The Impact of Population Aging and Public Health Support on EU Labor Markets

Mirela Cristea 1*, Gratiela Georgiana Noja 2, Petru Stefea 3 and Adrian Lucian Sala 4

1 Department of Finance, Banking and Economic Analysis, Faculty of Economics and Business Administration, University of Craiova, Center for Banking and Financial Research, 13 A I Cuza Street, 200585 Craiova, Romania
2 Department of Marketing and International Economic Relations, Faculty of Economics and Business Administration, West University of Timisoara, East European Center for Research in Economics and Business, 16 Pestalozzi Street, 300115 Timisoara, Romania; gratiela.noja@e-uvt.ro
3 Department of Management, Faculty of Economics and Business Administration, West University of Timisoara, 16 Pestalozzi Street, 300115 Timisoara, Romania; petru.stefea@e-uvt.ro
4 Doctoral School of Economics, Faculty of Economics and Business Administration, University of Craiova, 13 A I Cuza Street, 200585 Craiova, Romania; sala_lucian@yahoo.com

* Correspondence: mirelas.cristea@gmail.com

Received: 29 October 2019; Accepted: 21 February 2020; Published: 24 February 2020

Abstract: Population aging and public health expenditure mainly dedicated to older dependent persons present major challenges for the European Union (EU) Member States, with profound implications for their economies and labor markets. Sustainable economic development relies on a well-balanced workforce of young and older people. As this balance shifts in favor of older people, productivity tends to suffer, on the one hand, and the older group demands more from health services, on the other hand. These requisites tend to manifest differently within developed and developing EU countries. This research aimed to assess population aging impacts on labor market coordinates (employment rate, labor productivity), in the framework of several health dimensions (namely, health government expenditure, hospital services, healthy life years, perceived health) and other economic and social factors. The analytical approach consisted of applying structural equation models, Gaussian graphical models, and macroeconometric models (robust regression and panel corrected standard errors) to EU panel data for the years 1995–2017. The results show significant dissimilarities between developed and developing EU countries, suggesting the need for specific policies and strategies for the labor market integration of older people, jointly with public health expenditure, with implications for EU labor market performance.

Keywords: older workers; labor productivity; labor market policies; health expenditure; econometric procedures; European Union

1. Introduction

Health systems in developed and developing countries are in the process of adapting to population aging, due to significant increases in life expectancy, along with a downturn in birth rates [1]. Wide-ranging population aging is commonly associated with many consequences, such as increased costs for households, strains on public finances and healthcare providers and decreasing economic growth [2–5]. As demographic structures shift towards an aging population, greater pressure will be placed on the population of working age, particularly those aged between 55 and 64 years [6,7]. In most European Union (EU) Member States (MS), healthcare costs are covered from both private and public sources, while the public ones are financed by contributions collected from the working age population.
Thus, as the share of older recipients of services increases, so will their dependency on the working population, since the number of employed individuals will remain steady or decline. According to forecasts, the old age dependency ratio “has risen to 29.6% in 2016 and is projected to rise further, in particular up to 2050, and eventually reach 51.2% in 2070” [8] (p. 3), leading to decreased social security contributions collected from the population of working age. Thus, population aging applies high pressure on policy-makers, with critical challenges going forward.

In this regard, a series of policies and approaches have been implemented to ease the effects of aging, jointly with public healthcare service enhancement, and also to assure better utilization of existing infrastructure and human capital [9–12]. The EU-28 MS, on an individual basis, have made adjustments to healthcare to curb costs and transfer primary care from hospitals to local community centers, with promising results [8,10]. The focus within EU countries is on healthy and active aging, since the share of the population aged 65 and over within the EU grew from 14.9% in 1996 to 19.2% in 2016, with projections of 29% in 2070 [8]. Based on these projections “Europe will be most affected by population ageing” [13] (p. 7).

When contemplating these challenges, it can be argued that, in the absence of solid and versatile policies, a major restructuring of economic activity in both the public and private sectors might bring the end of the “welfare state” [14]. However, the majority of studies do not seem to support the argument that population aging will cause uncontrollable public sector expenditure [15–17].

Based on these facts, the links between population aging and increases in healthcare costs [18–20], as well as their implications for labor productivity [21–23], have been intensively debated and documented in the scientific literature, but, to the best of our knowledge, comparisons of the EU’s developed and developing countries have not been undertaken.

Based on these underpinnings, the general objective of our paper is to assess the effects of population aging and public health expenditure on labor market performance within the EU-28 MS, with a detailed analysis of the EU-15 (developed countries) and the EU-13 (developing countries) MS. We target four specific research guidelines and associated working hypotheses: respectively, the implications of the employment rate of the population aged 55–64 for labor productivity, the implications of health expenditure on aging coordinates (birth rate and life expectancy) and the health of older people (overall population health perception), as well as the overall (direct, indirect, total) joint implications of health dimensions (namely, health government expenditure, hospital services, healthy life years, perceived health) and aging for labor productivity. Our research is configured to enrich the literature with an updated, complex, and integrative assessment of the interlinkages between the aging phenomenon, health features, and labor productivity, by applying different econometric methods and techniques to ensure robust and accurate results that provide the groundings for our conclusions and policy recommendations. This research complements diverse strands of thought and contributes to increasing awareness concerning the fundamental importance of the aging process, through its multidimensional facets (social, psychological, political, and economic). Furthermore, it identifies the essential mechanisms, policies, and strategies that need to be designed and implemented in a tailored framework within the EU to support active and healthy aging, with benefit spillovers for the wellbeing of older people and the welfare of society as a whole.

We chose to compare these two panels of EU countries (EU-15 and EU-13), since there are specific dissimilarities between them, associated with homogeneous characteristics inside these groups, as regards the aging population (captured by the active aging index—AAI) and economic development relationship, as the UNECE/European Commission [24] has outlined. A comparative analysis within the EU MS between developed (EU-15) and developing (EU-13) countries provides a clearer picture of the tailored specific strategies that can be adopted for each group of countries, and to rethink the approach of covering the healthcare needs of older individuals. The dataset utilized in the analysis covers the period 1995–2017, compiled based on the availability of representative aging indicators, and health- and labor market-specific variables. The methodology applied consists of three advanced econometric procedures: (1) Structural equation modeling (SEM); (2) Gaussian graphical models (GGMs); and (3)
macroeconometric models (robust regression (RREG) and panel-corrected standard errors (PCSE)), each of them on two distinct panels (the EU-13 and the EU-15 groups of countries), to synergistically assess the influences of population aging on labor productivity, shaped by the health coordinates (namely, health government expenditure, hospital services, healthy life years, perceived health).

The rest of the paper is organized as follows. Section 2 elaborates a theoretical framework, where we summarize the most relevant studies on how population aging and healthcare expenditures tend to affect associated labor market outcomes, under digital transformations, associated with strategies and policies advanced by diverse strands of thought. Section 3 describes the data and methodology applied. Section 4 reports the results and provides a discussion of their implications. Section 5 offers final concluding remarks. Additional information and empirical evidence are provided as appendices.

2. Theoretical Framework

The link between healthcare spending and its effects on population aging, in relation to economic growth or labor market outcomes, has received a great deal of attention in the scientific literature, with an emphasis on national and regional policies and strategies employed to address changes in expenditure patterns.

2.1. Health and Aging

Population aging has led to consideration of the potential for increased medical costs and long-term care services for the older segment of the population, and to the imbalance between those of working age and the elderly through shifting dependency ratios. As the elderly dependency ratio increases, it is assumed that individuals will become more dependent on social services, whilst healthcare needs will increase due to conditions that accompany old age [25,26].

Healthcare expenditure at the level of the EU-28 is expected to increase between 2016 and 2070 due to changes in population structure in both the EU-15 and EU-13 MS [17]. Anticipated increases in expenditure will be driven by gains in longevity that lack increases in the quality of health of individuals, causing an increase in demand for healthcare services [18].

Withal, increases in health expectancy can be credited to a great degree to education, where, on average, “people with a low level of education can expect to live six years less than those with a high level of education” [10] (p. 12). These findings are explained by the fact that less educated people are less likely to participate in preventive healthcare, as Bremer et al. [27] found in the case of Germany. Furthermore, gains in life expectancy in EU-28 MS slowed, on average, between 2011 and 2018 by nearly 50% when compared to previous periods, mainly due to slower improvements and medical breakthroughs in terms of the management of diseases of the circulatory system and treatment of conditions associated with the later stages of life [28–30].

Several studies also put together aging and health in conjunction with other demographic factors (such as mortality, birth rate, people mobility), no education (“illiteracy rate”), the residence environment (“urbanization”), and industry sectors (main productive ones) [31] (pp. 6–7). As regards the implications of health and education upon aging, Yang et al. [31], by applying multifactorial econometric models for 2000 and 2010 in China, found favorable impacts induced by education and healthcare conditions on the evolution of the aging pattern, although at a decreasing rate over time.

Forecasts of healthcare expenditure by age group are driven, for the most part, by population aging, and are dependent on two categories of factors: firstly, changes in spending patterns between younger and older generations; and, secondly, the size of the elderly share of the total population. In the first category, governments can intervene to appease conflicts between younger and older cohorts through spending policies [17].

Regarding the link between population aging and increases in healthcare costs, besides age, a series of other factors shape the level of healthcare expenditure within developed and developing nations, as follows [8,10]: the size and age structure of a certain population; quality of life; access to basic hygiene and nutrition; the health of the elderly and elderly share of the total population; the “cost
of dying”; the size of the national economy as seen through gross domestic product (GDP) and the size of GDP per capita; personal choices (alcohol and cigarette consumption); environmental factors (i.e., air quality, electromagnetic pollution); preventive policies through primary care physicians and national awareness programs; new technological breakthroughs that help to cure existing conditions and innovations that optimize costs; the average cost of treatment in private versus public care facilities; the gross yearly cost of staffing hospitals and other healthcare facilities at a national level; the gross yearly cost associated with running and supplying hospitals and other healthcare facilities; and the total amount paid by individuals to public and private health insurance schemes.

2.2. Health, Aging, and Welfare/Labor Market

Aging populations are rapidly transforming economies by shifting demand for both goods and services to other sectors of the economy, due to the changing needs of older cohorts. As regards the effects of aging on labor productivity, it is argued that “ageing may represent a drag on labor productivity growth” [23] (pp. 90–91) due to the following factors: technological achievements that have led to a reduced share of workers involved in “manual labor (blue collar occupations)”, where those aged 55–64 are overrepresented; and reduced cognitive skills of older workers, skills that “are becoming increasingly important in the workplace”. Favorable impacts of aging upon labor productivity could be achieved by [23]: higher health expenditure allocated to support the active participation of the population aged 55–64 in the labor market, which would lead to better health conditions and increased productivity; the increasing trend in educational attainment of the workforce aged 55–64 would lead to better performances, since “more educated workers are better able to adapt to offset any negative effect of ageing on productivity”; and the flexibility of the employers in programming work, with “opportunities for part-time work, contract work, and telecommuting” would meet the needs of some older workers. In order to increase the labor market integration of older workers, Taylor [32] (p. 24) offers four distinctive workplace solutions: “Learning, training and development, flexible working practices and the modernization of work, workplace design and health promotion, changing attitudes within the organization”.

