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Aging and Economic Competitiveness in the Core of “North Euro-Zone”

Gina Cristina Dimian, Bogdan Vasile Ileanu, Mirela Ionela Aceleanu

The Bucharest University of Economic Studies (ASE)
6 Piata Romana, 1st district, Bucharest, 010374 Romania
E-mail. gina.dimian@csie.ase.ro, ileanu@csie.ase.ro, mirela.aceleanu@economie.ase.ro

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The paper addresses the problem of aging from a topical perspective, namely its impact on labour productivity, one of the main sources of an economy’s competitiveness. Labour resources tend to become a limited ‘asset’ in many European Union countries, even the most developed ones, like Germany or Italy, where the age structure of the population is changing towards an increase in the share of older persons. In this context, aging and its effects on the productivity of older workers can become a challenge for the countries that are trying to maintain their sustainable economic growth. Our article is founded on the success stories of some of the countries the most affected by aging, namely Germany, the Netherlands, Austria and Finland, and has the main aim to investigate how productivity and the number of older workers influence sectoral competitiveness in the studied countries. The originality of the paper lies in the comparative perspective from which this phenomenon is investigated: the comparison between four developed economies that seem to have managed preserving a positive correlation between productivity and the aging workforce in recent years, with the main purpose to identify the driving factors of their long-term competitiveness and the comparison between economic sectors, in order to identify those who can be the sources of sustainable economic growth. Modern econometric analysis using Dynamic OLS (DOLS) and ARDL models based on panel data on five economic sectors and 19 years scientifically substantiates some solutions possibly to be adopted by other countries facing the same demographic challenges. More precisely, less labour intensive industries and young people involvement in innovative industries are some of the key competitiveness factors.

Keywords: *Aging, Sectoral Structure, Labour Productivity, Dynamic Panel Data, Long-Run Vs. Short Run Relations.*

Introduction

Demographic transition towards an aging society affects individuals and groups of people from more than one perspective. It is expected to reduce human resources both in terms of quantity and quality. Aging diminishes a number of personal abilities, like physical and cognitive and develops others, such as professional and practical experience (Weidmann, 2014). In addition, one of the main sources of economic growth, namely labour productivity is also put into difficulty. If in industry and agriculture, for example, the machinery may replace humans, there are certain domains, especially in the service sector, in which labour productivity cannot be yet increased through automation or innovation, and the number and qualifications of people are key factors. One of the consequences may be the increased competition for skilled labour, i.e. a decline in unemployment and an increase in wages.

The European Union countries that have unused labour resources and are in the process of population aging can develop training and retraining policies and programs starting from the experience of the countries that have already faced the same problems, taking into consideration the opportunities, but also the risks that this phenomenon induces. In this regard, Kolasa and Rubaszek (2015) points to the fact that no policy change in the context of deepening population aging is expected to create significant imbalances even in the most developed countries like Germany, France, Italy and Spain.

Under these circumstances, the paper addresses the problem of aging in close relationship with the changes produced by this phenomenon in the economic structure of countries with the main purpose to investigate how productivity and the number of older workers can influence sectoral competitiveness and which may be the best solution to overcome the problems and ensure sustainable economic growth.

We comparatively analyse the effects of labour force aging on the economy of countries in which this phenomenon is accentuated and quantify its impact on the labour productivity focusing on sectoral changes. We started from the example of Germany, the Netherlands, Finland and Austria, the EU countries where the workforce is rapidly aging and labour resources supplies are limited (Peschner & Fotakis, 2013).

The most recent data provided by Eurostat shows that Germany is one of the countries with a relatively old population structure. In 2014, the median age in this country was 45.6 years, 9.6 percentage points higher than in Ireland, the country with the lowest value of this indicator. In addition, the proportion of young people, aged 0–14 years, was 13.1 % while the share of the population aged 65 years or over exceeded 20 %. By comparison, in Ireland these shares are reversed: 22 % is young population and 12.6 % elderly population (Eurostat, 2015).

The selection of these four developed countries to be analysed and use their experience to identify solutions generally available for increasing the competitiveness in demographic aging conditions was also based on the results of Feyrer (2007), who demonstrated that 'a significant portion of the productivity gap between rich and poor countries is related to different demographic structure.

Considering the obvious reality that population is aging and this phenomenon will lead to the development of certain economic sectors and the decline of others, involving risks and opportunities for both business and employees, the main research directions of the present article are: a) studying the main characteristics of the four economies in terms of the economic structure (employment distribution by sectors, specialization and economic sectors most affected by aging); b) quantifying the impact of an aging workforce on labour productivity at sectoral level; c) determining the correlations between the two above-mentioned analysis results and drawing conclusions about the type of policies to be adopted to successfully overcome the consequences of aging.

The conclusions will be particularly useful for developing countries, which, as Bloom *et al.* (2010) noticed, first will become old and then, maybe rich but in more difficult economic and social conditions.

The present paper consists of six sections. The next section focuses on the literature that discusses the impact of population aging on the productivity at macro and microeconomic level, concentrating on the above mentioned four developed countries and on the econometric models used to measure the aging-economic structure relationship. Statistical analysis in terms of the economic structure and sectoral distribution of the old employees is the subject of the section three. The methodology and the results of the econometric analysis aiming at measuring the impact of an aging employed population on the productivity, at economic sectors level, are presented in sections four and five. Main conclusions and recommendations for some policy actions arisen from the experience of the analysed countries are subject to section six.

Literature Review

It is widely recognized among the researchers of demographic phenomena and policy makers that population aging is a reality in most developed countries, but also in many of the developing ones (Mihaescu, *et al.* 2009; Brunow & Hirte, 2009; Lugauer, 2012; European Commission, 2014; European Economy, 2014; ILO, 2014; ECB, 2014) In these countries the population is shrinking and the age structure is changing, meaning that the share of elderly in total population grows due to declining in the fertility rates and increasing life expectancy, while shortages are difficult to cover only by immigration.

If for a long time the main topic among the researches of economic phenomena was represented by the financial crisis, in the years to come they will look for solutions for one of the main negative secondary effect: labour market or social crisis (Dimian *et al.*, 2013).

Studying the problem of population aging and its implications has gained momentum and researchers have especially focused on the relationship between demographic aging and health budgets or social systems, but an important perspective could be also the impact on companies' productivity and the economic structure of countries.

Economic competitiveness is influenced both by entrepreneurship development and the level of unemployment in an economy. Startiene and Remeikiene (2009) highlight that demographic factors influence the interaction between entrepreneurship and unemployment, showing that there is a close link between these factors and the degree of development of entrepreneurship and job creation. Age, education, marital status and experience are factors that can positively or negatively affect business development.

To preserve competitiveness and to avoid social inequalities, Rees *et al.* (2012) propose in addition to fiscal and social policies, demographic and migration policies. Rougoor and Van Marrewijk (2015) call attention to global income inequality, which, though it has declined in recent years, will increase after 2030, mainly due to demographic changes which will generate long term differences in population growth and population structure between countries.

