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ESTIMATING THE RELATIONSHIP BETWEEN DEPENDENCY RATIO AND SOCIAL PROTECTION EXPENDITURE. EVIDENCE FROM THE EUROPEAN UNION

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ABSTRACT. This study presents a comprehensive analysis of the relationship between the share of the dependent population in the working-age population and social protection expenditure. The analysis is conducted for a panel consisting of 25 European Union (EU) countries. Dependency ratios were used as the main determinants of social protection expenditures. The conducted pre-estimation tests examined cross-sectional dependence, slope heterogeneity, unit roots, and cointegration. The econometric approach was then used to estimate long-run elasticities. The effects were controlled using augmented mean group (AMG) and common correlated effects mean group (CCEMG) estimators, with robustness checks also performed. The findings demonstrate that population ageing, as proxied by the old-age dependency ratio, substantially affects social protection expenditure in EU economies. The key policy implication is that social support expenditures are more closely linked to the older adults than to the younger population, which highlights the need for targeted reforms and enhanced care for older adults in society. The research offers valuable insights into one of the most critical issues for the EU-namely, the strong trend of aging populations, the rise in social expenditures, and their long-run interconnections.

JEL Classification: C23, H50, H53, J11

Keywords: social protection expenditure, population ageing, dependency ratio, long-run elasticities

Introduction

The European Union countries have recently increased social protection expenditure. Concurrently, the demographic processes observed in these countries have affected the size of the dependent-to-working-age population ratio. The demographic changes, expressed mainly by an increase in older adults and a shrinking working-age population, have affected public spending, particularly social protection expenditure.

Social protection expenditures are the main category of general government spending in the European Union (EU) economies, with an average share of 36.6% in 2015, 39.7% in 2021, and 39.3% in 2022. When the spending is expressed as a percentage of GDP, the average ratio was around 19.5% in 1995, 20.3% in 2021, and 19.4% in 2022. The share of social protection spending was temporarily higher in 2020-2021 due to the effects of the Covid-19 pandemic. Social protection expenditure, by its definition, is mainly targeted at dependent people. In recent years, the changes in population structure, driven by advanced aging, have strongly influenced the share of dependent people (i.e., young people and the older individuals). A common economic indicator for measuring the dependent population is the total dependency ratio, i.e., the ratio of the sum of people younger than 15 and people older than 64 to the working-age population (i.e., those aged 15–64). The average value of the total dependency ratio for EU countries increased by around 7 percentage points (p.p.), from 49% in 1995 to 56.5% in 2022.

Population ageing has increased the share of older dependent people who are eligible for social protection. The increase in the dependency ratios affects the rise in social protection spending. In this context, it is necessary to analyse the relationship between social protection spending and the dependent population to evaluate governmental social support, given the potential increase in social costs associated with the high share of dependent people.

The literature offers studies that analyze the determinants of social (welfare) spending (Lindert, 1996, 2004; McManus, 2019; Haelg et al. 2022; Nguyen et al., 2023), including its association with age-dependency (see, e.g., Razin et al., 2002; Disney, 2007; Potrafke, 2009). However, there are relatively few studies that investigate the link in the context of long-run elasticities.

The empirical evidence on the long-run elasticities of social spending, including its association with dependent people, is not fully examined. Therefore, this study aims to fill this gap by investigating the long-run relationship between dependent people and social spending. This is crucial, especially given the advanced population ageing processes in developed economies and their impact on public spending related to age and social support. As mentioned, social expenditure analyses have not been explored with rigorous caution, and this study offers an in-depth analysis in the field, contributing to the literature.

This paper contributes in several ways. First, it investigates the long-run relationship between social spending and measures of the dependent population, highlighting an important issue for EU economies dealing with population ageing. The data covers the period when economies were affected by the consequences of the Covid-19 pandemic, which had a strong impact on the vulnerable population, including older adults. The crisis significantly affected all aspects of their lives, including social life, the labor market, and access to health services.

Secondly, the study analyzes the dependent population and social protection expenditure relationship using a set of dependency ratios. Novel aspects are introduced by estimating long-term elasticities, filling a gap in the literature that predominantly focuses on non-cointegrated relationships. Given the impact of the relationship between the dependency ratio and social-type spending may be ambiguous, there is a need for comprehensive studies, especially for EU economies where the ageing process is advanced and social protection spending constitutes a substantial share of total governmental spending.