From a different perspective, Bussolo et al. [26] examined health, aging, and macroeconomic effects in Europe and Central Asia and argued that aging would lead to an increase in labor productivity due to the extension of working age as a result of life expectancy rising. When examining how this phenomenon influences policies within the EU-28 MS, it becomes obvious that, as some researchers have pointed out, “gloom and doom” predictions are frequently misplaced, and population aging does not present as heavy a social and economic burden as once considered [19,33,34]. On the contrary, aging populations have favorable impacts on labor productivity, as evidenced in multiple studies [10,20,35–38]. Aging generates increases in the needs of old cohorts that are not as high as originally thought, and older individuals in good health tend to contribute long after retiring by providing compensated and uncompensated labor. Thereby, these findings demonstrate that, particularly in developed countries, older individuals contribute to society and to economic growth even after retirement. Hence, there is a keen need to strengthen the literature with new evidence on how to encompass the health and skills of older people in light of the aging phenomenon, and to support their proper integration in the labor market so as to enhance their labor productivity, with benefit spillovers for sustainable economic development. This study contributes to enlarging the discussion and de-gaps many of these essentials.

Furthermore, older people who have left the workforce continue to contribute through taxation and other forms of income redistribution, helping to sustain public sector expenditures [10]. Moreover, many older people have accumulated assets (real estate, financial assets, deposits) that contribute to welfare/economic growth and help sustain spending patterns, where a significant amount of expenses comes from income sources other than transfers from social security and pension schemes [8,39].

People who exit the labor force after the age of 64 or sooner, or who benefit from transfers from the public sector, are generally defined as “dependent”, with small contributions to society and to economic
growth [34]. However, the choice to continue to work can be made if health permits this, with positive benefits for individuals and society. Opting to continue to work depends also on policies implemented at a national level that encourage individuals to work past retirement age, on the performance of pension systems, on how employers view older workers, on how the productivity of older employees is perceived, and also on the flexibility of working hours in some circumstances [11,40,41]. Healthy older people tend to contribute through direct or indirect channels to welfare by undertaking voluntary work or by offering informal caregiving, “raising the future generations” [42] (p. 15). Thus, the term “silver economy” has been coined when referring to the advantages that an aging population brings to communities [34].

2.3. Implications of the “Digital Era”

A greater emphasis needs to be placed on adopting new technologies and changing approaches with regard to care services offered to the older population, since “both health spending and technological progress are a potential source of better welfare outcomes in terms of longevity” [43] (p. 8). Population aging induces growing costs in healthcare services, due to an increase in the utilization of age-related procedures and treatments that are pushing up costs of long-term care, which are expected to grow at a faster pace than other healthcare needs. In addition, improving datasets on age groups and conditions and integrating them in an easily accessible, secure network will ensure agility in providing services [44].

As a consequence, a myriad of studies put the spotlight on increasing research and development (R&D) in the health field, since healthy individuals are more productive and generate competitiveness [45], raising the standard of living for all [46,47].

Likewise, emerging technologies have helped to extend life expectancy, but without providing a permanent cure for common ailments. Thus, individuals tend to live longer lives, but with acute chronic conditions, adding to healthcare costs [44]. This will most likely be the case in the future, as demand for the adoption of new more expensive technologies becomes keenly requested by cohorts [48,49].

Furthermore, technological innovations entail the need for consideration of the role of active labor market policies (ALMPs), “aimed at reskilling the workers and at making them fit for the coming digital economy as pivotal issues” [50] (p. 9), especially for the older workforce.

2.4. Policies and Strategies

The focus of policy-makers is converging on healthy and active aging, with the aim of increasing the economic contribution of older people in order to help the transition of developed and developing nations to a “silver economy” status or “golden age” [8,26,34,51]. Active aging was put into EU strategy in 2012 [52] by setting its coordinates, together with specific policies for all MS, in an effort to increase opportunities for older people to continue to work and contribute to society in other ways and stay healthy for longer. Based on a literature review, Álvarez-García et al. [53] (p. 4) conclude that “the active ageing concept is currently based on four main pillars: participation, health, security and lifelong learning”. According to the European Commission [9], active aging refers to “helping people stay in charge of their own lives for as long as possible as they age and, where possible, to contribute to the economy and society” or “growing older in good health” [24] (p. 4). With these underpinnings, a composite instrument was framed for the EU-28 MS in order to assess and reveal the “active and healthy life of older people” [24] (p. 5), namely “the Active Ageing Index (AAI)” [54], which was measured for the years 2010, 2012, and 2014. The results revealed profound dissimilarities among developed and developing EU countries [24].

The healthy aging concept was included in the active aging framework [55], and was reinforced by the strategy of the World Health Organization (WHO) [12]. Healthy aging represents “the process of developing and maintaining the functional ability that enables wellbeing in older age”, in order to achieve sustainable development goals (SDGs), aging being “relevant to 15 of the 17 Goals” [12] (p. 4). The WHO’s strategy has five objectives, focused on two actions: “Five years of evidence-based
action to maximize functional ability that reaches every person; and, by 2020, establish evidence and partnerships necessary to support a Decade of Healthy Ageing from 2020 to 2030” [12] (p. 6).

Population aging will require a transformation of healthcare service providers, requiring new approaches to streamline healthcare services and optimize costs. A solution could be to transfer manageable cases from hospitals to local “people-center” care providers in the community [10,56]. These are the long-term guidelines in the EU countries where decreases in hospital capacity have been implemented, along with a reduction in the average number of days when patients are hospitalized.

Increasing the efficiency of healthcare spending within both developed and developing countries represents a top priority, since “up to one-fifth of health spending is wasteful and could be reallocated to better use” [10] (p. 4). The main causes are linked to healthcare professionals administering unnecessary treatments or medical tests, and where the utilization of cheaper treatments would produce the same curative effects as more expensive ones. Thus, reducing unnecessary spending without an effect on the quality of healthcare offered could prove a viable objective for the long-term sustainability of the healthcare system.

In terms of demographic aging, there is a wide gap between developed and developing countries, with different speeds among them [57,58], since developed countries are confronted to a greater extent with increased old dependency ratios (e.g., Italy, Portugal, Greece, Finland, Sweden, and Germany) [30]. Notable differences between developing and developed countries in terms of the implications of aging for health services have been identified by Lloyd-Sherlock [59], who states that, given the complexity and widespread of synergy between aging and health expenditure, less developed countries face a gap as regards the specific policies adopted. Moreover, Lloyd-Sherlock [59] (p. 887) notes that “patterns of ageing and their implications for policy are highly complex and variable”, shaped by each country’s environment (social, political, and economic) and, as a consequence, it would not be relevant to investigate them on a global perspective. Referring to differences between countries with regard to aging and labor productivity, Börsch-Supan [57] (p. 1) stressed that “due to the globalization of our economies, no study of aging can disregard these differential changes”.

For the purpose of optimizing resource utilization, a series of measures have been suggested by the Organisation for Economic Co-operation and Development (OECD) [10]: (1) Guaranteeing a high exchange rate between invested capital and products and services provided, procured and quoted process of pharmaceutical products using the “Health Technology Assessment” framework; (2) increasing possible cumulated funds from generics and biosimilars; (3) raising standards for more targeted prescriptions; and (4) increasing devotion on behalf of patients through awareness programs.

In order to sustain labor markets against a background of population aging the OECD [11] has proposed specific actions for policy-makers, social organizations, and individuals. Policy-makers need to provide incentives for the older workforce to remain in the labor market “by removing penalties to later retirement and providing more flexible work/retirement options”. The social partners need remove age discrimination from the labor market by employers “by promoting good management practices for age-diverse workplaces”, and offer training opportunities for older workers.

Accordingly, after reviewing the scientific literature, we infer that the connection between population aging, health, and labor productivity has been widely explored, being opened to debate, since the EU is highly affected by population aging and needs in-depth and continuous assessments targeted at specific development levels of MS. We summarize that, although there are various approaches as regards the conjunction between aging and health upon productivity, few studies have investigated the distinct groups (i.e., developed and developing) of countries within the EU; aging is increasing healthcare expenditure, there being a direct connection between aging and health; most studies suggest that the impact of aging upon productivity in the long run is unfavorable; healthy older individuals can actually enhance productivity through direct or indirect labor force participation (active and healthy aging); and essential aspects like education and lifelong learning, R&D and innovation expenditure, and active labor market policies, need to be enclosed by policies and strategies.
3. Data and Methodology

Based on the literature review, we included educational components [10] and R&D expenditure [28–30] among the specific variables comprising our models, alongside aging, health, and labor market representative indicators.

The dataset was divided into two panels of EU Member States, the developed EU-15 countries and developing EU-13 MS. The analyzed period covered the years 1995–2017 and encompassed specific variables on aging representative indicators, health measurements, and labor market and other specific socio-economic indicators, as follows (Table A1):

- **Aging representative indicators**: Employment rate, 55–64-year-old group (% of total population) (ER\_55\_64); life expectancy at birth, total population (years) (LE); crude birth rate (number of live births per 1000 people) (BR).
- **Health indicators**: Health government expenditure (% of GDP) (HGE); hospital services (% of GDP) (HS); healthy life years in absolute value at 65—females (years) (HLY\_F); healthy life years in absolute value at 65—males (years) (HLY\_M); share of people (aged 16+) with good or very good perceived health (%) (PGPH), as a targeted indicator of the Sustainable Development Goals (SDG), namely, SDG3 “Good health and wellbeing”, which “has been found to be a good predictor of people’s future health care use” [30].
- **Labor market and other specific indicators**: Labor productivity per person employed and hours worked (%), EU-28 = 100) (LP); active labor market policies (% of GDP) (ALMP); passive labor market policies (% of GDP) (PLMP); annual net earnings (purchasing power standard—PPS) (EARN); tertiary education level, 30–34-year old group (% of the population aged 30–34) (TE\_30\_34); population with secondary, upper, post-secondary, and tertiary education for 15–64-year-old group (levels 3–8) (% of 15–64 years) (EDU); total R&D expenditures (% of GDP) (GERD).

The data were extracted from the European Commission—Directorate-General for Employment, Social Affairs & Inclusion [60] for the active and passive labor market policies, and Eurostat [30] for all other variables.