Cervellati and Sunde (2015) have analysed a quantifiable unified growth theory to investigate the impact of demographic transition on economic development in different countries. Their research shows that there is a close link between the stages of development and demographic transition. Korotayev, Goldstone and Zinkina (2015) points to the fact that some models of economic growth focuses on economic issues and less on demographic, although there is a strong connection between the phases of demographic transition and economic evolution. Agenor (2015) argues that life expectancy, population health and demographic change should be supported by public expenditure for increasing labour productivity, competitiveness and poverty reduction, while Zhang *et al.* (2015) demonstrated that the changes in age structure are significantly correlated with economic growth rates.

Boersch-Supan (2001), for example, showed that population aging will result in a change in the demand for goods and services structure meaning an increase in housing and health care services.

Regarding the changes that population aging will produce into the structure of an economy and labour qualifications, OECD study (2013) indicates that, most likely, it will have a significant impact on peripheral regions with mono-functional economic structure and less in central urban regions focused on business services, industry and logistics.

Vaittinen and Vanne (2014) demonstrate that in Finland this phenomenon has already had an impact on economic development of this country. The authors point to the fact that changes in the age structure have increased total domestic demand for goods (affecting external balance) and non-tradable services (leading to increase in their prices) changing the labour market balance between demand and supply, towards a labour shortage.

Fougère *et al.* (2007) studied the effects of population aging on the economic structure of Canada (2050 compared to 2000). The largest increase of the share in total GDP (by 50 %) is expected to produce in health sector, while insurance, finance and real estate activities will be also benefiting from the changes that aging will bring in the consumption structure. Declines can be expected in manufacturing, construction, education, wholesaling and retailing. In this scenario, wage rises in health care sector will be twice those in the other sectors.

Threatened are particularly innovative sectors, given that older workers have often difficulties in adapting to changes and new technologies (World Bank, 2013). Basically, economic sectors with growth potential, that can become a reservoir of jobs and growth are those related to green economy, health care and ICT.

In terms of the human resources necessary to cover the deficit in various economic sectors, Heikkila (2012) reveals that immigrants are a viable alternative to declining number of the workforce population. In Finland for example, their distribution by economic sectors differs greatly depending on both gender and country of origin. Most of the immigrant women and men from Sweden, Great Britain, Germany, the United States and Poland were employed in teaching and education sectors, while women coming from outside EU worked mostly in cleaning and men in restaurant service.

One of the main solutions for covering the workforce shortage is also to extend the active life of older workers. From this point of view, WEF (2012) treats it as ironic that countries and sectors in which rich and healthy workers operates, older participation rate is much lower than in agriculture and informal jobs where poorer and less healthy people work until old age.

If population aging is a phenomenon with an unequivocal increasing tendency and the changes that will produce in the economic structure of countries are predictable, the quantitative research which has focussed on measuring its impact on labour productivity at company or entire economy level did not reach clear-cut results.

For example, using microeconomic data, Gronqvist (2009) estimated a production function that measured the impact of hours worked by older workers, women and men over 50 years on sectoral growth rate of labour productivity:

$$\Delta lp_{it} = \alpha_i + \beta_1 \cdot \Delta 50\, female_{it} + \beta_2 \cdot \Delta 50 male_{it} + \beta_3 \cdot x + \varepsilon_{it} \qquad (1)$$

where, Δlp_{it} is labour productivity growth, $50\, female_{it}$ and $50 male_{it}$ represents the share of hours worked by women, respective men of 50–64 years in industry *i* at time *t* and X includes some control variables related to capital, labour and business cycle.

If in the first period, the impact of aging on productivity has been negative, starting with 2010 the change in the age structure in Finland is expected to lead to an increase in labour productivity by 0.2–0.7 percentage points annually, during the timespan 2010–2020.

An analysis performed in Austria, based on company-level data, revealed that the share of older workers in total employment does not appear to adversely affect the productivity of a company and seems not to be associated with higher wages. Instead the proportion of young people is negatively correlated with productivity and wages, mainly in sectors such as industry and construction (Mahlberg *et al.*, 2013).

The above mentioned authors studied the impact of the age structure on labour productivity and wages in Austria at sectoral level using a matched employer-employee data covering the period 2002–2005. Starting from a Cobb-Douglas production function and the assumption of constant returns to scale, they created 2 models in which the labour factor is decomposed into a sum of *k* types of employees, weighted by each employee's productivity γ_k.

$$\ln\left(\frac{Y_i}{L_i}\right) = c + \alpha \ln\left(\frac{K_i}{L_i}\right) + (1-\alpha)\sum_{k=1}^{m} \gamma_k \frac{L_{ik}}{L_i} + \sum_{j=1} \delta_j X_{ij} + u_i \qquad (2)$$

$$\ln\left(\frac{W_i}{L_i}\right) = c^W + \tilde{\alpha} \ln\left(\frac{K_i}{L_i}\right) + (1-\tilde{\alpha})\sum_{k=1}^{m} \tilde{\gamma}_k \frac{L_{ik}}{L_i} + \sum_{j=1} \tilde{\delta}_j X_{ij} + u_i^W, \qquad (3)$$

where Y_i is the level of output and W_i refers to wages and salaries; K_i represents the capital and L_i the labour, while X_i includes other explanatory variables. The results for Austria are comparable to the ones obtained in the case of Finland.

Using a panel database that links firms and employees' characteristics, Gobel and Zwick (2009) obtained similar results for Germany with the above mentioned studies, invalidating the idea of a negative impact of the elderly on firms' productivity.

In their econometric model based also on a structural Cobb Douglas production function, a set of control variables and the dependent variable with its past values were included.

$$\ln(p_{j,t}) \approx c + \sum_k \alpha_k \ln(p_{j,t-k}) + \beta \ln(k_{j,t}) + \sum_{i-\{0\}} \gamma_j \left(\frac{L_i}{L}\right)_{j,t} + \varphi X_{j,t} + \varepsilon_{j,t} \qquad (4)$$

where *p* represents the value added per head, *k* the capital per head and L_i / L the share of the employees in age group *i* in total employment of the establishment *j*.

The dynamic model connects gross value added per capita, capital per capita and shares of various age groups in total employment. The relationship between the variables does not seem to have an inverted U shape, but rather a flat form: companies' productivity increases with age up to 50–55 years, but not decrease significantly after 60 years. However, there are large differences among firms in terms of the intensity of this relationship.

As a conclusion, in a country like Germany, the share of older employees in total employment appears to be a factor with a positive impact on productivity at sectoral level, while keeping older workers in activity does not involve for companies a greater level of payment compared to their labour productivity. In contrast, the proportion of young people has a negative impact on sectoral productivity, especially in industry and constructions. Gobel and Zwick (2009) explain these findings in relation with the particular context of the labour market in this country, where the retirement age is relatively low and the workers maintained by companies until advanced ages are probably the most productive.

