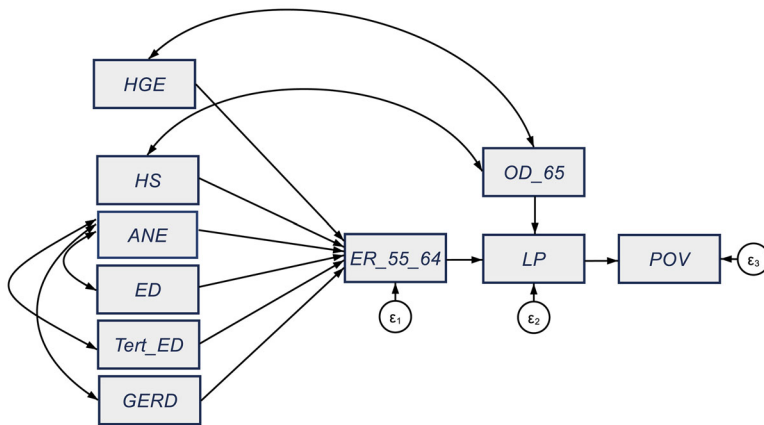
## 4. Results and discussions

### 4.1. Results of multifactorial macro-econometric models

As regards the first research hypothesis drawn, it can be stated that the direct impact of the selected explanatory variables on the variation of labour productivity ( $H_{1a}$ ) and poverty ( $H_{1b}$ ) is very important, these variables being jointly significant in influencing both labour productivity (Table 1) and poverty (Table 2) (as attested by the determination coefficient,  $R^2$ , for all panels). Moreover, the estimations resulted after applying the two econometric techniques for each panel (RREG, (1), and 2SLS(IV), (2)) are consistent in sign and relatively close as size (Tables 1 and 2), being robust across selection.

The results (Table 1) enhance relevant differences between the four groups of EU countries. Thus, in the case of the 1<sup>st</sup> panel, comprising ten countries ranking AAI below the EU average score (mostly CEE countries alongside with Greece), positive effects on labour productivity (highly significant from a statistical point of view) are accounted by: (i) annual net earnings (*ANE*) increases, motivating the working force to achieve a higher productivity (output per person employed) (Fisman & Luca, 2018); (ii) tertiary education of the population aged 30-34 years (*Tert\_ED*), since highly educated people tend to be more productive, by transferring their knowledge in the labour market outputs (Sharpe, 2011); (iii) also, health government expenditure (*HGE*), healthy people also being more productive (as highlighted by Sharpe, 2011).

On the contrary, unfavourable influences on labour productivity for the 1<sup>st</sup> panel were registered for the following variables: (i) educational attainment 15-64 years-aged (*ED*); hence, these countries should pay a greater attention to this factor, as one of the Europe 2020 targets, in terms of a better correlation of the competences achieved by people through the education curricula with the labour market needs and applying “the matching model” proposed by Pissarides (2010, p. 407): “a process whereby both workers and firms search for each other and jointly either accept or reject the match seemed to be closer to reality”; (ii) old dependency ratio (*OD\_65*), explained by a decrease in the number of working population (15-64 years) in favour of the people



**Figure 4.** SEM model constructed to assess the impact of ageing and social and economic representative indicators on labour productivity and poverty.  
Source: own process.

aged 65+ years, which can be counterbalanced by technological progress, achieved by leveraging the R&D financing; and public hospital services (*HS*) that implies a reconsideration of these services.

In the case of 2<sup>nd</sup> and 3<sup>rd</sup> panels, enclosing countries with medium (six countries from the EU-15 developed ones), respectively upper medium values (seven countries from the EU-15 and Baltic States) of the AAI, above the EU average, the analysis reveal that a positive and statistically significant impact on labour productivity has been registered through the increased tertiary education for the 30-34 age group (*Tert\_ED*) and R&D allocation (*GERD*), as other authors have proved (Börsch-Supan, 2005; Hank, 2011; Lopez-Rodriguez & Martinez-Lopez, 2017; Prskawetz et al., 2008). In the case of countries with better results as regards active ageing measuring (3<sup>rd</sup> panel), also the increases in annual net earnings (*ANE*) have spurred the working force to attain a higher productivity (Fisman & Luca, 2018), still inducing opposite impacts for the 2<sup>nd</sup> panel of countries. On the contrary, for both panels (2<sup>nd</sup> and 3<sup>rd</sup>), *OD\_65* has induced a downturn in the labour output per person employed, which reveal an unfavourable impact of the ageing phenomenon upon labour market outcomes and economic welfare. Also, public hospital services (*HS*) and educational attainment (*ED*) (statistically significant for the 3<sup>rd</sup> panel,  $p < 0.01$ ) had a negative impact on *LP*, being similar with the results obtained in the case of the 1<sup>st</sup> panel. Moreover, unfavourable influences on labour productivity in the 2<sup>nd</sup> panel (medium ranks according to AAI) were registered by the working ageing (*ER\_55\_64*), meaning that even if an increased number of persons from the cohort 55-64 years were inserted on the labour market, they could not achieve a higher productivity, possibly due to garnered experience during their active life, depreciation of knowledge and comprehension, and also due to manifold tendencies in mental and physical performance (Disney, 1996; Dixon, 2003). The results are similar to those obtained by Aiyar and Ebeke (2016), which proved that ageing has a significant negative impact on labour productivity.