As regards the aging representative indicators at the level of EU MS in 2017 (Figure 1), we can outline that there are distinctive results for the EU-15 and EU-13 panels, more emphasized for the former. The employment rate of people aged 55–64 years (ER\_55\_64) (Figure 1a) is at its highest levels in the Nordic States (Sweden, Denmark), alongside the United Kingdom (UK), the Netherlands, and Germany from the EU-15 group, but also Estonia and Lithuania from the EU-13 panel. Life expectancy (LE) (Figure 1b) is much higher across the EU-15 countries—namely, Italy, Spain, France, Luxembourg, and Sweden (over 82 years, and increasing)—than the EU-13 developing MS, except for Malta and Cyprus, where it also exceeds 82 years. The highest concentration of population aging is registered in Italy, where, during the period 1995–2017 [30], the birth rate (BR) continuously slowed down (from 9.2 in 1995 to 7.6 in 2017 live births per 1000 people), but also in Spain, Portugal, Finland, and Greece being at the lowest level from the EU-15 (Figure 1c). On the ceaseless decreasing trend of the birth rate, the most prominent values within the EU-28 were registered in 2017 by Ireland (12.9 live births per 1000 people), France, the UK, and Sweden from the EU-15 panel, and the Czech Republic from the EU-13 group.
Health dimensions within the EU-28 in 2017 (Figure 2) reveal the following: The most significant expenditure on health by governments in terms of GDP (HGE) occurs in France, the UK, Denmark, Belgium, the Netherlands, and Austria, but also in the Czech Republic (Figure 2a). The most substantial hospital services (HS) are allocated to the same countries as HGE (slightly less in France) from the EU-15, and Estonia from the EU-13 panel (Figure 2b). The highest proportion of people (aged 16+) with good or very good perceived health (PGPH) (Figure 2c) is in Ireland (over 83%), followed by Italy, Sweden, the UK, and the Netherlands from the EU-15, but also Cyprus and Malta from the EU-13, with over 75% of the population aged 16+. The lowest perceived health from the EU-28 was in Lithuania (43.9%). Age-related expenses for both males and females by age as percentage (%) of GDP per capita tend to increase for individuals aged 50+ at a faster pace, as the aging process progresses for both sexes [17].

As regards the labor market-specific indicators (Figure 3), we can see that in 2017, a higher level of labor productivity (LP) (Figure 3a) was observed in countries with a significant allocation from GDP of active and passive labor market policies (Figure 3b,c). The highest LP in relation to the EU-28 average occurred in Ireland (187.1%), and the lowest was in Bulgaria (45.5%).
For a suitable comparison between EU countries and to manage the stationarity of the indicators, firstly, the dataset was processed through the logarithm procedure. Then, the methodology used consisted of structural equation modeling (SEM), which was applied for the two distinctive panels, EU-13 and EU-15. SEM represents an integrative procedure that appraises overall interlinkages among considered variables, direct, indirect, and total. SEM models are configured through the general system of Equation (1).

\[
\begin{align*}
    b_{11}y_{2t} + \ldots + b_{1m}y_{mt} + c_{11}x_{1t} + \ldots + c_{1n}x_{nt} &= \epsilon_{1t} \\
    b_{21}y_{2t} + \ldots + b_{2m}y_{mt} + c_{21}x_{1t} + \ldots + c_{2n}x_{nt} &= \epsilon_{2t} \\
    \ldots \ldots \\
    b_{mt}y_{mt} + \ldots + b_{mn}y_{nt} + c_{m1}x_{1t} + \ldots + c_{mn}x_{nt} &= \epsilon_{mt}
\end{align*}
\]

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, \( i = 1, \ldots, m \), \( j = 1, \ldots, n \), and \( \epsilon \) comprises the error term (residuals) [61].

For our research endeavor, SEM (Figure 4) was utilized to assess the direct influence of the aging representative and health variables on labor productivity (LP) as follows: The employment rate for the 55–64-year-old group (ER_55_64), on the one hand, and the dimensions of aging population (BR and LE), healthy conditions of people aged 65+ (HLY_F and HLY_M) and population health perception (PGPH), on the other hand.

These influences are appraised under the cumulative effects of two main groups of variables (indirect influences upon labor productivity), firstly, representative factors of labor markets, which can influence the 55–64 years of age working people, such as the earnings obtained on the labor market (EARN), labor market policies, active and passive (ALMP, PLMP), educational component for the 15–64-year-old group (EDU) and tertiary education for 30–34-year-olds (TE_30_34), and R&D expenditure (GERD). The other group of indirect variables comprises health expenditure, namely, health government expenditures (HGE) and hospital services (HS) that can influence the aging dimensions (BR and LE) and people’s health conditions (65+ years, females and males) and perceptions (HLY_F, HLY_M, respectively, PGPH).

In our own research, we have considered and explored the impact that earnings increases can have on labor productivity, since higher wages can spur productivity by acting as an incentive and encouraging employees to engage in productivity enhancing activities [62]. In this frame, the so-called “efficiency wages”, namely wages that are above the market rate, are a key motivation for employees, that provide higher effort levels in response to higher earnings. The employment rate of persons aged 55–64 years was also considered to capture the mechanisms of integration of older people within the labor market.

The research endeavor was also based on several Gaussian graphical models (GGMs) configured through partial correlation (PCOR) and extended Bayesian information criterion (EBIC) with graphical
least absolute shrinkage and selection operator (LASSO). These types of models “with sparsity in the inverse covariance matrix are of significant interest in many modern applications” and “indeed lead to better model selection properties in practical relevant settings” [63] (p. 1). Hence, GGMs allow us to further observe the interconnections between all considered processes/coordinates in light of a network setting.

Based on the literature underpinnings and our own methodological endeavor, we tested the following hypotheses (H):

- **H1**: There are significant implications of the employment rate of the population aged 55–64 for labor productivity, more emphasized for developed countries (EU-15) than developing ones (EU-13);
- **H2**: There are significant implications of health expenditure (health government expenditure and hospital services) upon aging coordinates (birth rate and life expectancy) in both EU-15 and EU-13 panels, more prominent for developed countries (EU-15) than developing ones (EU-13);
- **H3**: There are substantial impacts of health expenditure (health government expenditure and hospital services) upon aging coordinates in both EU-15 and EU-13 panels;
- **H4**: There are overall (direct, indirect, total) significant implications of health dimensions and aging upon labor productivity, both for the EU-15 and EU-13 panels.

In order to reinforce SEM and GGM results, each of the above-stated working hypotheses was tested as well by the use of macroeconometric models (simple and multiple regression models), at the level of each distinctive panel, EU-13 and EU-15, during the 1995–2017 timespan. These models were processed through two estimation procedures, namely, robust regression (RREG), based on Cook’s distance (D), Huber, and biweights iterations, and panel-corrected standard errors (PCSE). Robust regression detaches the outliers or high leverage data points in the sample (hence the influential points are dropped), based on Cook’s distance (Cook’s D) and two types of weights on the iteration process (Huber and biweight weighting). At the same time, PCSE accounts for possible deviations in terms of cross-section contemporaneous correlation, as well as heteroskedasticity, thus providing accurate and robust estimates.

The general configuration of the macroeconometric models, deployed to test each working hypothesis, is presented in Equations (2)–(9):
For H1:
\[ \log LP = \delta + \beta_1 \log ER_{55\_64} + \theta_i + \lambda_t + \epsilon \]  
(2)

For H2 and H3:
\[ \log HLY_F = \delta + \beta_1 \log HGE + \beta_2 \log HS + \theta_i + \lambda_t + \epsilon \]  
(3)
\[ \log HLY_M = \delta + \beta_1 \log HGE + \beta_2 \log HS + \theta_i + \lambda_t + \epsilon \]  
(4)
\[ \log BR = \delta + \beta_1 \log HGE + \beta_2 \log HS + \theta_i + \lambda_t + \epsilon \]  
(5)
\[ \log LE = \delta + \beta_1 \log HGE + \beta_2 \log HS + \theta_i + \lambda_t + \epsilon \]  
(6)
\[ \log PGPH = \delta + \beta_1 \log HGE + \beta_2 \log HS + \theta_i + \lambda_t + \epsilon \]  
(7)

For H4:
\[ \log LP = \delta + \beta_1 \log ER_{55\_64} + \theta_i + \lambda_t + \epsilon \]  
(8)
\[ \log LP = \delta + \beta_1 \log HGE + \beta_2 \log HS + \beta_3 \log HLY_F + \beta_4 \log HLY_M + \beta_5 \log BR + \beta_6 \log LE + \beta_7 \log PGPH + \theta_i + \lambda_t + \epsilon \]  
(9)

where \( \delta \) and \( \beta \) are the parameters that need to be estimated, \( \epsilon \) is a stochastic element, and \( \theta_i \) and \( \lambda_t \) are variables that capture the country and time effects.

4. Results and Discussion

4.1. Results of the Structural Equation Model (SEM)

We applied the SEM technique for each panel of the EU-28 MS, namely, developing countries, new EU-13 MS, and developed countries, old EU-15 (we included the UK, since the analyzed period was 1995–2017, and the final stage of Brexit has yet to take place). The estimations are graphically represented in Figure 5, while the empirical results on total effects of all considered variables are presented in the Appendix A (Table A2). We applied several tests on the SEM models deployed in order to ensure the validity of the results obtained (also detailed in Tables A3–A5).

In the case of the EU-13 panel (Figure 5a), we can observe that LP is unfavorably influenced, on the one hand, by \( ER_{55\_64} \) (a coefficient of \(-0.144\), statistically significant, \( p < 0.01 \)), as also stated by [58] and [23]. These outcomes are under the indirect positive influence of only the educational components \( EDU \) and \( TE_{30\_34} \); both of them are significant from a statistical point of view, \( p < 0.01 \), more for \( EDU \) of people aged 15–64 than tertiary education within the 30–34-years-old group), being negatively affected under the other selected variables. Thus, the highest negative influence is the case of \( ALMP \) (\(-0.11\), significant, \( p < 0.01 \)), followed by \( PLMP \) (\(-0.066\), statistically significant, \( p < 0.05 \)) and \( EARN \) (\(-0.045\), statistically significant, \( p < 0.05 \)). In addition, \( GERD \) also exerts a negative influence on \( ER_{55\_64} \), although it is not statistically significant.

Under the indirect influences of health expenditure, HGE and HS, labor productivity is positively influenced by \( LE \) (a coefficient of 6.4, statistically significant, \( p < 0.001 \)), \( HLY_M \) (a coefficient of 0.27, statistically significant, \( p < 0.05 \)), and \( BR \), although not statistically significant. The other variables, \( HLY_F \) and \( PGPH \), negatively influence the LP within the EU-13 panel (both of them are statistically significant, \( p < 0.001 \)). As regards HGE, the results show that government health expenditure is not enough to ensure healthy conditions for people of both genders aged 65+ in terms of good or very good perceived health. Moreover, HGE does not seem to encourage the birth rate or sustain life expectancy increases (since the coefficients for all these components are negative and statistically significant). At the same time, the most emphasized unfavorable effects of HGE are the health conditions as perceived by the population (PGPH) (a coefficient of 0.23, statistically significant, \( p < 0.001 \)), with overflow implications upon LP. As for HS, the results are opposite to those of HGE, leading to favorable impacts upon all considered variables (positive coefficients and statistically significant), including for the 65+
female health conditions (a coefficient of 0.41, statistically significant, \( p < 0.05 \)), but also life expectancy (LE), being similar to the results obtained by Yang et al. [31] for some regions in China.

In the case of the EU-15 panel (Figure 5b), LP is also unfavorably influenced by ER_55_64, but it is more visible than in the case of the EU-13 panel (a coefficient of \(-0.292\), statistically significant, \( p < 0.001 \)), under the jointly indirect impacts of the selected socio-economic factors. Thereby, positive interplays upon ER_55_64 are also induced by the educational component, tertiary component (TE_30_34), GERD expenditure (both of them are significant from the statistical point of view, \( p < 0.01 \) and ALMP (even though not statistically significant). Opposite, negative impacts on ER_55_64 are induced by increased allocations on passive labor market policies (PLMP) \((-0.182\), statistically significant, \( p < 0.001 \)), EARN \((-0.309\), statistically significant, \( p < 0.01 \)), and EDU (although not statistically significant). Thus, we can say that, our first hypothesis, \( H_1 \): There are significant implications of the employment rate of the population aged 55–64 for labor productivity, more emphasized for developed countries (EU-15) than developing ones (EU-13), was supported.