Thirdly, this study uses augmented mean group (AMG) and common correlated effects mean group (CCEMG) approaches as the baseline methods to estimate long-run elasticities. The added value of this study lies in estimating long-run elasticities at aggregate and individual levels. This is another contribution of the study, especially since most studies in the field are not based on estimating the long-run relationship, and, as mentioned, do not offer unambiguous findings.

Lastly, and most importantly, the study also evaluates if social expenditures in EU economies are related to dependent populations. It also explores if there is a relationship between income and globalization in the long term and if improved well-being and increased globalization lead to higher welfare protections. Thus, this study links the gap in the literature by comprehensively evaluating the effects of dependent population on social expenditure, including level of income and country-well being and globalization issues.

As mentioned, the study offers an examination of the previously not fully unexplored long-term nexus between social expenditures and the dependent population, introducing a novel factor and thus addressing a gap in the existing literature.

The set of explanatory variables applied in this study is limited due to the time and country sample, with trade openness used as a proxy of globalization and the real GDP per capita used to control economic development and income. The analysis of data and the results of the pre-estimation tests revealed the cointegration relationship between social protection expenditure and a set of explanatory variables, including the effects of the dependent population. The estimated long-term elasticities for the old-age dependency ratio were positive and statistically significant. Additionally, the controlled effect of income was significant, implying a negative relationship with economic development. The long-term relationship covered by the coefficient for the relationship between trade openness and globalization, if statistically significant, was negative.

The rest of the paper is structured as follows. The next section describes a brief literature review. In next section methods and data are outlined. The Results section provides the outcomes and an interpretation of the pre-estimation tests. It also shows the estimates of elasticities obtained using the baseline AMG and CCEMG approaches and robustness checks for fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) estimators. Next section includes discussion. The final section is the conclusions.

1. Literature review

The literature review provides examples of studies in which the relationship between the dependency ratio (as well as young- and old-age dependency ratios) and social expenditures is analyzed. However, there is a clear gap and room for analysis here, especially in the area of long-term analysis, resulting from the properties of the time series.

As revealed, the research generally did not apply the cointegration and long-term investigation between social spending and dependency ratios. Examples of those (non-cointegrating) studies include Bryant (2003) and Disney (2007), who tested the impact of the age dependency ratio on welfare spending, investigating a net positive relationship between these two variables. Potrafke (2009) and Tepe and Vanhuysse (2009) also mentioned the positive relationship between the age dependency ratio and welfare spending in OECD countries. By contrast, Razin et al. (2002) found a negative relationship between the dependent variable, which was social transfers per capita, and the dependency ratio. Haelg et al. (2022) included the old-age dependency and young-age dependency ratios in the regression of social expenditures in 31 OECD countries between 1980 and 2016. They showed a positive relationship between population ageing (old-age dependency ratio) and social expenditures, presented as a % of GDP. Busemeyer (2009) analyzed a panel of 21 OECD countries between 1980 and 2004, reporting a positive but not significant relationship between the change in public social spending and a change in the age dependency ratio. Gugushvili and Meuleman (2022) used the old-age dependency ratio as an explanatory variable for social protection spending in a random effect model in post-communist countries from 1995–2019. The old-age dependency ratio revealed the importance of the variable in a social protection specification, and the estimates showed that nearly a unit increase in the variable was associated with a 0.19 unit increase in social protection spending. They concluded that in post-communist countries, as in Western countries, the relationship between population ageing and welfare spending was positive. Karaalp-Orhan et al. (2024), in their study on OECD economies, applied dependency ratios in their specification for social expenditures. They found a significant effect of the old-age dependency ratio, while the effect of the young-age dependency ratio was insignificant. Moreover, the old-age dependency ratio emerged as the most influential demographic factor for social expenditure.

Most studies, primarily based on non-cointegration analyses, provides another set of variables applied in social protection spending regressions or wider categories of spending consider factors reflecting income and economic level (proxied by GDP or GDP per capita, unemployment rate), as well as globalization (proxied by trade openness, globalization indexes). Important are also other socio-economic factors like inflation rate, level of government efficiency, the structure of the population, level of corruption, and many others (for details, see Habibi, 1994; Lindert, 1996; Rodrik, 1998; Ko and Min, 2019; Razin et al., 2002; Haelg et al., 2022). However, trade openness (or globalization) and income level are important for a set of macroeconomic determinants.