**Table 1.** Results of the models processed to assess the direct impacts of ageing upon labour productivity, four groups of EU countries, 1995-2017.

Variables	1 <sup>st</sup> Panel		2 <sup>nd</sup> Panel	
	(1) <i>log_LP RREG</i>	(2) <i>log_LP 2SLS(IV)</i>	(1) <i>log_LP RREG</i>	(2) <i>log_LP 2SLS(IV)</i>
<i>log_ER_55_64</i>	0.00450 (0.0475)	-0.0120 (0.122)	-0.235** (0.0722)	-0.210*** (0.0582)
<i>log_HGE</i>	0.485*** (0.0535)	0.874*** (0.139)	-0.165 (0.0835)	-0.152** (0.0542)
<i>log_HS</i>	-0.309*** (0.0437)	-0.158 (0.0985)	-0.100*** (0.0125)	-0.103*** (0.00823)
<i>log_ANE</i>	0.595*** (0.0193)	0.109 (0.0778)	-0.172** (0.0523)	-0.162*** (0.0340)
<i>log_ED</i>	-1.084*** (0.0758)	-1.537*** (0.141)	-0.0884 (0.0864)	-0.103 (0.0564)
<i>log_Tert_ED</i>	0.138*** (0.0288)	0.316*** (0.0752)	0.187*** (0.0355)	0.176*** (0.0271)
<i>log_GERD</i>	-0.0117 (0.0221)	0.0709 (0.0563)	0.394*** (0.0565)	0.392*** (0.0320)
<i>log_OD_65</i>	-0.772*** (0.0565)	-0.792*** (0.111)	-0.508*** (0.131)	-0.513*** (0.112)
_cons	4.392*** (0.496)	9.970*** (1.234)	9.027*** (0.770)	8.922*** (0.554)
<i>N</i>	98	99	68	68
<i>R</i> <sup>2</sup>	0.977	0.835	0.944	0.956
Variables	3 <sup>rd</sup> Panel		4 <sup>th</sup> Panel	
	(1) <i>log_LP RREG</i>	(2) <i>log_LP 2SLS(IV)</i>	(1) <i>log_LP RREG</i>	(2) <i>log_LP 2SLS(IV)</i>
<i>log_ER_55_64</i>	0.0378 (0.193)	0.131 (0.141)	0.0451 (0.0363)	0.0114 (0.0351)
<i>log_HGE</i>	-0.00600 (0.104)	0.0636 (0.116)	-0.0105 (0.0430)	-0.0339 (0.0422)
<i>log_HS</i>	-0.355*** (0.0906)	-0.410*** (0.0978)	-0.0650*** (0.0135)	-0.0712*** (0.0167)
<i>log_ANE</i>	0.0515* (0.0233)	0.0533* (0.0242)	0.00787 (0.0392)	0.0860 (0.0505)
<i>log_ED</i>	-0.261*** (0.0562)	-0.288*** (0.0519)	-0.757*** (0.0815)	-0.618*** (0.0989)
<i>log_Tert_ED</i>	0.163*** (0.0466)	0.164*** (0.0327)	-0.0212 (0.0398)	-0.00718 (0.0376)
<i>log_GERD</i>	0.456*** (0.0503)	0.438*** (0.0580)	0.0643* (0.0256)	0.0880** (0.0271)
<i>log_OD_65</i>	-0.694*** (0.0827)	-0.724*** (0.0758)	0.0518 (0.0729)	0.0141 (0.0681)
_cons	6.777*** (0.910)	6.532*** (0.827)	7.665*** (0.497)	6.452*** (0.649)
<i>N</i>	77	77	55	55
<i>R</i> <sup>2</sup>	0.864	0.876	0.896	0.815

Standard errors in parentheses: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Source: own process of panel data in Stata.

For the 4<sup>th</sup> panel, the group of developed countries with the highest ranking values of AAI within the EU (Sweden being placed first in this rank), a significant favourable impact on labour productivity was registered by increased R&D allocation (*GERD*), while unfavourable effects were induced by the educational attainment (*ED*) and public hospital services (*HS*). The ageing variables for this panel, respectively old dependency ratio (*OD\_65*) and employment rate 55-64 years-aged (*ER\_55\_64*), which

**Table 2.** Results of direct impacts of ageing and labour productivity upon poverty, four groups of EU countries, 1995-2017.