The reasons for diminished labor productivity associated with the employment of people in the 55–64 year age group may be found in a lack of availability of educational and training opportunities,
a depreciation of psychological and physiological capacities (as Börsch-Supan and Weiss [64] and Feyrer [65]), and the emergence of new technologies that limit employment opportunities. In this vein, as other authors have stated [32], managers need to sustain the aging of the workforce group (55–64-years-old cohort) through offering opportunities for lifelong learning and training, flexible working arrangements, and health assistance. Employers report a range of factors that favor the hiring of older workers [66]. Bersin and Chamorro-Premuzic [67] argue that employers must take action to “give older people titles and roles that let them contribute their expertise”.

In this regard, the need for reconsidered strategies in both groups of countries is justified, since “less productive older workers should not be considered a reason not to promote the increased participation in the labor force of this population” [23] (p. 94).

Furthermore, under the cascade effects of health expenditure, HGE and HS (indirect influences), LP is positively influenced by almost all variables, more visible for LE (a coefficient of 2.252, statistically significant, p < 0.01) and BR (a coefficient of 0.239, statistically significant, p < 0.01). These results are similar to those obtained by Bussolo et al. [26] (p. 113), who argued that “as people live longer they also work until older ages. With slower population growth, it can become easier to increase capital-to-labor ratios and boost worker productivity”. A positive influence on LP, in our case, is also obtained by PGPH (a coefficient of 0.405, statistically significant, p < 0.001) and HLY_F (a coefficient of 0.528, statistically significant, p < 0.001), being in line with Hansen [47] and Gong, Li, and Wang [46], who argued that healthy individuals are more productive, raising the standard of living for all. The only variable that induced negative impacts upon LP under the HGE and HS implications is HLY_M (a coefficient of 0.435, statistically significant, p < 0.01). In this situation, further analysis concerning female and male health conditions is required in order to deepen understanding. Therefore, we can say that our third hypothesis, H3: There are substantial impacts of health expenditure on older people’s health conditions and overall health perceptions, both for the EU-15 and EU-13 panels, was supported.

As regards health expenditure, in contrast to the EU-13 panel, in the case of the EU-15, HGE induced positive effects upon all variables, namely, aging dimensions (BR and LE) and healthy conditions and perception (HLY_F, HLY_M, and PGPH), since the coefficients for all of these components are positive and statistically significant. The most outstanding favorable impacts of HGE are on healthy conditions of women (HLY_F) and birth rate (BR), which are very significant as regards aging support and positive implications for labor market outcomes, since “the average health conditions of an ageing population play a first-order effect in a macroeconomic perspective, and will represent a key factor for economic growth in the 21st century” [22] (p. 2). As for HS, the results are opposite to HGE and those obtained within the EU-13 group, with unfavorable effects upon the aging dimensions, health conditions (both women and men) and people’s health perceptions—PGPH (negative coefficients and statistically significant). Thus, the second hypothesis, H2: There are significant implications of health expenditure upon aging coordinates (birth rate and life expectancy) in both the EU-15 and EU-13 panels, more distinguished for developed countries (EU-15) than developing ones (EU-13), was partially supported.

Ultimately, the fourth hypothesis, H4: There are overall (direct, indirect, total) significant implications of health dimensions and aging upon labor productivity, both for the EU-15 and EU-13 panels, was also supported.

In summary, for the EU-13 countries, labor productivity is highly unfavorably influenced by the “share of people with good or very good perceived health”, a very significant SDG target, as regards the health goal. These results bring to the fore several essentials in the case of the EU-13 MS that those concerned with developing labor market policy must consider following the good practice model of the Nordic states [68,69] and, as stressed by Káčerová and Mládek [3] (p. 275), the importance of looking for “opportunities for further utilization of the capabilities and knowledge of the elderly population”: maintaining the 55–64 age group’s skills formation, with particular regards to digital transformation, to which this cohort of people are less adapted than the younger generation [70–72]; public health expenditure for further increasing birth rates and sustaining life expectancy, since the highest health needs/consumptions are for the elderly, both women and men; and public health expenditure for
increasing the general health condition and perception of people, which would positively influence labor productivity, as argued by Sharpe [23].

For the EU-15 countries, the focus has to be on the following policy interventions: A rethinking of passive labor market policies in order to sustain the 55–65-year-old working group, but also to target increases of active labor market policies for this age cohort; keeping up the R&D expenditure, oriented toward labor skills of the 55–64-year-old working group; reconsideration of EDU for 55–64-year-olds, levels 3–8, oriented towards migrants’ inclusion in educational programs (since, in these countries, there is a large flow of migrants from developing countries) [73], and also to 55–64-year-olds for native working people by reshaping their skills as requirements are transformed by the emergence of new digital technologies [68,74]; oriented hospital services to boost healthy conditions and perceptions of people, and thus, making them confident in the public health expenditure in the case of child birth and care, therefore indirectly sustaining birth rates and life expectancy; further government health expenditure aimed at tackling the population aging phenomenon correlated with increasing long-term healthcare in the case of the elderly; and promoting and supporting preventive health actions among people aged 55–64 and low- and medium-educated people, since these categories are the most distant from health prevention, as Bremer et al. [27] demonstrated. Under these cumulative interventions, labor productivity within developed EU MS will increase, with direct effects on wellbeing and overall economic development [10,20,35–38].

4.2. Results of the Gaussian Graphical Models (GGMs)

On the back of accurate SEM findings, we continued the research endeavor by designing two sets of Gaussian graphical models (GGMs). These new research settings allowed us to observe the intensity and configuration of the interlinkages between all selected variables/indicators for both EU-13 and EU-15 countries, and to reassess our hypotheses. GGMs are deployed based on partial correlation (PCOR) (Figure 6) and extended Bayesian information criteria (EBIC)/least absolute shrinkage and selection operator (LASSO) (Figure A1 in the Appendix A), separately for the EU-13 and EU-15 countries, for the period 1995–2017. Each indicator previously described in Section 3 (Data and Methodology) represents a node in the configured network, connected with the other coordinates/nodes through significant paths, according to the intensity of the interdependencies between them.

The GGMs (Figure 6) allowed us to obtain new insights into the strong relationships between labor productivity (LP) and the share of people with good or very good perceived health (PGPH) in the case of both panels of EU-13 and EU-15 countries, which are further linked with health support, namely, healthy life years in absolute value at 65+ for males (HLY_M) and females (HLY_F) (reconfirmation of H3) and the employment rate of the population aged 55–64 years (ER_55_64) (reconfirmation of H1), mediated by the life expectancy (LE) (reconfirmation of H2). These results are in line with Hansen [47] and Gong, Li, and Wang [46], who also found that healthy individuals are more productive and generate competitiveness, raising the standard of living for all. In the case of the EU-13 countries, health expenditure and the employment rate of population aged 55–64 years are decisively connected with labor productivity through labor market policies (active and passive) (ALMP, PLMP) (reconfirmation of H4). When considering the EU-15 MS, however, these linkages are mediated by birth rate (BR), along with educational background (TE_30_34), and the expenditure granted for research and development activities (GERD).

At the same time, public health expenditure has significant effects on aging coordinates (birth rate and life expectancy) and the employment rate of the population aged 55–64 (ER_55_64) in EU-13 countries, as entailed by the strong connections between life expectancy (LE), birth rate (BR), health government expenditures (HGE), and hospital services (HS) (reconfirmation of H2). In EU-15 countries, these linkages and the impact on the labor market integration of older workers (ER_55_64) are further enhanced through active and passive labor market policies (ALMP, PLMP), with positive spillovers for labor productivity (LP) (reconfirmation of H1).
Figure 6. Gaussian graphical models (GGMs), 1995–2017, partial correlation (PCOR): (a) EU-13; (b) EU-15. Source: Authors’ research in R.

Similar results were obtained when we processed the GGMs through the extended Bayesian information criteria (Figure A1), namely, labor productivity in relation to a proper insertion of persons aged 55–64 into the labor market (a significant active participation of people aged 55–64 years into the labor market reflected through increases in ER_55_64) under the decisive contribution of health expenditure (HS and HGE), leading to an improvement in terms of older people’s health conditions (HLY_F, HLY_M) and overall population’s health perceptions (PGPH). Hence, the GGMs (Figure 5;
Figure A1) reinforce the previous SEM results and confirm the strong interdependences between all considered variables and the significant implications of good public health for labor market performance/outcomes for all EU-28 MS. Thereby, the fourth integrative hypothesis, $H_4$: There are overall (direct, indirect, total) significant implications of health dimensions and aging upon labor productivity, both for the EU-15 and EU-13 panels, was reconfirmed and supported.

### 4.3. Results of Macroeconometric Models

The results obtained after processing these new sets of macroeconometric models (RREG and PCSE) for each of the four working hypotheses are similar to the SEM model, being robust and consistent throughout different techniques, as follows: unfavorable implications of the proportion of employees aged 55–64 for labor productivity, more emphasized for developed countries (EU-15) than developing ones (EU-13) ($H_1$, revealed by the results from Table A6); significant implications of health expenditure upon aging coordinates (birth rate and life expectancy), on the one hand, and on elderly health conditions and overall population health perception, on the other hand, in both EU-15 and EU-13 panels, although more prominent for former ($H_2$ and $H_3$, disclosed by the results from Table A7); and significant implications of health and aging dimensions upon labor productivity, both for the EU-15 and EU-13 panels ($H_4$, as shown by the results from Table A8).

Hence, the macroeconometric models reinforce previous estimations, thus confirming and fulfilling each research hypothesis. Along these lines, this current research also points to many crucial gaps in knowledge and capacity, and strengthens the existing empirical aging literature with an updated complex assessment of the implications of health expenditure upon aging coordinates (birth rate and life expectancy), and further upon the EU labor market’s performance, namely, labor productivity.

Our estimations support several policy interventions that should be implemented by policy-makers across the EU, in about a five-year timeframe, in order to support a decade of concerted actions on the aging phenomenon, so as to strengthen healthy aging, in line with the global strategy of the World Health Organization [42]. Some of these actions include: Additional governmental financial expenditure for health and long-term care systems, since our regression results have shown that an increase in $HGE$ leads to significant increases in labor productivity ($LP$); and financial incentives and support services for new mothers to increase birth rates, since our estimations demonstrate that increased birth rates and life expectancy also lead to an increase in labor productivity. Other policy actions should focus on the collection of better global data on healthy aging and, particularly, an accurate dataset at the EU level, promoting research oriented to the needs of older people in order to identify proper means/mechanisms to increase labor productivity and to ensure their adequate labor market integration, reconfiguring health and long-term care systems in every EU Member State (particularly in EU-13 countries) to support the needs of older people and to enhance an age-friendly environment for the community. All of these aspects should be long-term-oriented and generally cover a few decades in order to support active and healthy aging, with benefit spillovers for the wellbeing of older people and the welfare of society as a whole.