The effects of globalization were verified by two competing hypotheses (Garrett, 2001): The “efficiency” hypothesis predicts that globalization leads to a cut in social spending to improve the competitiveness of national producers, whereas the “compensation” hypothesis predicts that globalization increases economic volatility and insecurity. It thus creates public demand for social protection and leads to an increase in public expenditure (Cameron, 1978; Rodrik, 1998). Consequently, there is a mix of results reported in the literature (see e.g., Avelino et al., 2005; Potrafke, 2019; Bergh, 2021; Santos and Simoes, 2021; Schuknecht and Zemanek, 2021; Lim et al., 2022; Bharati et al., 2023; Wu et al., 2023).

Another important measure is GDP per capita, which is often used as a proxy of income or the measure of economic condition. This variable was an important determinant in the works of Wagner (1883), Avelino et al. (2005) or Gugushvili and Meuleman (2022), among others. The link between economic recession and spending on health insurance was examined by Artabe and Sigüenza (2019) for Spain between 2006 and 2012. They revealed that recession did not influence the level of expenditure on private health insurance.

The long-run relationship analysis in the context of public spending is becoming more important, and there has been a particular focus on healthcare spending (Dreger and Reimers, 2005; Barkat et al., 2019; Nasreen, 2021; Espinosa et al., 2023). Nasreen (2021) applied long-run analysis to health expenditures based on a sample of 20 Asian countries between 1995 and 2017. The methods for estimating long-run coefficients were CCEMG and AMG. The study analyzed the long-run association between health expenditures, economic growth, and environmental pollution and showed that environmental pollution significantly increased health spending. The analysis incorporated the Dumitrescu-Hurlin (2012) causality test, revealing two-way causality between health expenditures and economic growth and unidirectional causality from environmental pollution to health expenditures.

Azolibe et al. (2020) conducted a long-run investigation on the determinants of general public expenditure for ten African countries between 1989 and 2018. Using panel dynamic ordinary least squares (DOLS) and fully modified ordinary least squares (FMOLS) approaches, they investigated the influence of the population age structure on public expenditure. The panel cointegration test showed a long-run cointegrating relationship between the dependent variable and a set of selected socio-economic factors (including the age structure of the population, inflation rate, GDP per capita, unemployment rate, and corruption, among others). The FMOLS results showed that the share of older individuals (aged 65 and above) negatively influenced public expenditures, but insignificantly. A positive relationship was observed for populations aged 0–14 and 15–65, with a stronger and more significant influence for the group aged 0–14. The long-run relationship was not significant for public expenditure and GDP per capita.

Several studies refer to general social spending. For example, Lee and Chang (2006) provided a cointegration test for a panel of countries using FMOLS. They obtained long-run bidirectional causality between GDP and social security expenditure for a cross-section of OECD countries. However, that study focused more on the impact of social spending on growth.

2. Methodological approach

2.1. Data and final specifications

The country sample includes 25 EU countries (Ireland and Croatia were excluded due to the gaps in data) for the period from 1995 to 2022. The annual data were obtained from the Eurostat database and the World Development Indicators (WDI) database of the World Bank. The dependent variable is social protection expenditure, expressed as a percent of GDP obtained from Eurostat's COFOG database. The explanatory variable is the non-working population (dependents) expressed as a share of the economically active population. The economically inactive population was captured by the age-dependency ratio, divided into old-age and young-age dependency ratios. The age dependency ratio is understood as the sum of dependents (people younger than 15 and people older than 64) to the working-age population, i.e., those aged 15-64. Thus, the old-age dependency ratio is the ratio of older dependents (i.e., those aged 64 and more) to the working population aged 15-64, while the young-age dependency ratio is the share of those below 15 to the population aged 15-64. The other explanatory variables are real GDP per capita expressed in constant 2015 prices and trade openness. The two control variables were chosen due to their importance in explaining social expenditures presented in the literature. To maintain the same comparativeness, real GDP per capita is expressed in US dollars, and the variable was derived from the WDI database of the World Bank. The variable is applied as a proxy of income and economic development. The variable for trade openness is expressed as a share of the sum of imports and exports in GDP. The importance of the variable was explained in the literature review section and was used to capture the effect of globalization. The final general equation is expressed by formula (1), and it is as follows.