A similar analysis was performed in the paper Age, Wage and Productivity in Dutch Manufacturing (Van Ours & Stoeldraijer, 2011). The authors investigated, among other things, if there is a productivity-pay gap in Dutch companies and the results have shown that the gap is not significant. This can be an incentive for companies to retain older workers and an explanation why for an older worker there is more difficult to find a job.

Having as its starting point the aforementioned literature, this article proposes a comparative macroeconomic approach of the problem of labour force aging in four countries: Germany, Netherlands, Austria and Finland, with a focus on identifying the driving factors of their long-term competitiveness (positive correlation between the share of elderly and labour productivity).

The comparative approach is used to offer conclusions extra consistency, given that the results of previous studies on the same subject are relatively controversial. Control variables selected to be included in the econometric model seek to capture the influence of fixed capital on labour productivity and can contribute to a better explanation of the phenomenon.

Descriptive Satistics

The first step in studying the problem of population aging impact on economic productivity was to create an overall picture of what each country's economy represents in terms of sectoral structure compared to the EU average.

The purpose of this approach is to highlight the economic structure of the four countries: Germany, Netherlands, Austria and Finland, in order to capture which may be the source of their long-term competitiveness in the European Union.

Kernel-density estimates emphasize the existence in 2014 of three groups of European Union countries regarding the share of population employed in agriculture and significant differences between them. The lowest percentages are found in countries like Luxembourg and Belgium, but also Germany and Netherlands (between 1 and 2 %). Most of the countries form the group who have the EU average (about 5 %). These include both Austria and Finland. Bulgaria and Romania greatly exceed this average, with shares of 19.4 % and 29.4 % respectively (Figure 1).

Box plots graphs in Figure 1 show that, during 1995–2014, the share of people employed in agriculture in the EU countries has tended to decrease from 7.55 % in 1995 to a value little over 4 % in 2014, but the differences between the minimum and maximum values remain high, around 28 percentage points in 2014. This demonstrates the existence of large disparities regarding competitiveness in agriculture between the Nordic countries, on the one hand, and the countries of Central and Eastern Europe, or even Greece and Portugal, on the other hand.

Regarding the distribution of EU countries in terms of the proportion of people employed in industry, Kernel-density estimates demonstrate that most of the countries form a group close to the EU average. Three of the analysed countries (Finland, Austria and Germany) have the share of population employed in industry around the EU average, of about 22 %. In Netherlands, instead, this percentage is around 15 %, one of the lowest in the EU. High share of the population employed in industry are found in Central and Eastern European countries, with a maximum of almost 37 % in the Czech Republic (Figure 1).

As illustrated by Kernel-densities graphs, box plots in Figure 1 reveal that industry employment situation is more balanced between EU countries than employment in agriculture. The trend is still downward, declining from a median of 28 % in 1995 to around 23 % in 2014.

Throughout the period 1995–2014, the four countries analysed had the share of people employed in industry around the median, except the Netherlands where this proportion was among the lowest.

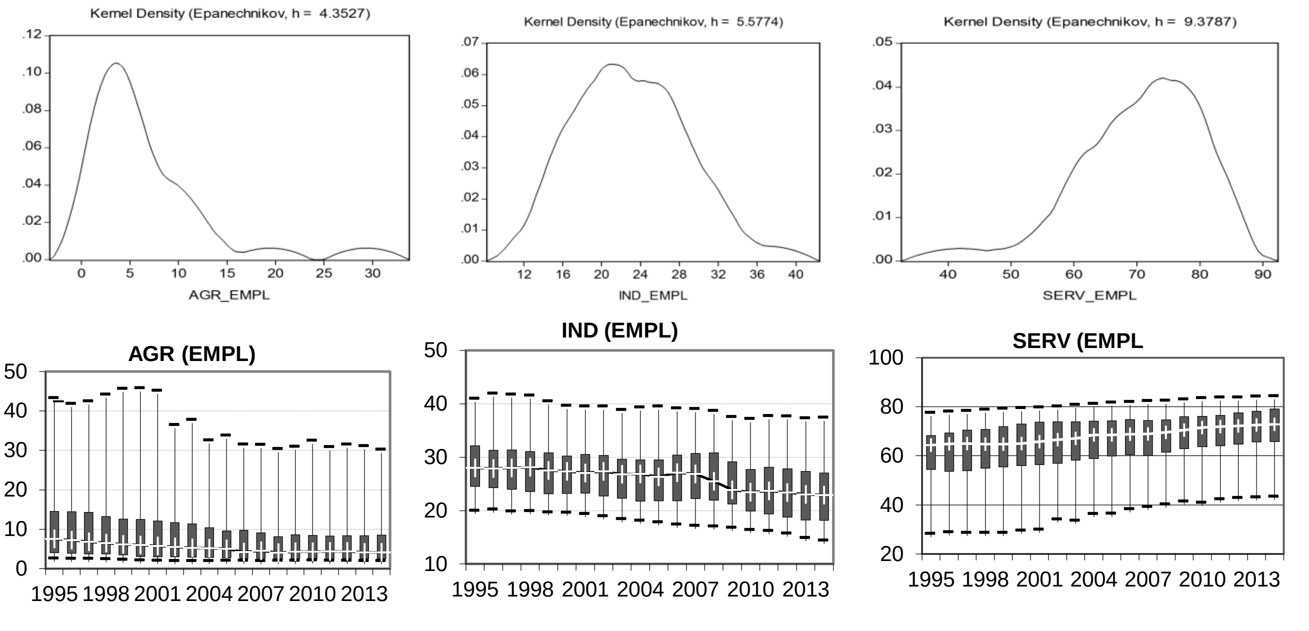

Figure 1. Kernel-density estimates (2014) and box plots (1995–2014) of employment structure by economic sectors in European Union countries (%)

As expected, the majority of the developed EU countries have most of the labour force employed in the service sector: from about 73 % in Austria and Finland to almost 83 % in the Netherlands. Figure 1 highlights the difference between two groups: the Central and Eastern European countries such as Romania and Bulgaria (with shares of 42 % and 56 %) and the Nordic countries. At the intersection of these two groups are the Baltics, like Lithuania, Estonia and Latvia with shares of about 70 %.

Box plots graphs for the employment in the services sector show a similar situation to that in agriculture, only now the largest differences appear between the median and the small values (Figure 1).

Aiming to identify the most important sectors for creating gross value added, Balassa specialization indexes were calculated for the recent period, 2000–2014, and 10 industry sectors.

$$I_k^i(t) = \frac{x_k^i(t)}{X_{EU}^i(t)} : \frac{x_k(t)}{X_{EU}(t)}, \qquad (5)$$

where x refers to value added, i the activity branch, k is the analysed country and X is total value added in EU.