Variables	1 <sup>st</sup> Panel		2 <sup>nd</sup> Panel	
	(1) <i>log_POV RREG</i>	(2) <i>log_POV 2SLS(IV)</i>	(1) <i>log_POV RREG</i>	(2) <i>log_POV 2SLS(IV)</i>
<i>log_LP</i>	-0.361*** (0.0822)	-0.300*** (0.0675)	0.287* (0.131)	0.174 (0.124)
<i>log_ER_55_64</i>	-0.191* (0.0883)	-0.235* (0.0947)	-0.0914 (0.0700)	-0.177* (0.0731)
<i>log_HGE</i>	-0.601*** (0.124)	-0.697*** (0.0995)	0.149 (0.0770)	0.0580 (0.0866)
<i>log_HS</i>	0.0871 (0.0852)	0.146 (0.0913)	0.0601** (0.0175)	0.0601*** (0.0175)
<i>log_ANE</i>	0.0395 (0.0243)	0.00693 (0.0304)	0.175** (0.0512)	0.129** (0.0408)
<i>log_ED</i>	0.0745 (0.212)	0.144 (0.145)	0.361*** (0.0781)	0.339*** (0.0853)
<i>log_Tert_ED</i>	-0.202** (0.0736)	-0.217*** (0.0550)	0.00666 (0.0392)	0.0308 (0.0425)
<i>log_GERD</i>	-0.168*** (0.0433)	-0.184*** (0.0335)	-0.553*** (0.0719)	-0.450*** (0.0787)
<i>log_OD_65</i>	0.779*** (0.136)	0.853*** (0.0881)	1.090*** (0.134)	0.866*** (0.148)
_cons	3.984** (1.283)	3.826*** (0.901)	-5.000*** (1.357)	-2.825 (1.506)
<i>N</i>	92	92	68	68
<i>R</i> <sup>2</sup>	0.890	0.883	0.906	0.866

Variables	3 <sup>rd</sup> Panel		4 <sup>th</sup> Panel	
	(1) <i>log_POV RREG</i>	(2) <i>log_POV 2SLS(IV)</i>	(1) <i>log_POV RREG</i>	(2) <i>log_POV 2SLS(IV)</i>
<i>log_LP</i>	0.0696 (0.149)	0.0717 (0.143)	-0.848 (0.437)	-1.050** (0.383)
<i>log_ER_55_64</i>	-0.234 (0.235)	-0.238 (0.178)	-0.0207 (0.142)	-0.0981 (0.153)
<i>log_HGE</i>	-0.247 (0.126)	-0.333** (0.114)	-1.319*** (0.169)	-1.347*** (0.143)
<i>log_HS</i>	-0.247 (0.126)	-0.299* (0.119)	0.511*** (0.0612)	0.503*** (0.0588)
<i>log_ANE</i>	-0.00792 (0.0293)	-0.0173 (0.0194)	0.794*** (0.158)	0.820*** (0.130)
<i>log_ED</i>	-0.302*** (0.0805)	-0.316*** (0.0678)	0.673 (0.418)	0.513 (0.346)
<i>log_Tert_ED</i>	0.346*** (0.0615)	0.282*** (0.0662)	0.294 (0.156)	0.276* (0.140)
<i>log_GERD</i>	-0.299** (0.0893)	-0.301*** (0.0750)	0.395*** (0.107)	0.405*** (0.0820)
<i>log_OD_65</i>	0.312* (0.147)	0.267* (0.120)	-0.406 (0.285)	-0.324 (0.282)
_cons	3.755* (1.471)	4.501*** (1.226)	-2.739 (3.426)	-1.214 (3.070)
<i>N</i>	77	77	55	55
<i>R</i> <sup>2</sup>	0.779	0.791	0.849	0.864

Standard errors in parentheses: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Source: own process of panel data in Stata.

account the highest levels (Figure 2), have positive coefficients, still not significant from a statistical point of view.

As regards the effects of the ageing dimensions and labour productivity on poverty for each of the four considered panels (Table 2), the employment rate 55-64 years-aged

(*ER\_55\_64*) induced a poverty downsizing in countries from the 1<sup>st</sup> and 2<sup>nd</sup> panels, while the old dependency ratio (*OD\_65*) has registered an unfavourable impact for countries from the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> panels. These results underline the need to redesign policies and strategies that will ultimately support the labour market integration and active participation, especially of people from the 55-64 years' cohort. In order to counteract the increases in the old dependency ratio, a solution could be the rise of R&D funds (that have induced favourable significant impacts on poverty alleviation for the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> panels). Increases in R&D expenditure would also compensate labour productivity (with poverty reduction in the case of 1<sup>st</sup> and 4<sup>th</sup> panels) that might be diminished by the ageing phenomenon. Also, public health allocation (*HGE*) has beneficial effects on poverty reduction for the 1<sup>st</sup>, 3<sup>rd</sup> panels and, the highest, for the 4<sup>th</sup> panel.