$$ln\_soc\_p_{i,t} = \alpha_0 + \alpha_1\, ln\_dependencies_{it} + \alpha_2\, ln\_gdp\_pc_{it} + \alpha_3\, ln\_trade_{it} + \varepsilon_{i,t} \quad (1)$$

where:
$soc\_p_{i,t}$ – it denotes the dependent variable, which is the social protection expenditure to GDP ratio in the i-th country in the t-th year;
$dependencies_{it}$- is the general representation of the variable in the i-th country in the t-th year covering the share of the dependent population in the working-age population of EU economies. Under investigation were the old-age dependency ratio ($oadr_{it}$), the young-age dependency ratio ($yadr_{it}$), and the total age dependency ratio (adr_{it}). The variables describe the population structure in the economic context. The old-age dependency ratio was also used as a proxy for population ageing. Due to the importance of the three variables, three separate specifications with $dependencies_{it}$ were analyzed: (Model 1) in the sense of the total age dependency ratio, (Model 2) replacement of the total dependency ratio by the sum of the old- and young-age dependency ratios, and (Model 3) the old-age dependency ratio applied as a proxy of population ageing.
$trade_{it}$- is the index for trade openness of EU countries in the i-th country in the t-th year. It is a sum of export and import to GDP ratio;
gdp_pc_{it} - real GDP per capita is a proxy of income in the i-th country in the t-th year.

The data were expressed as natural logarithms, which makes it possible to interpret the estimated coefficients α_1, α_2 and α_3 as elasticities. The selected descriptive statistics for the variable used in the estimations are presented in *Table 1A* in the Appendix.

2.2. Pre-estimation tests and estimation technique

Pre-estimation tests involved the cross-sectional dependency test, a test for slope homogeneity, and a unit root test to analyze the quality of the data and the appropriate choice of estimation techniques. The cross-sectional dependency was validated by the Pesaran (2004) CD test as presented in equation (2).

$$\mathrm{CD} = \sqrt{\frac{2\mathrm{T}}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(\widehat{\rho_{ij}}\right) \Rightarrow \mathrm{N}\ (0,\ 1) \quad (2)$$

where T represents the period, N denotes the cross-section dimension, and $\widehat{\rho_{ij}}$ denotes the sample estimate of the pairwise correlation of the residuals obtained from individual OLS estimations. If the null hypothesis about the cross-section independence is rejected, slope homogeneity is tested in the next step. The test for heterogeneity or homogeneity in the slope coefficients was based on the Pesaran and Yamagata (2008) test, which assumes that $\varepsilon_{i,t}$ and $\varepsilon_{j,s}$ are independently distributed for i ≠ j or t ≠ s, or both, but allows f or heterogeneous variance. Pesaran and Yamagata (2008) based their approach on Swamy's (1970) slope homogeneity test, creating two test statistics: $\tilde{\Delta}$ and $\tilde{\Delta}\ adj$. The null hypothesis is that slope coefficients are homogenous (see Bersvendsen and Ditzen, 2021, for details about the test). The rejection of null for both the test for slope homogeneity and the test for cross-sectional independence involves the second-generation unit root test. In this paper, the Pesaran (2007) test is proposed with the CIPS (augmented cross-sectional IPS) test statistics determined based on the average of the cross-sectional Augmented Dickey-Fuller (CDF) test, and the CIPS is displayed as formula (3):

$$\mathrm{CIPS} = \frac{1}{N}\sum_{i=1}^{n} CDF_i \quad (3)$$

If the series are tested as I(1), then the presence of long-run cointegration is examined. The cointegration of the variables is tested by the Westerlund (2007) cointegration test, which provides four statistics: two group-means statistics G_τ and G_α (equations 4 and 5) and two statistics, P_α and P_τ, (equations 6 and 7) for the panel as follows:

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \quad (4)$$

$$G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \quad (5)$$

$$P_\tau = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \quad (6)$$

$$P_\alpha = T\hat{\alpha} \quad (7)$$

where $SE(\hat{\alpha}_i)$ i is the conventional standard error $\hat{\alpha}_i$, α_i is the error correction parameter, T is the time-series dimension, and N is the cross-sectional dimension. Rejecting the null hypothesis of no error correction denotes the rejection of the null hypothesis of no cointegration.