Balassa indexes show that three of the four countries experience a relative specialization in *manufacturing*, the highest index was registered by Finland, followed by Germany and then Austria. Finland recorded a relative specialization in *agriculture*, along with the Netherlands. The latter, still has two branches of activity for which the Balassa indices indicate relative specialization, namely: *professional, scientific and technical activities; administrative and support service activities* and *financial and insurance activities* (Table 1).

Finland is the country that proves to be characterized by a higher degree of specialization than the EU average in most of the industries: in six of the 10 industries Balassa indexes were higher than 1. However, the country's economic activity is concentrated mainly in *agriculture* and *manufacturing* sectors. The Netherlands is the country for which five Balassa indices were above 1 (Table 1).

In Germany, industries that concentrates a greater share of value added than in the European Union are *manufacturing* and *arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies*. The lowest degree of specialization seems to be encountered in Austria. In this country Balassa indices showing a relative specialization are *manufacturing*, *construction* and *wholesale and retail trade and transport, accommodation and food service activities*.

Table 1

Balassa specialization indexes (2000–2014 averages)

Branches	GER	NETH	AUT	FIN
Agriculture, forestry and fishing	0.446	1.150	0.824	1.679
Manufacturing	1.368	0.811	1.229	1.430
Construction	0.666	0.912	1.102	1.080
Wholesale and retail trade, transport, accommodation and food service activities	0.829	1.034	1.195	0.882
Information and communication	0.981	0.952	0.621	1.011
Financial and insurance activities	0.950	1.232	0.910	0.457
Real estate activities	1.095	0.647	0.892	1.025
Professional, scientific and technical activities; administrative and support service activities	1.040	1.351	0.803	0.655
Public administration, defence, education, human health and social work activities	0.930	1.108	0.924	1.048
Arts, entertainment and recreation; other service activities.	1.223	0.678	0.787	0.786

Authors' calculation based on Eurostat Database, 2015

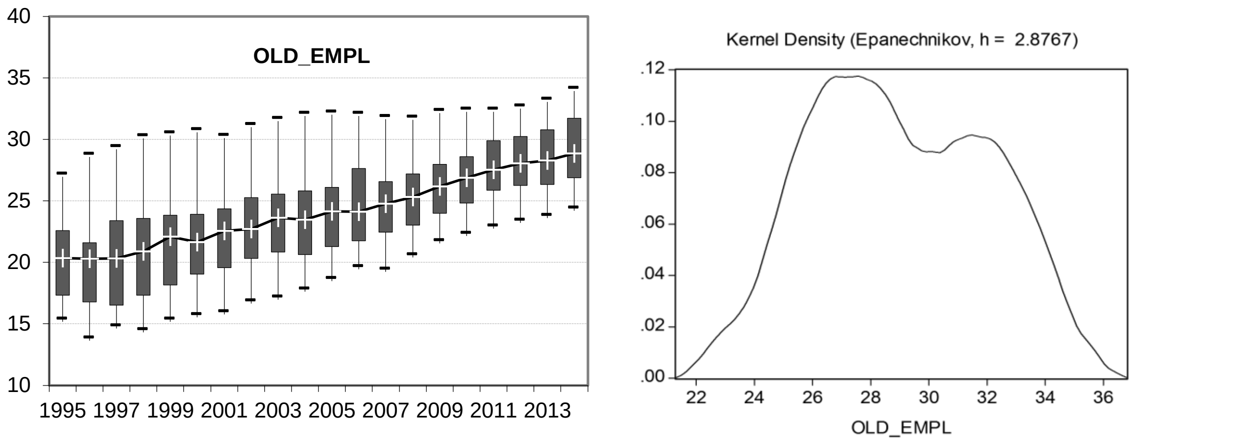

Figure 2. Box plots (1995–2014) and Kernel-density estimates (2014) of the old employment ratio (50 years and over/15 years and over) in European Union countries (%)

The investigation of the situation of EU countries in terms of the share of elderly population in total employment has shown that the aging workforce is a reality not only in developed countries but also in developing ones. Basically, the most challenging problems are expected in the latter and they are also the ones that will have the most to learn from the experience of countries that have come to successfully cope with the challenges of this phenomenon.

Overall, we can suppose that some of the factors contributing to increasing competitiveness of the analysed countries are an economic structure based on high-tech and less labour intensive industries and involvement of young people in innovative activities.

Data and Methods

In order to check whether and to what extent aging population may have an impact on labour productivity, especially which of the sectors will be most affected, an econometric model with panel data was constructed.

The literature consecrated different representations of the economic competitiveness or labour productivity, each of which being decomposed in several driving factors.

For example, GDP per capita can be decomposed into two elements, summarizing the main sources of competitiveness (productivity and employment rate):

$$\frac{GDP}{Population} = \frac{GDP}{Employment} * \frac{Employment}{Population} \qquad (6)$$

Other ways of decomposition GDP per capita, which capture the influence of different factors (i.e. productivity, employment rate, activity rate, work-leisure, age structure of the population), are:

$$\frac{GDP}{Population} = \frac{GDP}{Employment} * \frac{Employment}{Labour\_resources} * \frac{Labour\_resources}{Population} \quad (7)$$

or (Cambridge Econometrics, 2003):

$$\frac{GDP}{Population} = \frac{GDP}{Hours\_worked} \cdot \frac{Hours\_worked}{Employment} \cdot \frac{Employment}{Working\_age\_population} \cdot \frac{Working\_age\_population}{Population} \quad (8)$$

In this paper, labour productivity has been decomposed in two factors: labour productivity of the elderly and their share in labour force.

A Cobb-Douglas production function was estimated, which wants to measure the impact of sectoral share of older employees on labour productivity in the sectors analysed:

$$\ln EP_{it} = \alpha_i + \beta_1 \cdot \ln OLDEP_{it} + \beta_2 \cdot \ln OLDEMPL_{it} + \beta_3 \cdot D_t + \sum_i \gamma_i \cdot \ln X_{it} + \varepsilon_{it} \quad (9)$$

where EP_{it} is GVA/employment (15 years and over), $OLDEP_{it}$ represents GVA/old employment (50 years and over), $OLDEMPL_{it}$ is the share of the employees aged 50 years and over in total employment (15 years and over), D_t is a dummy variable that takes 1 for the year 2008 and 0 otherwise, X_{it} contains other control variables related to the capital endowment (two variables has been separately tested: intellectual property products per person employed and total fixed assets per person employed), *i* is the cross-section index and *t* refers to time period.

Panel Data Analysis has been used in order to study the cross-sectional and time variation, analysing the available data from two perspectives:

(1) At first, equation (9) has been applied for each country considering *t* as the time period and *i* the cross-section, the domain/ the sector of the economy. The five sectors on which econometric analysis was focused are: *Agriculture (AGR), Manufacturing (MAN), Construction (CONS), Market services (MARK)* (Wholesale and retail trade, transport, accommodation and food service activities, Information and communication, Financial and insurance activities, Real estate activities), the *Other services (OTH).*

(2) Then, equation (9) has been used for each sector of the economy considering *t* as the time period and *i* the cross-section, the country.