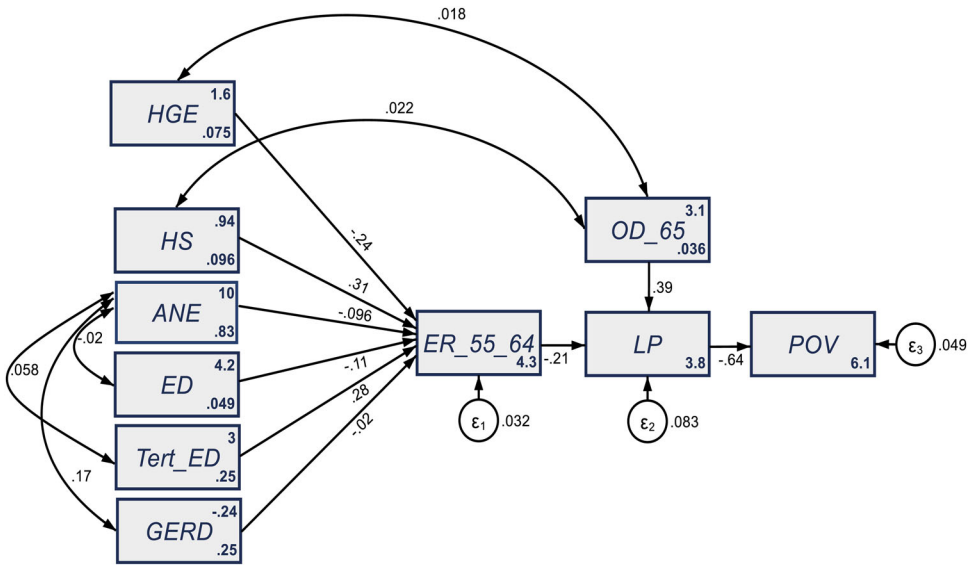
Thus, we can attest that the 1<sup>st</sup> hypothesis,  $H_1$ : *There are significant direct implications of ageing dimensions and other social and economic variables upon labour productivity ( $H_{1a}$ ), respectively poverty ( $H_{1b}$ ), with tangible disparities between the four groups of the EU MS, is fulfilled*, with the mention of different impacts for the EU countries, which require specific strategies and policies for each considered group.

#### 4.2. Results of SEM models

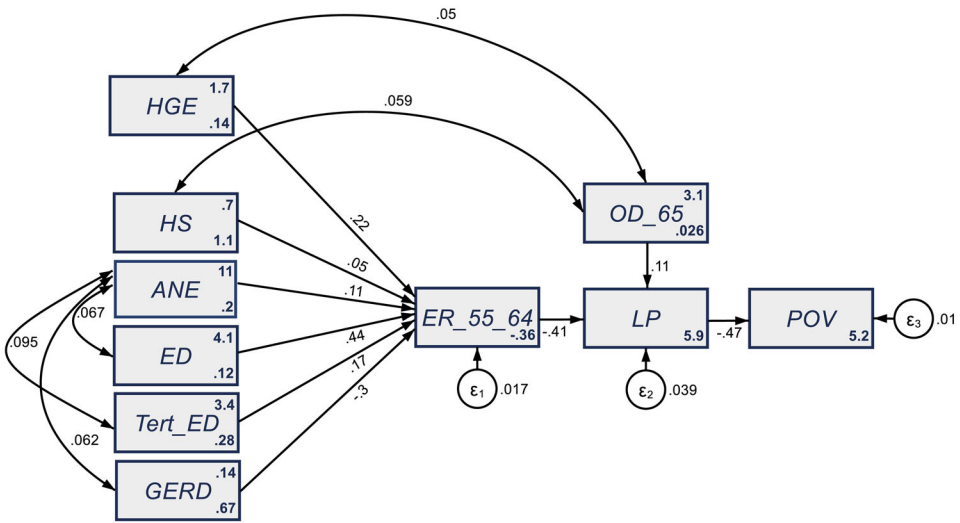
We have further applied the Structural Equation Modelling (SEM) on the four distinct groups of EU MS, to examine the direct, indirect, bidirectional and total inter-causalities and impacts of considered factors on labour productivity, and, further, on poverty risk. SEM models are also processed using the transformed (log) variables through the *Maximum Likelihood Estimator (MLE) method with missing values*, since several variables used to configure the SEM model have missing values. Within an integrative approach, we have established two direct effects of the employment rate of the persons aged 55-64 years (*ER\_55\_64*) and old dependency ratio (*OD\_65*) on labour productivity (*LP*), but also several indirect and bidirectional influences of the jointly significant selected factors, with ultimate cascade impacts on poverty.

In order to validate the SEM results, we have firstly applied a series of specific tests, such as the Wald test for each equation (Appendix, [Table A2](#)), the good-fit tests (Likelihood ratio, Information criteria, Baseline comparison, Size of residuals) (Appendix, [Table A3](#)), and Cronbach's Alpha values for assessing scale reliability (Appendix, [Table A4](#)), which proved the validity and reliability of the SEM models. Overall, the results show that tackling poverty under the direct influences of labour productivity (cumulative effects of all considered variables) is well-marked in the case of the 4<sup>th</sup> panel (a coefficient of -2.1,  $p < 0.001$ ) ([Figure 5\(d\)](#)). Moreover, we have noticed that poverty is diminished for all considered EU panels under the sheer implications of selected factors (statistically significant,  $p < 0.001$ ).