If the panel exhibits heterogeneity and cross-sectional dependence, and if the series is I(1) and co-integrated in the long term, then the proposal for the main estimation technique is the AMG estimator by Bond and Eberhardt (2009) and Eberhardt and Teal (2010), and the CCEMG estimator by Pesaran (2006). The AMG estimator uses a two-step method to estimate an unobserved common dynamic process and allows for cross-sectional dependence by including the common dynamic process parameter. The estimated coefficients for elasticities were also robustness-checked using standard FMOLS and DOLS estimators. These methods make it possible to control for the endogeneity and serial correlation observed in non-stationary panels (see Kao and Chiang 2001; Narayan and Narayan 2005).

3. Results

3.1. Pre-estimations

The pre-estimation analysis was based on the cross-sectional dependency test, the investigation of slope homogeneity, and the unit root test. The cointegration analysis is also considered as part of the pre-estimation analysis. The results of the Pesaran CD (2004) test are presented in *Table 2A* in Appendix. They indicate that the null hypothesis of cross-section independence is rejected for each variable. Thus, there is strong evidence of cross-section dependency between variables.

In the next step, slope heterogeneity was investigated using the slope heterogeneity test proposed by Pesaran and Yamagata (2008). The null hypothesis of the test statistic is that slope coefficients are homogenous. *Table 3A* presents the results for three different specifications depending on which variable was used to cover the dependent population. It confirms the existence of slope heterogeneities in the empirical setup (due to the rejection of the null). The conclusion is confirmed for both statistics for standard and adjusted deltas. The results affect the choice concerning the unit root test. The cross-section dependency and slope heterogeneity involved the second-generation CIPS unit root test and the Pesaran (2007) test was used. The results are presented in *Table 4A* in Appendix under the null hypothesis that assumes non-stationarity. As indicated in *Table 4A*, the null hypothesis about non-stationarity was not rejected for data in levels (the statistics are lower than the critical value for the 10% significance level). Thus, all variables were tested for unit root at a higher order of integration. The tests for first differences show that the null was rejected. The first difference of each variable is established to be stationary at the 1% significance level. The outcomes imply that all variables are I(1).

The presence of cross-sectional dependency, the first order of integration, and slope heterogeneity support the analysis of the long-term relationship. The cointegration was confirmed, as shown in *Tables 5A–6A* in Appendix. The main test is based on the Westerlund (2007) approach, and the results were verified by the Westerlund (2005) tests of cointegration on a panel dataset.

As shown in *Table 5A*, the statistics G_τ and P_τ generally lead to the rejection of the null in each specification, except for the specification with ln_oadr_{it} and ln_yadr_{it}, where only the P_τ statistics supported rejection. Thus, when ln_oadr_{it} and ln_yadr_{it} were used as regressors (Model II), the Westerlund (2007) panel cointegration test did not reject the null hypothesis of no cointegrating relationship for both two group-mean tests. Therefore, an additional test was applied, and the results of Westerlund's (2005) tests are presented in *Table 6A* for each model. The results in *Table 6A* show that the null is rejected at a 5% significance level for the specification that includes the age dependency ratio (Model I). When the old-age dependency and young-age dependency ratios were applied together (Model II) and when the specification with the old-age dependency ratio (Model III) is examined, the null was rejected at 10%. However, considering the results of both the Westerlund (2007) test and the variance ratio test, the assumption is made that a long-term relationship exists between variables in all three specifications.

3.2. Estimation results

The results for the AMG estimator are presented in *Table 1*. This approach allows for unobserved correlation across panel members (cross-section dependence). The results for the equation involving the age dependency ratio show an insignificant impact on social protection expenditure. Upon differentiating the effect between old-age and young-age dependency ratios, the obtained estimates explain the lack of significance for the total age dependency ratio variable due to the opposite effects of these two variables. As presented in column II of Table 1 (Model II), the effect of the old-age dependency ratio was significant. The estimated elasticity was positive with a value of 0.695, while the effect of the young-age dependency ratio was not significant. The positive and significant effect of population ageing was also obtained when the old-age dependency ratio was only included in the regression (Model III). In this case, the estimated elasticity was slightly lower (around 0.417).