Giving that the time span is sufficiently long (1995–2013) and 4, respectively 5 cross-sections have been included in the models, the following approach on the panel analysis has been preferred:

A. Stationarity of the series;
B. Cointegration analysis;
C. Parameter estimation according to the results obtained at points A) and B);
D. Testing parameters and the most important hypotheses.

Results

In the first perspective, equation (9) has been applied for each country considering t the time period and i the cross-section, the domain/ the sector of the economy.

A. The stationarity analysis was made using both types of test available in Eviews, Levin, Lin and Chu (2004) and Breitung Tests (2000) which assume common unit root and respectively Im, Pesaran and Shin-IPS (2003), ADF-Fisher and PP-Fisher which assume individual unit root process. The Hadri test of which null hypothesis assume non-stationarity has been applied occasionally, only to have a better image of the results. The tests have been applied including both variants “individual intercept” and “individual intercept and trend”. The majority tests’ results are usually convergent but sometimes their conclusions are mixed. The criterion of “majority” has been completed with the results of IPS test which is more powerful than other mentioned above. The synthetized conclusions are thus given in Table 2.

Table 2

Panel stationarity of implied series at level decision

Are the analysed time series stationary?	GER	NETH	AUT	FIN
LOG(GVA_EMP15)	NO	NO	NO	NO
LOG(GVA_EMP50)	NO	NO	NO	NO
EMPL50_15	NO	NO	NO	NO
LOG(ASSET/EMP)	NO	NO	NO	NO

Note: 1. *the decisions were taken at p-values lower than 0.05
2. GER-Germnay, NETH-Netherlands, AUS-Austria, FIN-Finland

As the results presented in Table 2 demonstrate, the variables analysed are not stationary. The same tests have been applied after taking the first differences and the results are convergent, the series have become stationary. Thus all the variables included in the model are considered to have a first order integration or I(1). Since all the series are assumed to be I(1) then the co-integration analysis has been performed.

B. Several cointegration tests are available in the literature with two different perspectives. Mc Coskey and Kao (1998), Kao (1999) and Pedroni (1995; 1997; 1999) have a residual based approach, while Groen and Kleibergen (1999), Larsson and Lyhagen (1999) and Larsson, Lyhagen and Lothgren (2001) follow a maximum likelihood approach. Gutierez (2003) and later Deniz and Karaman (2007) have shown that when T=10 to 25 and N=10 the Kao test is more powerful than Pedroni Test and LR based test. Thus even if more variants of cointegration tests have been used, the Kao (1999) test results has been chosen to take the final decision regarding the cointegration analysis in the investigation process. The results of Kao test are synthetically presented in Table 3.

Table 3

Cointegration analysis results in the four countries

Are the listed variable cointegrated?	GER	NETH	AUT	FIN
LOG(GVA_EMP15), LOG(GVA_EMP50), EMPL50_15, LOG(ASSET/EMP)	YES***	YES**	YES**	YES***

Note:1. Decision was taken at *** p-value <1%, ** p-value 1-5%

The results point to the fact that the analysed variables are co-integrated, confirming thus a long-run relationship between them.

C. Equation and parameters estimations

In order to provide trustable estimators, the appropriate methods of estimation have been identified and applied. Kao and Chiang (2000) show that for finite dynamic panels, Dynamic DOLS, proposed by Stock, and Watson (1993) and developed by Mark and Sul (2003) for panel data, overfit the classical OLS and Fully modified (FMOLS) estimators.

DOLS approach start from the classical panel model but brings as factors the lags and leads of the I(1) determinant variables. So the model can be expressed for each country like:

$$y_{it} = \alpha_i + x_{it}\beta + \sum_{k=l}^{L} \delta_i \Delta x_{i,t+k} + \varepsilon_{it} \qquad (10)$$

where y is the dependent variable, in our case the overall productivity and x the covariates/factors. Δx represents the lags and leads "artificial" factors obtained from the initial x covariates. The last term of the equation is the error term or the perturbance assumed to be white noise.

Thus, in this case, the method Cointegrating Panel Regression, Panel DOLS was applied in order to estimate de long-run relationships and the results are given in Table 4.

Table 4

Equation estimation results****

Covariates (factors)	Coefficient/Country			
	GER	NETH	AUT	FIN
LOG (GVA_EMP50)	0.782***	0.549***	0.817***	0.626***
EMPL50_15	0.0249***	0.0321***	0.015***	0.004***
LOG (ASSET/EMP)	-0.093***	0.0107***	-0.067***	0.044***
DUM	0.027**	-0.022***	0.109***	0.016***
R-squared	0.821***	0.376***	0.682***	0.692***

Note: 1. *** p-value<1% ** p-value 1–5% **** no additional trends were considered and the pooled option was also used as a base in the estimation procedure.

Note: 2. Eviews 9 Software was used for performing all the tests and estimations procedures.

D. The Wald test was also performed for each set of coefficients for every country. The null hypothesis was rejected in each case (country) at p-value level less than 0.1 %.

The second perspective assumes that equation (9) is now applied for each sector of the economy considering t, time period and i, the cross-section, the country.

The same procedure as in the first perspective has been followed and the synthetized conclusions for the stationarity are presented in the Table 5.

Table 5

The results of panel stationarity analysis

Which is the integration order of the series?	AGR	MAN	CONS	MARK	OTH
LOG(GVA_EMP15)	I(1)	I(1)	I(1)	I(1)	I(1)
LOG(GVA_EMP50)	I(1)	I(1)	I(1)	I(1)	I(1)
EMPL50_15	I(1)	I(1)	I(1)	I(1)	I(1)
LOG(ASSET/EMP)	I(0)	I(1)	I(1)	I(1)	I(0)

Note:1. *the decisions were taken at p-values lower than 0.05

The results are similar with those obtained in the first perspective but now some series are stationary at level or I(0). In this case also, the cointegration analysis was run but, as mentioned before, the Kao test was used as guideline for the final decision. The results are varying from one sector to another as it can be seen in the next table (Table 6).

Table 6

Cointegration analysis results

Are the listed variable cointegrated?	AGR	MAN	CONS	MARK	OTH
LOG (GVA_EMP15), LOG (GVA_EMP50), EMPL50_15, LOG (ASSET/EMP)	x	YES**	NO	YES ***	x

Note:1. Decision was taken at *** p-value <1 %, ** p-value 1–5 %, x – not applicable

When the equation implied only the I(1) series, like in Manufacturing and Market sectors, the long-run and short run relations were studied by cointegration analysis. Due to the fact that cointegration analysis shows a long-run relationship, the PDOLS estimation method has been again chosen, as described in the "per country" approach and long-run coefficients are given in Table 7. When the mix of I(0) and I(1) as in the case of Agriculture and Other sectors or I(1) only, but not cointegrated variables, (the case of Construction) were included in the equation, the Autoregressive Distributed Lag (ARDL) approach proposed by Pesaran and Shin (1999) was performed for long-run or short run estimations. The Akaike criterion regarding the automatic lag selection in the ARDL approach indicates that in the case of Agriculture and Construction the best model is given by an ARDL (2,2,2,2) meanwhile in the Other sectors the best model is represented by ARDL (2,1,1,1).