### 5. Conclusions

The population aging phenomenon brings with it challenges and opportunities for both developed and developing nations, more emphasized for the EU region than others. The main challenges posed by the increasing share of older individuals are of an economic and social nature, where governments need to cope with increasing expenditures and declining revenues. In this article, we focused on the fact that population ageing tends to equate to increased healthcare expenditure, especially in the case of long-term care needs, with possible implications for labor market outcomes. Thus, the general objective of our paper was to assess the effects of population aging and public health expenditure on labor market performance within the EU-28 MS, with a detailed analysis of the EU-15 (developed countries) and the EU-13 (developing countries) MS.
This research endeavor focused on testing four hypotheses by applying three advanced and integrative econometric techniques, namely, structural equation modeling, Gaussian graphical models (GGMs), and macroeconometric models (robust regression (RREG) and panel corrected standard errors (PCSE)).

After testing the first hypothesis, we found significant implications of the employment rate of the population aged 55–64 for labor productivity, under several social and economic shaping factors, more prominent for developed countries (EU-15), given their higher level of aging dimensions, than for developing ones (EU-13). Special attention, in this regard, for the EU-13 countries must be paid to labor market policies (active and passive), R&D expenditure oriented toward the labor conditions of the workforce aged 55–64, educational support for the 55–64 age group’s skills formation connected to digital transformation. For the EU-15 countries the removal of passive labor market policies is necessary, since PLMP are an important factor for labor market insertion, covering mainly unemployment benefits and early retirement schemes that can act as a disincentive for active labor market participation, along with tailored educational programs, to reshape the skills of the workforce aged 55–64.

Further, the second hypothesis assessed significant impacts of health expenditure on aging dimensions in both EU-15 and EU-13 panels, also more distinguished for the former. We found particular directions to be pursued by the EU-13 countries in this vein, namely, on public health expenditure for further encouraging birth rates and sustaining life expectancy. In the case of the EU-15 countries, attention has to be oriented toward hospital services’ contribution to enhance people’s perceptions with regard to public health support, in order to boost the birth rate and life expectancy (aging dimensions). Fundamentally, reshaped policies and strategies embedded in the best practices of EU MS with the highest birth rates are needed (respectively, France, the UK, Sweden, and Austria).

The third hypothesis revealed substantial impacts of health expenditure on elderly health conditions and overall population health perceptions, both for the EU-15 and the EU-13 panels. For the EU-13 countries, we found a lack of public health expenditure, and for the EU-15, of public hospital services. Thus, specific policies have to be made to enhance the overall health perception of people (in EU-13), and to assure better health conditions for people aged 65+ (in EU-15) through the public system.

Finally, under the cumulative interventions, for assessing the fourth hypothesis, when integrative research was applied by SEM and GGMs, we found that labor productivity is significantly shaped by health dimensions and aging, both for the EU-15 and EU-13 MS. Within the EU-13, particular focus has to be given to the employment rate of those aged 55–64, people’s health perceptions, and the healthy conditions of women aged 65+. In the case of the EU-15 countries, the focus has to be also on the working labor force aged 55–64 and the health conditions of men aged 65+.

We emphasize that the lack of decisive accurate polices designed to address imbalances will put a strain on public finances, households, and, eventually, lead to lowered productivity and welfare or stagnation. Older individuals who are healthy can support growth through direct or indirect labor force participation or by participating in community programs aimed at assisting other older individuals to cope with the challenges of aging. The first step in improving the health status of a population is to adopt healthy aging mindsets through preventive approaches, with the help of medical professionals and awareness campaigns, especially for the elderly and the segment of the population aged 55–64.

Research limitations reside in the fact that predicting with a high degree of certainty how population aging will affect healthcare costs, and vice versa, is rather difficult, since the aging–health–labor market conjunction is “highly complex and variable”, as Lloyd-Sherlock [59] (p. 887) has emphasized. Aging and health paradigms are influenced by a plethora of factors, hence this research cannot claim to be all-encompassing. Further research will foresee other dimensions related to each country’s economic and social conditions, broken down by countries’ regions (as Yang et al. [31] proposed, taking into consideration, for instance that, capital cities are more developed within each country), but also older people’s gender specificity with regard to their involvement in society [74], as well as related to the aging implications on company risk and return, particularly in emerging markets [75]. A distinct
focus of our future research will be on aging policies that need to be tailored to each EU Member State according to their heterogeneity.

**Author Contributions:** M.C., G.G.N., and P.S. drew the conceptualization, validation of the outputs, visualization, and wrote the manuscript. G.G.N. applied the methodology; M.C. and A.L.S. collected the data and reviewed the literature. PS. performed final additions and key editing of the manuscript. A.L.S. and P.S. were involved in funding support. All authors read and approved the final manuscript.

**Funding:** This work was supported by the grant POCU380/6/13/123990, co-financed by the European Social Fund within the Sectorial Operational Program Human Capital 2014–2020.

**Acknowledgments:** The authors would like to thank the academic editor and the reviewers for their accurate and thoughtful comments that were very useful in enhancing the overall research and the final version of the manuscript.

**Conflicts of Interest:** The authors declare no conflicts of interest.

**Appendix A**

Table A1. Summary statistics for the EU-28, 1995–2017.

| Variables   | N  | Mean  | Sd   | Min  | Max  |
|-------------|----|-------|------|------|------|
| **EU-13**   |    |       |      |      |      |
| LP          | 169| 70.75858 | 14.42612 | 35.7 | 96.1 |
| ER_55_64    | 261| 41.49157 | 11.0632 | 17.1 | 68.1 |
| GERD        | 299| 0.8074314 | 0.4609393 | 0.024 | 2.604 |
| EDU         | 299| 71.79532 | 14.59404 | 17.1 | 88  |
| EARN        | 273| 35414.8 | 43926.32 | 666.42 | 265212 |
| LE          | 273| 75.16593 | 3.220439 | 67.7 | 82.7 |
| BR          | 299| 10.07358 | 1.053504 | 7.6  | 15.2 |
| TE_30_34    | 299| 26.13512 | 12.49351 | 1    | 58.7 |
| ALMP        | 161| 0.2024037 | 0.1598259 | 0.019 | 0.873 |
| PLMP        | 162| 0.3844074 | 0.2232345 | 0.065 | 1.365 |
| HLY_F       | 161| 7.165217 | 2.504128 | 2.7  | 14.2 |
| HLY_M       | 161| 7.017391 | 2.335047 | 3    | 13.5 |
| HGE         | 289| 4.975779 | 1.415306 | 1.8  | 7.9  |
| HS          | 251| 2.669323 | 0.6839117 | 0.8  | 5.1  |
| PGPH        | 164| 59.72256 | 9.925003 | 35   | 80.3 |
| **N total** |    | 131   |      |      |      |

| **EU-15**   |    |       |      |      |      |
| LP          | 195| 115.0303 | 21.86116 | 75.6 | 188.2 |
| ER_55_64    | 343| 45.74577 | 12.38773 | 22.2 | 76.4 |
| GERD        | 345| 1.886067 | 0.8329314 | 0 | 3.914 |
| EDU         | 341| 63.13856 | 13.93617 | 19.3 | 82.3 |
| EARN        | 317| 46101.44 | 27095.49 | 1648.52 | 311052 |
| LE          | 330| 79.63242 | 1.790216 | 75.3 | 83.5 |
| BR          | 345| 11.01391 | 1.720831 | 7.6  | 16.7 |
| TE_30_34    | 345| 33.01696 | 11.05093 | 8.6  | 54.6 |
| ALMP        | 266| 0.6394812 | 0.3517511 | 0.034 | 2.082 |
| PLMP        | 278| 1.362842 | 0.6684728 | 0.15 | 3.126 |
| HLY_F       | 192| 9.878646 | 2.337115 | 5.2  | 16.8 |
| HLY_M       | 192| 9.684375 | 1.839294 | 6.2  | 15.7 |
| HGE         | 345| 6.488696 | 1.085938 | 3.7  | 8.9  |
| HS          | 304| 3.065461 | 1.436566 | 0    | 6.3  |
| PGPH        | 196| 70.79031 | 8.242352 | 45.9 | 84.5 |
| **N total** |    | 146   |      |      |      |

Source: Authors’ contribution in Stata.
Table A2. Empirical results for SEM models designed to capture total effects of population aging and public healthcare services on labor productivity in the EU, 1995–2017.

| Variables | Coef. EU-13 | Std. err. EU-13 | p-Value EU-13 | Coef. EU-15 | Std. err. EU-15 | p-Value EU-15 |
|-----------|-------------|-----------------|---------------|-------------|-----------------|---------------|
| Log_ER_55_64 <- Log_EARN | -0.044 | 0.020 | 0.025 | -0.308 | 0.099 | 0.002 |
| Log_ALMP | -0.106 | 0.019 | -0.000 | 0.040 | 0.033 | 0.237 |
| Log_PLMP | -0.066 | 0.259 | 0.011 | -0.181 | 0.036 | 0.000 |
| Log_EDU_ATT | 0.495 | 0.079 | 0.000 | -0.135 | 0.104 | 0.195 |
| Log_TE_30_34 | 0.326 | 0.040 | 0.000 | 0.293 | 0.060 | 0.000 |
| Log_GERD | -0.037 | 0.285 | 0.184 | 0.314 | 0.046 | 0.000 |

| Variables | Coef. EU-13 | Std. err. EU-13 | p-Value EU-13 | Coef. EU-15 | Std. err. EU-15 | p-Value EU-15 |
|-----------|-------------|-----------------|---------------|-------------|-----------------|---------------|
| Log_LP <- Log_ER_55_64 | -0.144 | 0.050 | 0.004 | -0.292 | 0.046 | 0.000 |
| Log_BR | 0.105 | 0.152 | 0.488 | 0.239 | 0.079 | 0.003 |
| Log_LE | 6.366 | 0.351 | 0.000 | 2.521 | 0.803 | 0.005 |
| Log_PGPH | -0.585 | 0.088 | 0.000 | 0.404 | 0.106 | 0.000 |
| Log_HLY_F | -0.440 | 0.109 | 0.000 | 0.527 | 0.140 | 0.000 |
| Log_HLY_M | 0.266 | 0.131 | 0.043 | -0.434 | 0.155 | 0.005 |
| Log_EARN | 0.006 | 0.003 | 0.078 | 0.090 | 0.032 | 0.005 |
| Log_ALMP | 0.015 | 0.006 | 0.012 | -0.011 | 0.010 | 0.245 |
| Log_PLMP | 0.009 | 0.005 | 0.057 | 0.053 | 0.013 | 0.000 |
| Log_DU_ATT | -0.071 | 0.027 | 0.010 | 0.039 | 0.031 | 0.204 |
| Log_TE_30_34 | -0.047 | 0.017 | 0.007 | -0.085 | 0.022 | 0.000 |
| Log_GERD | 0.005 | 0.004 | 0.228 | -0.091 | 0.019 | 0.000 |
| Log_HS | 0.247 | 0.140 | 0.078 | -0.067 | 0.029 | 0.021 |
| Log_HGE | -0.001 | 0.119 | 0.989 | 0.277 | 0.145 | 0.056 |