As regards the direct effects of the ageing dimensions upon labour productivity, the results have attested that a proper labour market insertion of the population aged 55-64 years (*ER\_55\_64*), placed under the indirect and bidirectional influence of the other selected factors, induced positive effects upon labour productivity (statistically significant coefficients of 0.74, respectively 0.16) only in the case of well-ranked EU



(a)



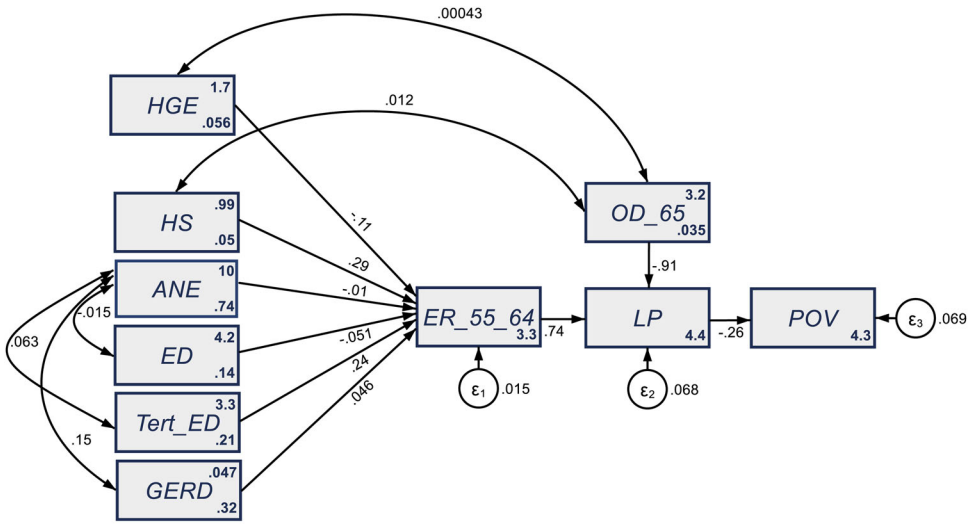
(b)

**Figure 5.** SEM model for ageing and social and economic representative indicators' interlinkages with labour productivity and poverty, at the EU level, 1995-2017, 1<sup>st</sup> panel (a), 2<sup>nd</sup> panel (b), 3<sup>rd</sup> panel (c), 4<sup>th</sup> panel (d).

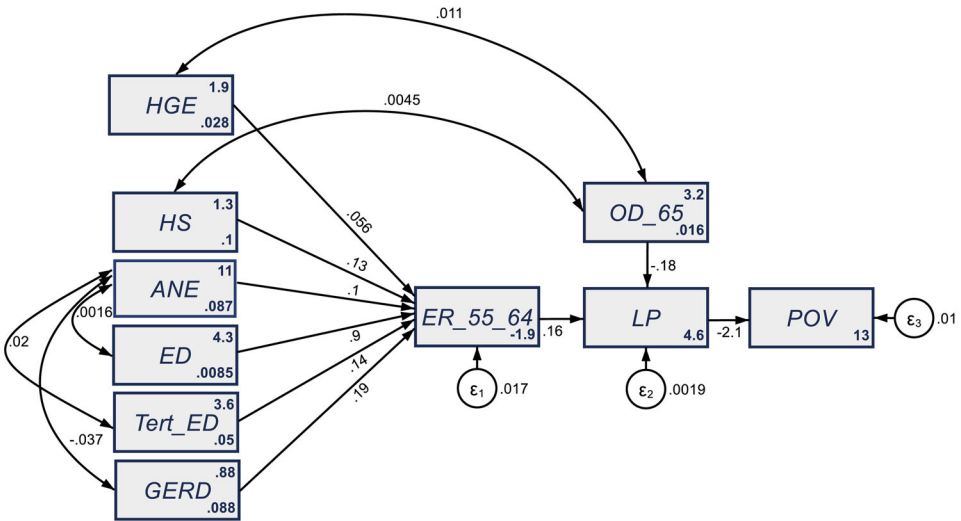
Source: own process in Stata

panels, respectively 3<sup>rd</sup> and 4<sup>th</sup> panels, and negative effects in the case of the 1<sup>st</sup> panel (statistically significant coefficient of -0.21) and the 2<sup>nd</sup> panel (statistically significant coefficient of -0.41). These results are similar with the previous ones, obtained after





(c)



(d)

Figure 5. Continued.

processing the multifactorial models. It can be noticed that, when we have allowed for a correlation between the old dependency ratio ( $OD_{65}$ ) with public health expenditure ( $HGE$ ) and hospital services ( $HS$ ), through the bidirectional (curved) paths, it was registered a further negative impact (statistically significant) on labour productivity, only in the case of the 3<sup>rd</sup> and 4<sup>th</sup> panels, and a favourable one in the case of the 1<sup>st</sup> and 2<sup>nd</sup> panels. The bidirectional paths pointed out that, in all four

panels, there is a positive correlation between the variables connected, namely between the old dependency ratio ( $OD_{65}$ ) and the healthcare system, captured through both health financial allocations ( $HGE$ ) and hospital services ( $HS$ ). In other words, the number of retired people that a potential worker has to sustain is strongly related to the long-term care services and health support provided for the population that significantly increases the life expectancy, with additional pressures on the sustainability of the social welfare systems.