Table 7

The long-run relations estimated by ARDL or PDOLS methods

Dependent variable	D(log (GVA_EMP15))	Log (GVA_EMP15)	D(log (GVA_EMP15))	Log (GVA_EMP15)	D(log (GVA_EMP15))
Covariates (Factors)/sector	AGR	MAN	CONS	MARK	OTH
LOG(GVA_EMP50)	0.872***	0.998***	-0.745	0.763***	0.540***
EMPL50_15	0.011**	0.051***	-0.010*	0.035***	0.009
LOG(ASSET/EMP)	-0.088*	-0.275***	0.975	-0.095**	0.077
DUM(*)	0.022**	0.042	0.001	0.056	-0.0007
Cointegration coefficient	-0.017*		-0.017		-0.063**
Estimation method	Panel ARDL	PDOLS	Panel ARDL	PDOLS	Panel ARDL
Adj. R-squared		0.76		0.87	

Note:1. *** p-value<1% ** p-value 1-5% *p-value <10%.

2. (*)The dummy variable measuring the crisis impact was specified only in the short-run equation.

3. Supplementary settings for PDOLS-no trend specification, lag and lead, automatic selection by Akaike criterion, panel method=grouped

Conclusion

Given demographic context in which developed and developing countries are functioning (reducing the number of their population, increasing the share of elderly, growing migration, changes into the structure of abilities, skills, qualifications held by workers and so on) this paper has set as main objective to comparatively analysed the effects of aging on sectoral productivity in the most attractive part of the Euro-zone, the North (Germany, Netherlands, Austria and Finland) looking for the driving factors of these countries long-term competitiveness, as key solutions to the problems caused by aging.

The main research questions for which we sought answers in this paper are: a) which are the main characteristics of the four economies in terms of the economic structure (employment distribution by sectors, specialization and economic sectors most affected by aging) b) how an aging workforce can influence labour productivity at sectoral level; c) what type of policies should be adopted to successfully overcome the consequences of aging.

The analysis of statistical data related to the economic structure of the four countries in terms of value added and employed population shows that the economy of these countries rely priority on manufacturing, while in recent years the branches that have had some of the highest growth rates of employment were *professional, scientific and technical activities; administrative and support service activities*; *real estate activities* and *information and communication*. The latter are also the sectors where the share of elderly population is the lowest. This means that one of the factors contributing to increasing competitiveness of the analysed countries is an economic structure based on high-tech and less labour intensive industries and involvement of young people in innovative activities.

Moreover this paper has tested the hypothesis that aging (increasing the share of elderly, 50+, in total employment, 15+) could have a positive impact on sectoral productivity in the four developed countries analysed.

The first econometric model analysing the impact of aging on national competitiveness, more precisely on total labour productivity, has verified the influence of factors such as: labour productivity of older employees, their share in employment, fixed capital (represented by total assets per person employed) and the year 2008, when economic and financial crisis began.

The results for each of the four countries allow drawing some general observations for the group and highlighting some differences between them. Due to the fact that the entire coefficients are statistically significant the defined relations between variables are long term relationships.

In line of other recent studies on the same subject, it seems that both labour productivity and proportion of older people have a positive impact on total labour productivity in each of the four countries. The influence of fixed capital is differentiated by groups of two countries, positive in the Netherlands and Finland and negative in Germany and Austria. The starting year of the crisis, 2008, tends to be negatively correlated with labour productivity only in Netherlands, the coefficients obtained for the other three countries being positive. The variation of the results between countries is relatively small. Assuming that the variables are homogenous in scale, it can be noticed that the highest impact of the older age productivity on total productivity is in Austria and Germany, meanwhile the highest impact of older employee share is in Germany and the Netherlands.

The results relatively surprising about the negative impact of fixed capital on labour productivity in Germany and Austria may be linked to the large share of elderly employed in branches using advanced technology, but also large share of these industries in gross value added. Thus, according to the studies mentioned in this paper, an aging society tends to affect priority innovative sectors in terms of labour productivity, older people having greater difficulties in adopting new technologies.

The second econometric model has analysed the influence of the same factors on total labour productivity for each of the five sectors considered. This analysis reveals a high heterogeneity of the results. Even so, there are some commune features which have important economic implications.

The older adults' productivity has a positive and direct impact on the overall productivity. The effect seems to be absent in the construction sector. This result can be explained by the fact that in this field of activity the specificity implies mostly working with young and not too highly educated labour force, capable to carry out hard work.

The dummy variable measuring the impact of the starting year of the crisis is generally not significant, perhaps showing a high homogeneity across the sectors within the same country.

The asset/employee variable generally has curious effect, implying negative influence on total productivity, being now a subject for further investigations.

Across the sectors it seems to be a mix of long-run and short-run relationships. Disequilibria have been identified in Agriculture, Construction and Other sectors with magnitude values between 1.7 % (Agriculture) and 6.3 % (Other sectors), meaning that 1.7 % and respectively 6.3 % of the imbalances are absorbed in one year.

Therefore, we expect that at macroeconomic level, especially in emerging countries, the sectors most affected by workforce aging to be the least technologically advanced and those that require as main qualities either brute force or intelligence and openness to new and innovation.

In this sense, it is important to also take a look to the difficulties that developed countries have faced in trying to solve the problem of aging through measures that targets older workers. Van Dallen *et al.* (2010) points out to the differences arising between the policies promoted by the Dutch Government and their practical implementation by companies.

In this context, government policies that promote retention in activity for a longer period of time of older workers and measures to increase their productivity should be accompanied by concrete measures to stimulate companies to implement them.

The problem of an aging workforce can be solved, according to the Ciutiene & Railaite (2015) by changing attitudes about the ability of older workers to learn new things, to adapt to new. Aging workforce must be integrated into the working environment without discrimination, through the use of age management techniques that focus on individual qualities and not on age. But, this problem has not a miracle solution, because "the challenges of aging workforce require a complex and interdisciplinary solutions."

On the other hand, attracting young immigrants with the aim to supplement labour resources can enhance economic competitiveness if these people are stimulated and help to acquire higher qualifications such that they can be involved in activities that bring added value for the economy and higher income and standards of living for their families. Otherwise, there is a risk of being accelerated the polarization of employment towards the sectors that have low productivity and widened the gap between rich and poor social categories. Aging itself is a process that contributes to the growth of these sectors, e.g. elderly care services.