| Variables | Coef. EU-13 | Std. err. EU-13 | p-Value EU-13 | Coef. EU-15 | Std. err. EU-15 | p-Value EU-15 |
|-----------|-------------|-----------------|---------------|-------------|-----------------|---------------|
| Log_BR <- Log_HS | 0.096 | 0.031 | 0.002 | -0.081 | 0.026 | 0.002 |
| Log_HGE | -0.095 | 0.027 | 0.000 | 0.371 | 0.130 | 0.004 |

| Variables | Coef. EU-13 | Std. err. EU-13 | p-Value EU-13 | Coef. EU-15 | Std. err. EU-15 | p-Value EU-15 |
|-----------|-------------|-----------------|---------------|-------------|-----------------|---------------|
| Log_LE <- Log_HS | 0.069 | 0.016 | 0.000 | -0.007 | 0.001 | 0.000 |
| Log_HGE | -0.023 | 0.014 | 0.097 | 0.033 | 0.009 | 0.001 |

| Variables | Coef. EU-13 | Std. err. EU-13 | p-Value EU-13 | Coef. EU-15 | Std. err. EU-15 | p-Value EU-15 |
|-----------|-------------|-----------------|---------------|-------------|-----------------|---------------|
| Log_PGPH <- Log_HS | 0.215 | 0.073 | 0.003 | -0.028 | 0.021 | 0.190 |
| Log_HGE | -0.230 | 0.062 | 0.000 | 0.048 | 0.108 | 0.655 |

| Variables | Coef. EU-13 | Std. err. EU-13 | p-Value EU-13 | Coef. EU-15 | Std. err. EU-15 | p-Value EU-15 |
|-----------|-------------|-----------------|---------------|-------------|-----------------|---------------|
| Log_HLY_F <- Log_HS | 0.405 | 0.158 | 0.011 | -0.095 | 0.040 | 0.017 |
| Log_HGE | -0.264 | 0.135 | 0.050 | 0.406 | 0.200 | 0.043 |

| Variables | Coef. EU-13 | Std. err. EU-13 | p-Value EU-13 | Coef. EU-15 | Std. err. EU-15 | p-Value EU-15 |
|-----------|-------------|-----------------|---------------|-------------|-----------------|---------------|
| Log_HLY_M <- Log_HS | 0.384 | -0.146 | 0.009 | -0.072 | 0.031 | 0.021 |
| Log_HGE | -0.354 | 0.124 | 0.004 | 0.277 | 0.158 | 0.080 |

Source: Authors’ contribution in Stata.
### Table A3. Cronbach’s alpha for the SEM models, EU-13 and EU-15, 1995–2017.

| Test Scale | Mean (Standardized Items) | Alpha | Obs | Sign | Interitem Correlation | Alpha | Obs | Sign | Interitem Correlation |
|------------|---------------------------|-------|-----|------|-----------------------|-------|-----|------|-----------------------|
| **EU-13**  |                           |       |     |      |                       |       |     |      |                       |
| Log_ER_55_64 | 261                       | −     | 0.0782 | 0.5428 | 343                 | +     | 0.1895 | 0.7660 |
| Log_LP      | 169                       | +     | 0.0577 | 0.4615 | 195                 | +     | 0.1632 | 0.7319 |
| Log_BR      | 299                       | −     | 0.0963 | 0.5988 | 345                 | +     | 0.1848 | 0.7604 |
| Log_LE      | 273                       | +     | 0.0478 | 0.4129 | 330                 | +     | 0.1948 | 0.7720 |
| Log_PGPH    | 164                       | +     | 0.0534 | 0.4413 | 196                 | +     | 0.1657 | 0.7355 |
| Log_HLY_F   | 161                       | +     | 0.0502 | 0.4250 | 192                 | +     | 0.1597 | 0.7269 |
| Log_HLY_M   | 161                       | +     | 0.0460 | 0.4029 | 192                 | +     | 0.1642 | 0.7334 |
| Log_EARN    | 273                       | +     | 0.0614 | 0.4779 | 317                 | +     | 0.1774 | 0.7512 |
| Log_ALMP    | 161                       | −     | 0.0812 | 0.5530 | 266                 | +     | 0.1856 | 0.7613 |
| Log_PLMP    | 162                       | +     | 0.0726 | 0.5230 | 278                 | +     | 0.20006 | 0.7784 |
| Log_EDU_ATT | 299                       | −     | 0.0694 | 0.5106 | 341                 | +     | 0.1616 | 0.7296 |
| Log_TE_30_34| 299                       | +     | 0.0901 | 0.3808 | 345                 | +     | 0.1502 | 0.7121 |
| Log_GERD    | 299                       | +     | 0.0873 | 0.5725 | 344                 | +     | 0.1724 | 0.7447 |
| Log_HS      | 251                       | +     | 0.0709 | 0.5163 | 287                 | −     | 0.1985 | 0.7762 |
| Log_HGE     | 289                       | −     | 0.1089 | 0.6310 | 345                 | −     | 0.2389 | 0.8146 |
| **EU-15**   |                           |       |     |      |                       |       |     |      |                       |
| Log_ER_55_64 | 261                       | −     | 0.0782 | 0.5428 | 343                 | +     | 0.1895 | 0.7660 |
| Log_LP      | 169                       | +     | 0.0577 | 0.4615 | 195                 | +     | 0.1632 | 0.7319 |
| Log_BR      | 299                       | −     | 0.0963 | 0.5988 | 345                 | +     | 0.1848 | 0.7604 |
| Log_LE      | 273                       | +     | 0.0478 | 0.4129 | 330                 | +     | 0.1948 | 0.7720 |
| Log_PGPH    | 164                       | +     | 0.0534 | 0.4413 | 196                 | +     | 0.1657 | 0.7355 |
| Log_HLY_F   | 161                       | +     | 0.0502 | 0.4250 | 192                 | +     | 0.1597 | 0.7269 |
| Log_HLY_M   | 161                       | +     | 0.0460 | 0.4029 | 192                 | +     | 0.1642 | 0.7334 |
| Log_EARN    | 273                       | +     | 0.0614 | 0.4779 | 317                 | +     | 0.1774 | 0.7512 |
| Log_ALMP    | 161                       | −     | 0.0812 | 0.5530 | 266                 | +     | 0.1856 | 0.7613 |
| Log_PLMP    | 162                       | +     | 0.0726 | 0.5230 | 278                 | +     | 0.20006 | 0.7784 |
| Log_EDU_ATT | 299                       | −     | 0.0694 | 0.5106 | 341                 | +     | 0.1616 | 0.7296 |
| Log_TE_30_34| 299                       | +     | 0.0901 | 0.3808 | 345                 | +     | 0.1502 | 0.7121 |
| Log_GERD    | 299                       | +     | 0.0873 | 0.5725 | 344                 | +     | 0.1724 | 0.7447 |
| Log_HS      | 251                       | +     | 0.0709 | 0.5163 | 287                 | −     | 0.1985 | 0.7762 |
| Log_HGE     | 289                       | −     | 0.1089 | 0.6310 | 345                 | −     | 0.2389 | 0.8146 |

Total scale: 0.6346 0.7674

Source: Authors’ contribution in Stata.

### Table A4. Wald tests for equations associated with the SEM models, EU-13 and EU-15, 1995–2017.

| Variables | EU-13 | EU-15 |
|-----------|-------|-------|
| Chi²      | df    | p-Value | Chi² | df   | p-Value |
| Log_ER_55_64 | 140.69 | 6 | 0.0000 | 108.28 | 6 | 0.0000 |
| Log_LP | 456.36 | 6 | 0.0000 | 207.21 | 6 | 0.0000 |
| Log_BR | 14.34 | 2 | 0.0008 | 10.34 | 2 | 0.0057 |
| Log_LE | 17.92 | 2 | 0.0001 | 16.34 | 2 | 0.0003 |
| Log_PGPH | 14.97 | 2 | 0.0006 | 2.37 | 2 | 0.3057 |
| Log_HLY_F | 7.06 | 2 | 0.0293 | 5.86 | 2 | 0.0535 |
| Log_HLY_M | 9.84 | 2 | 0.0073 | 5.33 | 2 | 0.0695 |

H₀: All coefficients excluding the intercepts are 0. We can thus reject the null hypothesis for each equation, with limitations on PGPH in the case of the EU-15 sample. Source: Authors’ contribution in Stata. df, degrees of freedom.

### Table A5. Goodness-of-fit tests for the SEM models, EU-13 and EU-15, 1995–2017.

**EU-13**

#### Likelihood ratio

| chi²_ms(55) | 905.818 | model vs. saturated |
|-------------|---------|---------------------|
| p > chi²   | 0.000   |                     |

#### Information criteria

| AIC | −266.492 | Akaike’s information criterion |
| BIC | −162.984 | Bayesian information criterion |

#### Baseline comparison

| CFI | 0.280 | Comparative fit index |
| TLI | −0.008 | Tucker-Lewis index |

#### Size of residuals

| SRMR | 0.070 | Standardized root mean squared residual |
| CD  | 0.681 | Coefficient of determination |
Table A5. Cont.

| EU-15 |
|-------|
| Likelihood ratio | |
| chi2_ms(26) | 1217.706 | model vs. saturated |
| $p > \text{chi2}$ | 0.000 |
| chi2_bs(38) | 1466.510 | baseline vs. saturated |
| $p > \text{chi2}$ | 0.000 |
| Information criteria | |
| AIC | $-1259.765$ | Akaike’s information criterion |
| BIC | $-1152.355$ | Bayesian information criterion |
| Baseline comparison | |
| CFI | 0.163 | Comparative fit index |
| TLI | $-0.171$ | Tucker-Lewis index |
| Size of residuals | |
| SRMR | 0.040 | Standardized root mean squared residual |
| CD | 0.550 | Coefficient of determination |

Source: Authors’ contribution in Stata.

(a)
Figure A1. GGMs (Gaussian graphical models), 1995–2017, extended Bayesian information criterion (EBIC), and least absolute shrinkage and selection operator (LASSO): (a) EU-13; (b) EU-15. Source: Authors’ research in R.

Table A6. Results of macroeconometric models deployed for H1, EU-13 and EU-15, 1995–2017.

|              | EU-13 | EU-15 |
|--------------|-------|-------|
|              | (1)   | (2)   | (1)   | (2)   |
| RREG log_LP  |       |       |       |       |
| PCSE log_LP  |       |       |       |       |
| log_ER_55_64 | -0.107| -0.0918*| -0.0770*| -0.127*** |
|              | (0.0698) | (0.0470) | (0.0365) | (0.0264) |
| _cons        | 4.680*** | 4.583*** | 5.026*** | 5.224*** |
|              | (0.265) | (0.175) | (0.142) | (0.103) |
| N            | 169   | 169   | 195   | 195   |

Note: Standard errors in parentheses, * p < 0.05, ** p < 0.01, *** p < 0.001. Source: Authors’ contribution in Stata.
Table A7. (a) Results of macroeconometric models deployed for H2 and H3, Robust regression (RREG), EU-13 and EU-15, 1995–2017. (b) Results of macroeconometric models deployed for H2 and H3, panel-corrected standard errors (PCSE), EU-13 and EU-15, 1995–2017.