The negative influences upon  $ER_{55\_64}$  were inflicted only in the case of low ranked countries (1<sup>st</sup> panel), by the annual net earnings ( $ANE$ ), (a coefficient of -0.1,  $p < 0.001$ ), suggesting that higher wages do not attract an increased number of people aged 55 to 64 years to actively participate on the labour market, since the earnings levels in these countries are significantly lower and basically act as a disincentive in this regard and rather an incentive for early retirement, putting additional pressures on pension system. Same negative impact is induced on  $ER_{55\_64}$  by public health expenditures ( $HGE$ ) in the case of the 1<sup>st</sup> (a coefficient of -0.24,  $p < 0.05$ ) and 3<sup>rd</sup> (a coefficient of -0.11,  $p < 0.05$ ) panels. For the medium average ranked countries, 2<sup>nd</sup> panel, an unfavourable influence is induced by R&D expenditures ( $GERD$ ).

On the other hand, the beneficial effects on  $ER_{55\_64}$  were generated by  $Tert\_ED$  (a coefficient of 0.28,  $p < 0.001$ ), and hospital services ( $HS$ ), for all considered panels. R&D expenditures have induced favourable impacts on  $ER_{55\_64}$  only for the highest ranked developed countries, 4<sup>th</sup> panel, as Aiyar and Ebeke (2016) also highlighted.

Based on SEM results, we can attest that the 2<sup>nd</sup> hypothesis,  $H_2$ : *There are overall (direct, indirect, bidirectional and total) significant implications of ageing dimensions jointly with relevant economic and social factors upon labour productivity ( $H_{2a}$ ), with cumulative cascade effects on poverty ( $H_{2b}$ ), is fulfilled*, being enhanced well-marked influences for the highest ranked countries (4<sup>th</sup> panel) than for the other groups of EU countries.

## 5. Concluding remarks

This study comes on the background of complexity and highly significance of the ageing phenomenon around the world, with multiple consequences upon economic and social dimensions. It therefore entails an integrative analysis regarding the ageing implications on labour productivity and poverty within the EU-28 MS. For accurate closure, the analysis was made on four specific groups, based on the UNECE/ European Commission (2019) mapping of EU countries, according to the Active Ageing Index (AAI) for 2018, respectively: (i) below the EU average score, comprising ten countries, mostly CEE states; (ii) medium ranks above the EU average, enclosing six MS; (iii) upper medium values over the EU average, with seven MS; and (iv) the highest values of AAI, comprising five developed EU countries. Our research endeavoured enclosed the assessment of two hypotheses, namely: the direct implications of ageing dimensions and other social and economic variables on labour productivity and poverty, respectively, overall (direct indirect, bidirectional and total) impacts of ageing jointly with relevant economic and social factors upon labour productivity, with cumulative cascade effects on poverty. The results have revealed significant

different outcomes for the four groups of EU countries, which require specific policy interventions/incentives designed for each investigated panel.

Therefore, in the case of the highest ranked countries according to the AAI (namely Finland, the UK, Netherlands, Denmark and Sweden) and upper medium ranked countries above the EU average (Lithuania, Portugal, Latvia, the Czech Republic, Estonia, Ireland, Germany), we entail the following measures/policy interventions: a greater consideration of the educational attainment, especially tertiary education, and adequate insertion on the labour market of the highly skilled people, since the knowledge and capabilities of persons aged 55-64 years are essential but need to be updated, especially in the new era of digital transformations; in order to sustain the 55-64 years working group to achieve a higher labour productivity, policy-makers have „to improve job matching for older unemployed people” by a „seniorjob schemes” promoted and supported by specific centers for the older people (OECD, 2015, p. 14), and by orienting their jobs for adequate skills, older people being better managers and administrators, offering more robust judgements and presence; public hospital services’ also significantly contribute to the enhancement of labour productivity while supporting healthy and active ageing.

Relying on the results obtained for the medium ranked countries above the EU average (2<sup>nd</sup> and 3<sup>rd</sup> panels), we recommend the following policy interventions: educational enhancement all levels, as one of the main target of the Europe 2020, and training of older working force (55-64 years) in order to adapt their skills with new digital transformations; a better integration on the labour market of people aged 55-64 years.