In the case of developing countries, education remains one of the domains that need to invest in priority. Today, young people should be provided with skills and competencies that make them adaptable to future labour market needs. Middle-aged population should be engaged in training programs and lifelong learning for the same reasons.

The developed countries have adopted proactive measures of employment and social protection to mitigate the effects of the demographic crisis, in the medium and long term.

At the macroeconomic level, demographic policies should be correlated to other economic policies, in order to stimulate fertility, increased life expectancy and improved quality of life, reduction of dependence of the elderly, reforming pension systems and supporting programs for lifelong learning.

References

Agenor, P. R. (2015). Public capital, health persistence and poverty traps. *Journal of Economics*, 115(2), 103–131. http://link.springer.com/article/10.1007/s00712-014-0418-0

Bloom, D. E., Canning, D., & Fink, G. (2010). Implication of population ageing for economic growth. *Oxford Review of Economic Policy*, 26 (4), 583–612. http://www.ifa-fiv.org/wp-content/uploads/2015/03/4-Implications-of-Population-Ageing-for-Economic-Growth.pdf http://dx.doi.org/10.1093/oxrep/grq038

Boersch-Supan, A. (2001), Labor Market Effects of Population Aging, NBER Working Paper Series, http://www.nber.org/papers/w8640.pdf

Brunow, S., & Hirte, G. (2009). The age pattern of human capital and regional productivity: A spatial econometric study on German regions. *Papers in Regional Science*, 88 (4), 799–823. http://dx.doi.org/10.1111/j.1435-5957.2009.00228.x

http://econpapers.repec.org/article/blapresci/v_3a88_3ay_3a2009_3ai_3a4_3ap_3a799-823.htm

Cambridge Econometrics (2003). A Study on the Factors determining Regional Competitiveness in the EU. European Commission, Brussels. http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/3cr/competitiveness.pdf

Cervellati, M., & Sunde, U. (2015). The Economic and Demographic Transition, Mortality and Comparative Development. *American Economic Journal-Macroeconomics*, 7 (3), 189–225. http://dx.doi.org/10.1257/mac.20130170

http://pubs.aeaweb.org/doi/pdfplus/10.1257/mac.20130170

Ciutiene, R., & Railaite R. (2015). Challenges of managing an ageing workforce. *Engineering Economics*, 26(4), 391–397. http://www.inzeko.ktu.lt/index.php/EE/article/view/7081/7168 http://dx.doi.org/10.5755/j01.ee.26.4.7081

Deniz, O., & Karaman, D. (2007). Comparison of Panel Cointegration tests. *SBF 649 Discussion Paper 2007-029*, Humboldt-Universitat zu Berlin, Germany. http://edoc.hu-berlin.de/series/sfb-649-papers/2007-29/PDF/29.pdf.

Dimian, G.C., Ileanu, B., Jablonsky, J., & Fabry, J. (2013). Analysis of European labour market in the crisis context. *Prague Economic Papers*, 1, 50–71. http://www.vse.cz/pep/440?lang=en http://dx.doi.org/10.18267/j.pep.440

European Central Bank – ECB. (2004). Sectoral Specialisation in the EU: A Macroeconomic Perspective. Occasional paper series, 19 (2004). https://www.ecb.europa.eu/pub/pdf/scpops/ecbocp19.pdf?ba55e236c83544d51379d097ffa2198d

European Commission. (2014). The 2015 Ageing Report. Underlying Assumptions and Projection Methodologies. http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee8_en.pdf

European Economy 8/2014, Joint Report prepared by the European Commission, (DG ECFIN) and the Economic Policy Committee (AWG). http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee8_en.pdf

European Statistics – EUROSTAT. (2015). Population structure and ageing. http://ec.europa.eu/eurostat/statistics explained/index.php/Population_structure_and_ageing.

European Statistics - EUROSTAT Database. (2015). http://ec.europa.eu/eurostat/data/database.

Feyrer, J. (2007). Demographics and Productivity. *Review of Economics and Statistics*, 89(1), 100–109. http://www.mitpressjournals.org/doi/abs/10.1162/rest.89.1.100#.VpubxumD5z8 http://dx.doi.org/10.1162/rest.89.1.100

Fougere, M., Mercenier, J., & Merette, M. (2007). A sectoral and occupational analysis of population ageing in Canada using a dynamic CGE overlapping generations model. *Economic Modelling*, 24 (4), 690–711. https://www.researchgate.net/

publication/221993056_A_Sectoral_and_Occupational_Analysis_of_Population_Ageing_in_Canada_Using_A_Dynamic_CGE_Overlapping_Generations_Model http://dx.doi.org/10.1016/j.econmod.2007.01.001

Gobel, C., & Zwick, T. (2009). Age and Productivity – Evidence from Linked Employer Employee Data. *Discussion Paper No. 09-020*. ftp://ftp.zew.de/pub/zew-docs/dp/dp09020.pdf.

Gronqvist, C. (2009). The effect of labour force ageing on productivity in Finland. Bank of Finland, Monetary Policy and Research, 15 April 2009. https://helda.helsinki.fi/bof/bitstream/handle/123456789/8471/161455.pdf?sequence=1.

Groen, J. J. J, & Kleibergen, F. (1999), Likelihood-Based Cointegration Analysis in Panels of Vector Error Correction Models, http://papers.tinbergen.nl/99055.pdf

Gutierez, L. (2003). On the power of panel cointegration tests: a Monte Carlo Comparison. *Economics Letters*, 80, 105–111. http://down.cenet.org.cn/upfile/54/200542093613124.pdf http://dx.doi.org/10.1016/S0165-1765(03)00066-1

Heikkila, E. (2012). Labour Market Participation of Immigrants in Finland and its Regions. The European Social Science History Conference, Glasgow, Scotland, UK, 11–14 April 2012. http://maine.utu.fi/articles/078_Heikkila_Labour_Market.pdf

International Labour Organization. (2014). Global Employment Trends 2014: Risk of a jobless recovery? International Labour Office. Geneva: ILO (2014). www.ilo.org/wcmsp5/groups/public/---.../wcms_233953.pdf

Kao, C., & Chiang, M. H. (2000). On the Estimation and Inference of a Cointegrated Regression in Panel Data. *Advances in Econometrics*, 15, 179–222. http://dx.doi.org/10.1016/S0731-9053(00)15007-8

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.6.6161&rep=rep1&type=pdf

Kolasa, A., & Rubaszeck, M. (2015). The effect of ageing on the European economies in a life-cycle model. *Economic Modelling,* 52(A), 50–57. http://www.sciencedirect.com/science/article/pii/S0264999315001753

Korotayev, A., Goldstone, J.A., & Zinkina, J. (2015). Phases of global demographic transition correlate with phases of the Great Divergence and Great Convergence. *Technological Forecasting and Social Change Journal*, 95, 163–169. http://cliodynamics.ru/download/Korotayev_Goldstone_Zinkina_Great_Convergence_TFSC_2015.pdf http://dx.doi.org/10.1016/j.techfore.2015.01.017

Larsson, R., & Lyhagen, J. (1999), Likelihood-based inference in multivariate panel cointegration models. Working Paper Series in Economics and Finance, 331, Stockholm School of Economics.