### (a)

| EU-13 | (1) | (2) | (3) | (4) | (5) |
|-------|-----|-----|-----|-----|-----|
| log_HLY_F | log_HLY_M | log_BR | log_LE | log_PGPH |
| log_HGE | $-0.219$ | $-0.400^{**}$ | $-0.126^{***}$ | $-0.0182$ | $-0.279^{***}$ |
| | (0.128) | (0.121) | (0.0229) | (0.0107) | (0.0603) |
| log_HS | $0.491^{**}$ | $0.466^{**}$ | $0.0952^{***}$ | $0.0697^{***}$ | $0.235^{**}$ |
| | (0.150) | (0.142) | (0.0258) | (0.0119) | (0.0708) |
| _cons | $1.802^{***}$ | $2.101^{***}$ | $2.407^{***}$ | $4.286^{***}$ | $4.312^{***}$ |
| | (0.179) | (0.169) | (0.0297) | (0.0139) | (0.0826) |
| N | 161 | 161 | 251 | 237 | 164 |

### (b)

| EU-13 | (1) | (2) | (3) | (4) | (5) |
|-------|-----|-----|-----|-----|-----|
| log_HLY_F | log_HLY_M | log_BR | log_LE | log_PGPH |
| log_HGE | $0.377^{*}$ | $0.245$ | $-0.219^{**}$ | $0.102^{***}$ | $-0.195^{***}$ |
| | (0.182) | (0.143) | (0.0702) | (0.00822) | (0.0527) |
| log_HS | $-0.0648$ | $-0.0536$ | $0.0108$ | $-0.0172^{***}$ | $0.0256^{*}$ |
| | (0.0356) | (0.0280) | (0.0170) | (0.00202) | (0.0103) |
| _cons | $1.606^{***}$ | $1.832^{***}$ | $2.805^{***}$ | $4.204^{***}$ | $4.638^{***}$ |
| | (0.326) | (0.256) | (0.121) | (0.0141) | (0.0944) |
| N | 179 | 179 | 287 | 273 | 182 |

| EU-15 | (1) | (2) | (3) | (4) | (5) |
|-------|-----|-----|-----|-----|-----|
| log_HLY_F | log_HLY_M | log_BR | log_LE | log_PGPH |
| log_HGE | $-0.301^{***}$ | $-0.391^{***}$ | $-0.143^{***}$ | $-0.0195^{***}$ | $-0.255^{***}$ |
| | (0.0430) | (0.0285) | (0.0137) | (0.00538) | (0.0123) |
| log_HS | $0.493^{***}$ | $0.451^{***}$ | $0.112^{***}$ | $0.0602^{***}$ | $0.234^{**}$ |
| | (0.0702) | (0.0605) | (0.0185) | (0.00682) | (0.0303) |
| _cons | $1.914^{***}$ | $2.088^{***}$ | $2.422^{***}$ | $4.298^{***}$ | $4.261^{***}$ |
| | (0.0563) | (0.0498) | (0.0184) | (0.00787) | (0.0257) |
| N | 161 | 161 | 251 | 237 | 164 |

Note: Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Source: Authors’ contribution in Stata.
Table A8. Results of macroeconometric models deployed for H₄, EU-13 and EU-15, 1995–2017.

|                | EU-13       | EU-15       |                | EU-15       |
|----------------|-------------|-------------|----------------|-------------|
|                | (1) RREG    | (2) PCSE    | (3) RREG       | (4) PCSE    |
| log_LP         | 0.195 ***   | 0.174 ***   | 0.554 ***      | 0.371 ***   |
|                | (0.0460)    | (0.0232)    | (0.0684)       | (0.0966)    |
| log_HGE        | 0.174 ***   | 0.174 ***   | 0.554 ***      | 0.371 ***   |
|                | (0.0232)    | (0.0232)    | (0.0684)       | (0.0966)    |
| log_HS         | −0.178 ***  | −0.134 ***  | −0.218 ***     | −0.189 ***  |
|                | (0.0525)    | (0.0354)    | (0.0135)       | (0.0177)    |
| log_HLY_F      | −0.361 **   | −0.376 ***  | 0.357 ***      | 0.395 ***   |
|                | (0.111)     | (0.0860)    | (0.0939)       | (0.0821)    |
| log_HLY_M      | 0.213       | 0.227 *     | −0.414 ***     | −0.443 ***  |
|                | (0.135)     | (0.106)     | (0.107)        | (0.0829)    |
| log_BR         | 0.205       | 0.120       | 0.0462         | 0.144       |
|                | (0.142)     | (0.158)     | (0.0563)       | (0.0795)    |
| log_LE         | 6.112 ***   | 6.113 ***   | −0.833         | 0.0420      |
|                | (0.378)     | (0.319)     | (0.577)        | (0.352)     |
| log_PGPSH      | −0.417 ***  | −0.407 ***  | 0.564 ***      | 0.511 ***   |
|                | (0.0847)    | (0.0603)    | (0.0726)       | (0.0576)    |
| cons           | −20.90 ***  | −20.75 ***  | 5.162 *        | 1.621       |
|                | (1.459)     | (1.078)     | (2.482)        | (1.436)     |
| N              | 148         | 148         | 165            | 165         |
| R²             | 0.759       | 0.771       | 0.797          | 0.771       |

Note: Standard errors in parentheses, *p < 0.05, **p < 0.01, ***p < 0.001. Source: Authors’ contribution in Stata.

References

1. Börsch-Supan, A.; Chiappori, P.A. Aging population: Problems and policy options in the US and Germany. *Econ. Policy* 1991, 6, 104–139. [CrossRef]
2. Coleman, D. Population ageing: An unavoidable future. In *The Welfare State Reader*, 2nd ed.; Pierson, C., Castles, F.G., Eds.; Polity Press: Cambridge, UK; Malden, MA, USA, 2006; pp. 298–308.
3. Káčerová, M.; Mladek, J. Population ageing as generation substitutions: Economic and social aspects. *Ekon. Cas.* 2012, 60, 259–276.
4. Cristea, M.; Mitrica, A. Global ageing: Do privately managed pension funds represent a long term alternative for the Romanian Pension system? Empirical research. *Rom. J. Polit. Sci.* 2016, 16, 63–106.
5. Song, J.; Ryu, D. Aging effects on consumption risk-sharing channels in European countries. *Zb. Rad. Ekon. Fak. U Riječi Časopis Za Ekon. Teor. Praksu* 2018, 36, 585–617.
6. Andor, L. Employment Trends and Policies for Older Workers in the Recession. European Foundation for the Improvement of Living and Working Conditions. 2012, pp. 1–12. Available online: https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef1235en.pdf (accessed on 2 October 2019).
7. Bengtsson, T.; Qi, H. Ageing workforce, social cohesion and sustainable development: Political challenges within the Baltic Sea region: Sweden. In *Ageing Workforce, Social Cohesion and Sustainable Development: Political Challenges within The Baltic Sea Region*; Becker, P., Schütz, J., Zimmermann, A., Eds.; Max Planck Society/Population Europe: Berlin, Germany, 2018; pp. 55–59.
8. European Commission. *The 2018 Ageing Report: Underlying Assumptions and Projection Methodologies*; Publications Office of the European Union: Luxembourg, 2017; pp. 1–240.
9. European Commission. Ready for the Demographic Revolution? Measuring Active Ageing. 2016. Available online: https://ec.europa.eu/social/main.jsp?langId=en&catId=752&furtherNews=yes&newsId=2430 (accessed on 1 October 2019).
10. OECD/EU. *Health at a Glance: Europe 2018: State of Health in the EU Cycle*; OECD Publishing: Paris, France, 2018.
11. OECD. *Working Better with Age*: Ageing and Employment Policies; OECD Publishing: Paris, France, 2019.
12. World Health Organization (WHO). *Global Strategy and Action Plan on Ageing and Health*; World Health Organization: Geneva, Switzerland, 2017; pp. 1–46.
13. Taylor, P. *Ageing Labour Forces: Promises and Prospects*; Edward Elgar Publishing: Cheltenham, UK; Northampton, MA, USA, 2008.
14. Gusmano, M.K.; Okma, K.G.H. Population aging and the sustainability of the welfare state. *Hastings Cent. Rep.* 2018, 48, S57–S61. [CrossRef]
15. Jensen, S.E.H.; Bo Nielsen, S. Population ageing, public debt and sustainable fiscal policy. *Fisc. Stud.* 1995, 16, 1–20. [CrossRef]
16. Zokalj, M. The impact of population aging on public finance in the European Union. *Financial Theory and Practice* 2016, 40, 383–412. [CrossRef]
17. European Commission. *The 2018 Ageing Report: Economic and Budgetary Projections for the 28 EU Member States* (2016-2070); Publications Office of the European Union: Luxembourg, 2018; pp. 1–383.
18. Breyer, F.; Costa-Font, J.; Felder, S. Ageing, health, and health care. *Oxf. Rev. Econ. Policy* 2010, 26, 674–690. [CrossRef]
19. Cohen, N. The Silver Economy: Healthier and Wealthier. Available online: https://www.ft.com/content/08bf556-52c7-11e4-a236-00144feab7de (accessed on 12 October 2019).
20. Bosch-Ferré, C.; Garre-Olmo, J.; Bonmati-Tomàs, A.; Malagón-Aguilera, M.C.; Gelabert-Vilella, S.; Fuentes-Pumarola, C.; Juvinylá-Canal, D. Prevalence and related factors of active and healthy ageing in Europe according to two models: Results from the Survey of Health, Ageing and Retirements in Europe (SHARE). *PLoS ONE* 2018, 13, 1–19. [CrossRef]
21. Griffiths, A. Ageing, health and productivity: A challenge for the new millennium. *Work Stress* 1997, 11, 197–214. [CrossRef]
22. Garibaldi, P.; Oliveira Martins, J.; van Ours, J. *Ageing, Health, and Productivity: The Economics of Increased Life Expectancy*; Oxford University Press: Oxford, UK, 2010; pp. 1–288.
23. Sharpe, A. Is ageing a drag on productivity growth? A review article on Ageing, Health and Productivity: The Economics of Increased Life Expectancy. *Int. Prod. Monit.* 2011, 21, 82–94.
24. UNECE/European Commission. Active Ageing Index 2014 Analytical Report; Report prepared by Asghar Zaidi and David Stanton, Geneva, Italy. 2015. Available online: https://ec.europa.eu/eip/ageing/library/2014-active-ageing-index-aai-analytical-report_en (accessed on 11 September 2019).
25. Gray, A. Population Ageing and Health Care Expenditure. In *Oxford Institute of Ageing, Ageing Horizons*; Available online: https://www.ageing.ox.ac.uk/download/15 (accessed on 19 September 2019).
26. Bussolo, M.; Koettl, J.; Sinnott, E. Golden Aging: Prospects for Healthy, Active, and Prosperous Aging in Europe and Central Asia; Europe and Central Asia Studies; The World Bank: Washington, DC, USA, 2015; pp. 1–330.
27. Bremer, D.; Lüdecke, D.; von dem Knesebeck, O. Social relationships, age and the use of preventive health services: Findings from the German Ageing Survey. *Int. J. Environ. Res. Public Health* 2019, 16, 4272. [CrossRef] [PubMed]
28. Beltrán-Sánchez, H.; Soneji, S.; Crimmins, E.M. Past, present, and future of healthy life expectancy. *Cold Spring Harb. Perspect. Med.* 2015, 5, 1–18. [CrossRef] [PubMed]
29. Klenk, J.; Keil, U.; Jaensch, A.; Christiansen, M.C.; Nagel, G. Changes in life expectancy 1950–2010: Contributions from age- and disease-specific mortality in selected countries. *Popul. Health Metr.* 2016, 14, 1–11. [CrossRef] [PubMed]
30. European Commission. Eurostat Database. 2019. Available online: https://ec.europa.eu/eurostat/data/database (accessed on 2 September 2019).
31. Yang, L.; Zhao, K.; Fan, Z. Exploring determinants of population ageing in Northeast China: From a socio-economic perspective. *Int. J. Environ. Res. Public Health* 2019, 16, 4265. [CrossRef]
32. Taylor, P. European Foundation for the Improvement of Living and Working Conditions. In *Employment Initiatives for an Ageing Workforce in the EU15*; Office for Official Publications of the European Communities: Luxembourg, 2006; pp. 1–95.
33. European Commission. Growing The European Silver Economy. 2015. Available online: http://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/silvereco.pdf (accessed on 2 September 2019).
34. Barkovic Bojanic, I.; Erceg, A. Silver Economy: Demographic Change and Economic Opportunity. Interdisciplinary Management Research XIII. 2017, pp. 1005–1020. Available online: https://bib.irb.hr/datoteka/879480.349724720-Interdisciplinary-Management-Research-XIII.pdf?sequence=1006 (accessed on 4 September 2019).