In the case of the countries ranked below the EU average of AAI, we recommend the following policy interventions: higher GDP allocations for R&D expenditures and their orientation towards the labour market, since these countries have the lowest contributions devoted to R&D within the EU, on average below the 1% threshold (Romania registered the lowest allocation in the EU), compared with the EU average of 2% of GDP (European Commission, 2019); adjusting the wage for the employment rate of 55-64 years group and higher public health expenditure in order to enhance their proper integration on the labour market.

The ageing phenomenon is influenced by a plethora of factors, in the framework of high complexity and variability of the ageing-labour market synergy, hence, this research does not pretend to have an all-embracing approach of such a topical subject. The main limits of our research consisted in a constrained availability of relevant data for longer time series. Future research directions will centre on the gender dimensions of ageing and the decomposition of the workforce within the EU by age structure.

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No potential conflict of interest was reported by the authors.

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## Appendix

**Table A1a.** Summary statistics, 1995-2017.

Variables	<i>N</i>	<i>mean</i>	<i>sd</i>	<i>min</i>	<i>max</i>
<b>1<sup>st</sup> Panel</b>					
<i>ER_55_64</i>	205	36.76878	8.148439	17.1	58.2
<i>LP</i>	130	76.60769	20.62791	35.7	115
<i>POV</i>	129	30.13411	9.021792	16.3	61.3
<i>ANE</i>	210	39283.51	48632.9	666.42	311052
<i>ED</i>	230	66.62	13.10983	23.2	86.1
<i>Tert_ED</i>	230	23.51217	10.07571	1	46.4
<i>GERD</i>	230	.8767043	.4185414	.024	2.604
<i>HS</i>	181	2.480663	1.038327	0	5.1
<i>OD_65</i>	224	23.81205	4.381963	16.3	34.8
<i>HGE</i>	220	5.380455	1.239837	1.8	7.9
<i>N</i>	230				
<b>2<sup>nd</sup> Panel</b>					
<i>ER_55_64</i>	134	37.19328	9.170271	22.2	56.3
<i>LP</i>	78	118.7577	25.95456	83.8	175.3
<i>POV</i>	85	20.38471	3.054018	15.5	28.9
<i>ANE</i>	128	44626.82	13776.84	1648.52	73077.97
<i>ED</i>	138	60.56812	15.55807	17.1	80.7
<i>Tert_ED</i>	138	32.45	12.58181	1.9	55.9
<i>GERD</i>	138	1.474377	.8431214	0	3.087
<i>HS</i>	126	2.784921	1.381308	.1	4.7
<i>OD_65</i>	138	22.69928	3.568649	16.4	30.8
<i>HGE</i>	138	5.734783	1.85412	2	8.2
<i>N</i>	138				
<b>3<sup>rd</sup> Panel</b>					
<i>ER_55_64</i>	152	50.08882	8.103196	36.1	70.1
<i>LP</i>	91	87.03297	30.79123	51.7	188.2
<i>POV</i>	95	25.35474	6.848136	12.2	46.3
<i>ANE</i>	147	36204.84	39417.34	1339.07	244134
<i>ED</i>	161	70.95342	18.47758	19.3	88
<i>Tert_ED</i>	161	30.6441	12.65055	9.4	58.7
<i>GERD</i>	161	1.221484	.682545	.241	2.939
<i>HS</i>	145	2.827586	.6016739	1.8	4.2
<i>OD_65</i>	161	23.8677	4.35733	15.6	32.5
<i>HGE</i>	161	5.755901	1.27249	2.9	7.9
<i>N</i>	161				
<b>4<sup>th</sup> Panel</b>					
<i>ER_55_64</i>	113	56.50531	10.39972	29	76.4
<i>LP</i>	65	111.4923	5.121471	100.2	119.5
<i>POV</i>	69	18.07971	2.734829	13.9	24.8
<i>ANE</i>	105	47604.91	13178.49	20249.2	90960.5
<i>ED</i>	111	71.10405	6.171187	50.5	81.6
<i>Tert_ED</i>	115	38.13609	8.057275	22.7	51.3
<i>GERD</i>	115	2.524783	.7378509	1.613	3.914
<i>HS</i>	103	3.805825	1.254234	2.1	6.3
<i>OD_65</i>	115	24.98	3.144117	19.3	33.2
<i>HE</i>	115	6.737391	1.088816	4.4	8.9
<i>N</i>	115				

Source: authors' process of panel data in Stata.

**Table A1b.** Unit Root Test – Im-Pesaran-Shin Test/Fisher-type – Dickey Fuller Test (Ho: All panels contain unit roots vs. Ha: Some panels are stationary/At least one panel is stationary).