Larsson, R., Lyhagen, J., & Lothgren, M. (2001) Likelihood-based cointegration tests in heterogeneous panels. Econometrics Journal, 4, 109–142 http://dx.doi.org/10.1111/1368-423X.00059

Levin, L., & Chu, LLC. (2002). Unit root tests in panel data: asymptotic and finite sample properties. *Journal of Econometrics*, 108, 1–24. http://www.sciencedirect.com/science/article/pii/S0304407601000987 http://dx.doi.org/10.1016/S0304-4076(01)00098-7

Lugauer, S. (2012). The supply of skills in the labor force and aggregate output volatility. *Research in Economics*, 66 (3), 246–232.http://www.sciencedirect.com/science/article/pii/S1090944312000154 http://dx.doi.org/10.1016/j.rie.2012.03.002

Mihaescu,C., Niculescu-Aron, I.G., & Petre D. (2009), Natality Impact on Recent Demographic Ageing Dynamics in Romania, *Journal of Applied Quantitative Methods*, 4 (3)., http://www.jaqm.ro/issues/volume-4,issue-3/pdfs/mihaescu_niculescu_petre.pdf

Organisation for Economic Co-operation and Development – OECD. (2013). Demographic change in the Netherlands: Strategies for labour markets in transition. www.oecd.org/cfe/leed/demo_change_netherlands.pdf

Mahlberg, B., Freund, I., Cuaresma, J. C., & Prskawetz, A. (2013). Ageing, productivity and wages in Austria, *Labour Economics*, 22(100), 5–15. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3626229/ http://dx.doi.org/10.1016/j.labeco.2012.09.005

Mark, N. C., & Sul, D. (2003) Cointegration Vector Estimation by Panel DOLS and Long-run Money Demand. *Oxford Bulletin of Economics and Statistics*, 65(5), 0305–9049, http://www3.nd.edu/~nmark/wrkpaper/PDOLS_Oxford_Bulletin.pdf

McCoskey, S., & Kao, C. (1998). A residual-based test of the null of cointegration in panel data. *Econometric Reviews*, 17(1), 57–84, http://dx.doi.org/10.1080/07474939808800403

Pedroni, P. (1995), Panel cointegration; asymptotic and finite sample properties of pooled time series tests, with an application to the PPP hypothesis, *Working Paper Series in Economics,* No. 95–013, Indiana University, http://dx.doi.org/10.1111/1468-0084.61.s1.14

Pedroni, P. (1999), Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics,* 61, 653–670. http://web.williams.edu/Economics/wp/pedronicriticalvalues.pdf

Pedroni, P. (1997) Panel Cointegration; Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with an Application to the PPP Hypothesis: New Results Working paper, Indiana University

Pesaran, M. H., & Shin, Y. (1999), An autoregressive distributed lag modelling approach to cointegration analysis", In: Strom, S., Holly, A., Diamond, P. (Eds.), *Centennial Volume of Rangar Frisch*, Cambridge University Press, Cambridge. http://dx.doi.org/10.1017/ccol521633230.011

Peschner, J., & Fotakis, C. (2013). Growth Potential of EU Human Resources and policy implication for future economic growth, *European Commission Working Paper* 3 (2013). ec.europa.eu/social/BlobServlet?docId=10939&langId=en

Rees, P., Van der Gaag, N., De Beer, J., & Heins, F. (2012). European Regional Populations: Current Trends, Future Pathways, and Policy Options. *European Journal of Population*, 28 (4), 385–416. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3496551/ http://dx.doi.org/10.1007/s10680-012-9268-z

Rougoor, W., & Van Marrewijk, C. (2015). Demography, Growth, and Global Income Inequality. *World Development Journal*, 74, 220–232. http://www.sciencedirect.com/science/article/pii/S0305750X15001229 http://dx.doi.org/10.1016/j.worlddev.2015.05.013

Startiene, G., & Remeikiene, R. (2009). The Influence of Demographical Factors on the Interaction between Entrepreneurship and Unemployment. *Engineering Economics*, 64(4), 60–70. http://www.inzeko.ktu.lt/index.php/EE/article/view/11613/6296

Stock, J. H., & Watson, M. W. (1993). A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems. *Econometrica*, 61 (4), July, 783–820. http://dx.doi.org/10.2307/2951763

Vaittinen, R., & Vanne, R. (2014). The role of demography in recent macroeconomic development in Finland, 10th International Symposium on Demographic Change and Policy Responses, Beijing, 13-14.11.2014. http://www.ntaccounts.org/doc/repository/Vaittinen%20and%20Vanne%20presentation.pdf.

Van Dalen, H. P., Henkens, K., & Schippers, J. (2010). How do employers cope with an ageing workforce? Views from employers and employees. *Demographic Research*, 22 (32), pp. 1015–1036. Van Ours, J.C., & Stoeldraijer, L. (2011). Age, Wage and Productivity in Dutch Manufacturing, *De Economist*, 159 (2), 113–137. DOI 10.1007/s10645-011-9159-4. http://paperity.org/p/31560370/age-wage-and-productivity-in-dutch-manufacturing. http://dx.doi.org/10.4054/ DemRes.2010.22.32

Van Ours, J.C., & Stoeldraijer, L., (2011) Age, Wage and Productivity in Dutch Manufacturing, De Economist, 159 (2) (2011), pp. 113–137. DOI 10.1007/s10645-011-9159-4. http://paperity.org/p/31560370/age-wage-and-productivity-in-dutch-manufacturing. http://dx.doi.org/10.1007/s10645-011-9159-4

Weidmann,J. (2014). Demographic challenges in Germany, Speech delivered at the Wirtschaftsgesprache am Main economic talks hosted by Wirtschaftsinitiative Frankfurt/Rhein-Main e.V., Frankfurt am Main, 2014-11-27, http://www.bundesbank.de/Redaktion/EN/Reden/2014/2014_11_27_weidmann.html.

WEF - World Economic Forum. (2012). Global Agenda Council on Ageing Society, Global Population Ageing: Peril or Promise? www.weforum.org/reports/global-population-ageing-peril-or-promise

World Bank, 2013. Mitigating the Economic Impact of an Aging Population: Options for Bulgaria Poverty Reduction and Economic Management Europe and Central Asia Region.

Zhang H. F., Zhang H. L., & Zhang J. S. (2015). Demographic age structure and economic development: Evidence from Chinese provinces. *Journal of Comparative Economics*, 43(1), 170–185. http://www.sciencedirect.com/science/article/pii/S0147596714000638 http://dx.doi.org/10.1016/j.jce.2014.07.002

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