35. Börsch-Supan, A.; Brandt, M.; Hunkeler, C.; Kneip, T.; Korbmacher, J.; Malter, F.; Schaab, B.; Stuck, S.; Zuber, S. Data resource profile: The survey of health, ageing and retirement in Europe (SHARE). *Int. J. Epidemiol.* 2013, 42, 992–1001. [CrossRef]

36. Mahlberg, B.; Freund, I.; Crespo Cuaresma, J.; Prskawetz, A. Ageing, productivity and wages in Austria. *Labour Econ.* 2013, 22, 5–15. [CrossRef]

37. Myck, M. Living longer, working longer: The need for a comprehensive approach to labour market reform in response to demographic changes. *Eur. J. Ageing* 2015, 12, 3–5. [CrossRef]

38. Akanni, M.T.; Čepar, Ž. Impact of population ageing on unemployment and entrepreneurial activity: The case of Slovenia. *Organizacija* 2015, 48, 232–245. [CrossRef]

39. Hsu, Y.H. Population Aging, Labor Force Participation, and Economic Growth. Available online: http://jbpnet.com/journals/Vol_4_No_1_March_2017/13.pdf (accessed on 12 September 2019).

40. Börsch-Supan, A. Population Aging, Social Security Design, and Early Retirement. Available online: https://www.jstor.org/stable/40751550 (accessed on 14 September 2019).

41. Berwick, D.M.; Nolan, T.W.; Whittington, J. The triple aim: Care, health, and cost. *Health Aff.* 2008, 27, 759–769. [CrossRef]

42. World Health Organization (WHO). *World Report On Ageing and Health*; World Health Organization: Geneva, Switzerland, 2015; pp. 1–247. Available online: https://apps.who.int/iris/bitstream/handle/10665/186463/9789240694811_eng.pdf?sequence=1 (accessed on 14 September 2019).

43. Dormont, B.; Martins, J.O.; Pelgrim, F.; Suhrcke, M. Health expenditures, longevity and growth. In *Ageing, Health, and Productivity: The Economics of Increased Life Expectancy*; Garibaldi, P., Oliveira Martins, J., van Ours, J., Eds.; Oxford University Press: New York, NY, USA, 2010; pp. 5–113.

44. Mannheim, I.; Schwartz, E.; Xi, W.; Buttigieg, S.C.; McDonnell-Naughton, M.; Wouters, E.J.M.; van Zaalen, Y. Inclusion of older adults in the research and design of digital technology. *Int. J. Environ. Res. Public. Health* 2019, 16, 3718. [CrossRef] [PubMed]

45. Koc, E.; Bozkurt, G.A. Hospitality employees’ future expectations: Dissatisfaction, stress, and burnout. *Int. J. Hosp. Tour. Adm.* 2017, 18, 459–473. [CrossRef]

46. Gong, L.; Li, H.; Wang, D. Health investment, physical capital accumulation, and economic growth. *China Econ. Rev.* 2012, 23, 1104–1119. [CrossRef]

47. Hansen, C.W. Life expectancy and human capital: Evidence from the international epidemiological transition. *J. Health Econ.* 2015, 32, 1142–1152. [CrossRef]

48. Gulavani, S.S.; Kulkarni, R.V. Role of Information Technology in Health Care. In *Proceedings of the 4th National Conference INDIA-Com 2010*, New Delhi, India, 25–26 February 2010.

49. Thimbleby, H. Technology and the future of healthcare. *Eur. J. Ageing* 2015–2016, 12, 2727. [CrossRef]

50. Bianco, A. *Active Labour Market. Policies for Digital Economy: Skills Development and Workforce Preparation*; Working Papers. ASTRIL—Associazione Studi e Ricerche Interdisciplinari sul Lavoro, 2018. Available online: http://host.uniroma3.it/associazioni/astril/db/434116a6-9952-477f-9ff-98da58bb36a7.pdf (accessed on 16 September 2019).

51. Taylor, P.; Jorgensen, B.; Watson-Lynn, E. Population ageing in a globalizing labour market: Implications for older workers. *China J. Soc. Work* 2010, 3, 259–272. [CrossRef]

52. European Union. *The European Year for Active Ageing and Solidarity between Generations* (2012); The European Parliament and the Council of the European Union: Brussels, Belgium, 2012.

53. Álvarez-García, J.; Durán-Sánchez, A.; Del Rio-Rama, M.D.; García-Vélez, D.F. Active ageing: Mapping of Scientific Coverage. *Int. J. Environ. Res. Public. Health* 2018, 15, 2727. [CrossRef]

54. European Commission. *Active Ageing Index at the Local Level. Peer Review in Social Protection and Social Inclusion 2015–2016*; Directorate-General for Employment, Social Affairs and Inclusion, Population Unit of the UNECE and the European Centre for Social Welfare Policy and Research in Vienna: Berlin, Germany, 2016.

55. Zaidi, A.; Gasior, K.; Zolyomi, E.; Schmidt, A.; Rodrigues, R.; Marin, B. Measuring active and healthy ageing in Europe. *J. Eur. Soc. Policy* 2017, 27, 138–157. [CrossRef]
56. Cylus, J.; Figueras, J.; Normand, C. Will population ageing spell the end of the welfare state? A review of evidence and policy options. In The Economics of Healthy and Active Ageing Series; Sagan, A., Richardson, E., Eds.; European Observatory on Health Systems and Policies; WHO Regional Office for Europe: Copenhagen, Denmark, 2018; pp. 1–43.

57. Börsch-Supan, A. The Impact of Global Ageing on Labor, Product and Capital Markets. 2005, pp. 1–32. Available online: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.569.1414&rep=rep1&type=pdf (accessed on 25 October 2019).

58. Aiyar, S.S.; Ebeke, C.; Shao, X. The Impact of Workforce Aging on European Productivity. IMF Working Paper 2016, 16/238, 1-30. Available online: https://ssrn.com/abstract=2924323 (accessed on 2 September 2019).

59. Lloyd-Sherlock, P. Population ageing in developed and developing regions: Implications for health policy. Soc. Sci. Med. 2000, 51, 887–895. [CrossRef]

60. European Commission. Directorate-General for Employment, Social Affairs & Inclusion. Statistical Data. 2019. Available online: https://ec.europa.eu/social/main.jsp?catId=1249&langId=en (accessed on 2 September 2019).

61. Cristea, M.; Noja, G.G. European agriculture under immigration effects: New empirical evidence. Agric. Econ. 2019, 65, 112–122. [CrossRef]

62. Fisman, R.; Luca, M. How Amazon’s Higher Wages Could Increase Productivity. Harvard Business Review Digital Article. 2018. Available online: https://hbsp.harvard.edu.product.H04LEC-PDF-ENG (accessed on 19 December 2019).

63. Foygel, R.; Drton, M. Extended Bayesian information criteria for Gaussian Graphical Models. Adv. Neural. Inf. Process. Syst. 2010, 23, 2020–2028.

64. Börsch-Supan, A.; Weiss, M. Productivity and age: Evidence from work teams at the assembly line. J. Econ. Ageing 2016, 7, 30–42. [CrossRef]

65. Feyrer, J. Aggregate evidence on the link between age structure and productivity. Popul. Dev. Rev. 2008, 34, 78–99.

66. Guest, R.; Shacklock, K. The impending shift to an older mix of workers: Perspectives from the management and economics literatures. Int. J. Organ. Behav. 2005, 10, 713–728.

67. Bersin, J.; Chamorro-Premuzic, T. The Case for Hiring Older Workers. Harvard Business Review. 2019. Available online: https://hbr.org/2019/09/the-case-for-hiring-older-workers (accessed on 22 January 2020).

68. OECD. Ageing and Employment Policies: Denmark 2015: Working Better with Age; Ageing and Employment Policies; Policies, OECD Publishing: Paris, France, 2015; pp. 1–160.

69. Noja, G.G.; Cristea, S.; Yüksel, A.; Pânzaru, C.; Drăcea, R. Migrants’ role in enhancing the economic development of host countries: Empirical evidence from Europe. Econ. Cas. 2018, 66, 719–749.

70. Smith, A.D. Memory. In Handbook of the Psychology of Ageing, 4th ed.; Birren, J.E., Ed.; Academic Press: New York, NY, USA, 1996; pp. 236–247.

71. Verhaeghen, P.; Salthouse, T.A. Meta-analyses of age-cognition relations in adulthood: Estimates of linear and nonlinear age effects and structural models. Psychol. Bull. 1997, 122, 231–249. [CrossRef] [PubMed]

72. Dufek, J.; Minarik, B. Age of population and the development of population ageing in the regions of the Czech Republic. Agric. Econ. 2009, 55, 259–270. [CrossRef]

73. Noja, G.; Cristea, S.; Yüksel, A.; Pânzaru, C.; Drăcea, R. Migrants’ role in enhancing the economic development of host countries: Empirical evidence from Europe. Sustainability 2018, 10, 894. [CrossRef]

74. Thalassinos, E.; Cristea, M.; Noja, G.G. Measuring active ageing within the European Union: implications on economic development. Equilibrium 2019, 14, 591–609. [CrossRef]

75. Pirtea, M.; Botoc, C.; Jurcut, C. Risk and return analysis: evidence from emerging markets. Transform. Bus. Econ. 2014, 13, 637–647.