Variables	1 <sup>st</sup> Panel	2 <sup>nd</sup> Panel	3 <sup>rd</sup> Panel	4 <sup>th</sup> Panel
LP	0.8727	1.0014	0.1783	0.1748
ER_55_64	-1.4222	-2.1584	-2.4613	-1.0658
POV	2.3223*	-1.2674	1.3295**	4.8403***
OD_65	-3.0735	-2.2500	-2.4959	0.6056
HGE	5.4699***	0.3795	-0.1182	-1.0835
HS	3.3399***	-0.0256	1.3311**	1.0821
ANE	6.2553***	1.3348**	1.9860**	3.6454***
ED	20.6851***	-0.7470	-2.0475	0.4755
Tert_ED	0.2956	-1.7969	-2.4027	-0.5507
GERD	3.0185***	-0.3399	-1.2430	1.6929**
Log_LP	1.6815**	1.9415**	-3.5313***	-3.4269***
Log_ER_55_64	1.2388*	0.6581*	-1.7193*	1.2746*
Log_POV	3.3196***	0.0005	13.1826***	0.0000
Log_OD_65	5.2751**	-1.3156*	-2.1572*	-3.8807***
Log_HGE	11.5652***	-2.2084**	0.0573*	-1.2616*
Log_HS	3.5763***	-0.1275*	1.4996**	1.1989*
Log_ANE	11.7574***	12.3496***	9.8736***	11.7148***
Log_ED	29.0017***	0.8824**	1.2310*	1.7884**
Log_Tert_ED	10.5265***	-3.7285***	0.7400*	-3.1935***
Log_GERD	11.2924***	-0.1692*	0.4643*	2.6870***

Source: authors' process of panel data in Stata.

**Table A2.** Wald test for equations associated with the SEM models, 1995-2017.

Variables	1 <sup>st</sup> Panel			2 <sup>nd</sup> Panel			3 <sup>rd</sup> Panel			4 <sup>th</sup> Panel		
	Chi <sup>2</sup>	df	p-value	Chi <sup>2</sup>	df	p-value	Chi <sup>2</sup>	df	p-value	Chi <sup>2</sup>	df	p-value
Log_ER_55_64	141.60	6	0.000	344.82	6	0.000	105.12	6	0.000	158.93	6	0.000
Log_LP	7.33	2	0.025	12.49	2	0.001	32.71	2	0.000	6.07	2	0.048
Log_POV	87.80	1	0.000	78.49	1	0.000	8.46	1	0.003	59.64	1	0.000

H0: All coefficients excluding the intercepts are 0.

We can thus reject the null hypothesis for each equation.

Source: authors' process of panel data in Stata.

**Table A3.** Goodness-of-fit tests for the SEM models, 1995-2017.

	1 <sup>st</sup> Panel	2 <sup>nd</sup> Panel	3 <sup>rd</sup> Panel	4 <sup>th</sup> Panel
Likelihood ratio				
Model vs. saturated chi <sup>2</sup> _ms (15)	371.569	303.885	292.881	213.804
p > chi <sup>2</sup>	0.000	0.000	0.000	0.000
Baseline vs. saturated chi <sup>2</sup> _bs (24)	551.588	535.983	404.969	360.469
p > chi <sup>2</sup>	0.000	0.000	0.000	0.000
Information criteria				
AIC (Akaike's information criterion)	698.401	171.889	520.865	-1181.122
BIC (Bayesian information criterion)	870.304	318.252	674.935	-1043.875
Baseline comparison				
CFI (Comparative fit index)	0.324	0.436	0.271	0.409
TLI (Tucker-Lewis index)	-0.081	0.097	-0.167	0.055
Size of residuals				
CD (Coefficient of determination)	0.502	0.738	0.597	0.650

Source: own research in Stata.

**Table A4.** Cronbach's alpha for the SEM models, 1995-2017.

Items	1 <sup>st</sup> Panel		2 <sup>nd</sup> Panel		3 <sup>rd</sup> Panel		4 <sup>th</sup> Panel	
	Item-test correlation	Alpha	Item-test correlation	Alpha	Item-test correlation	Alpha	Item-test correlation	Alpha
Log_ER_55_64	0.3774	0.7944	0.3618	0.7046	0.3716	0.6357	0.8251	0.6387
Log_LP	0.8853	0.6581	0.5370	0.6565	0.5489	0.5788	-0.0464	0.7571
Log_POV	0.6253	0.7025	0.7475	0.6234	0.6530	0.5556	0.3312	0.7410
Log_ANE	0.6548	0.6829	0.2590	0.7169	0.4265	0.6185	0.2501	0.7561
Log_ED	0.2490	0.7684	0.4233	0.6997	0.4506	0.6144	0.8281	0.6342
Log_Tert_ED	0.5335	0.7257	0.1468	0.7542	0.5115	0.5967	0.7427	0.6523
Log_GERD	0.7247	0.6744	0.9020	0.5484	0.4753	0.6000	0.7285	0.6534
Log_HS	0.6810	0.6986	0.2613	0.7172	0.4556	0.6083	-0.0810	0.7955
Log_OD_65	0.4393	0.7383	0.7933	0.5943	0.3041	0.6445	0.7875	0.6395
Log_HGE	0.8295	0.6426	0.9020	0.5514	0.7197	0.5186	0.7135	0.6612
Total scale		0.7344		0.6895		0.6240		0.7244

Source: own research in Stata.