The effect of real GDP per capita was negative and significant regardless of the variable used to capture dependencies. Trade openness was significant when the old-age dependency ratio was included in the specification (Model III) and when the old-age and young-age dependency ratios were included (Model II), and the estimated elasticity was negative. The validity of the estimates was also confirmed by the coefficient for the common dynamic process. In *Table 1*, the coefficient was significant in each specification, and the root mean squared error was very low. The model presented in Column II (Model II) had the lowest Root Mean Squared Error (RMSE), which denotes that it is the best fit for the dataset and that the inclusion of the old-age dependency and young-age dependency ratios is better for the precision of the estimates than relying on the total dependency ratio alone.

Table 1. Results for the AMG estimator

	$ln\_soc\_p_{it}$		$ln\_soc\_p_{it}$		$ln\_soc\_p_{it}$	
	Model I		Model II		Model III	
ln_adr_{it}	0.151	(0.177)				
ln_oadr_{it}			0.695**	(0.243)	0.417**	(0.167)
ln_yadr_{it}			-0.227	(0.191)		
$ln\_gdp\_pc_{it}$	-0.196***	(0.075)	-0.451***	(0.128)	-0.221**	(0.091)
ln_trade_{it}	-0.045	(0.050)	-0.107**	(0.038)	-0.110*	(0.056)
Const	4.339***	(0.849)	6.182***	(1.064)	4.126***	(0.703)
CDP	1.001***	(0.132)	0.848***	(0.124)	1.023***	(0.113)
Obs	700		700		700	
Root Mean Squared Error	0.0442		0.0362		0.0441	

CDP – stands for a common dynamic process.
*, **, *** denote significance at 10%, 5% and 1% respectively. Standard errors in parenthesis.

Source: *own compilation*

The effects for individual objects are presented in the Appendix. The significant effect of the age dependency ratio was estimated for 19 countries, including 13 countries with a positive effect and six with a negative effect (see *Table 7A* in Appendix). When only the old-age dependency ratio was included, the effect was positive and significant for 16 countries (see *Table 8A* in Appendix). The highest elasticity of the relationship between population ageing and social protection spending was obtained for Latvia, Netherlands, Estonia, Cyprus Greece, Spain. Conversely, negative and significant elasticities were found for Hungary, Malta, Slovenia, and Sweden. The inclusion of both the old-age and young-age dependency ratios in the same equation revealed that the two coefficients were significant for 13 economies (*Table 9A* in Appendix). A positive effect of old-age dependency and a negative effect of young-age dependency ratios were observed in seven countries: Belgium, Bulgaria, Czechia, Estonia, Italy, Latvia, and Poland (for Italy and Latvia the coefficients for a common dynamic process were not significant). Both variables were significant and positive for Denmark, Germany, Romania and Finland, although for Denmark, Germany the coefficients for a common dynamic process were not significant. Both coefficients were negative for Luxembourg and Malta (in the case of Malta the coefficient for a common dynamic process was not significant).

The coefficients for real GDP per capita, while statistically significant, were negative in most countries. However, for Hungary the estimated coefficient was statistically positive in each specification. The statistically positive effect of GDP per capita on social protection expenditure was also revealed for Lithuania, Greece and Portugal (Model I), Greece in Model II (see *Tables 7A - 9A* in Appendix). In most cases, the insignificant effect of trade openness on social protection expenditure was confirmed in estimates for individual countries (Tables *7A–9A* in the Appendix). However, if statistically significant, the coefficients were generally negative.

Table 2. Results for the CCEMG and MG estimators

	CCEMG[*]			MG		
	I	II	III	IV	V	VI
	Model I	Model II	Model III	Model I	Model II	Model III
ln_adr_{it}	0.647** (0.322)			0.515* (0.265)		
ln_oadr_{it}		0.499* (0.299)	0.602* (0.353)		1.234*** (0.282)	0.875*** (0.231)
ln_yadr_{it}		0.442 (0.358)			-0.877*** (0.306)	
$ln\_gdp\_pc_{it}$	-0.423*** (0.087)	-0.784*** (0.108)	-0.492*** (0.102)	-0.094 (0.095)	-0.737*** (0.140)	-0.364*** (0.089)
ln_trade_{it}	-0.192*** (0.057)	-0.180*** (0.059)	-0.241** (0.067)	-0.036 (0.048)	-0.203*** (0.043)	-0.160** (0.071)
const	1.454 (1.282)	7.677*** (2.519)	1.985* (1.154)	1.931 (1.306)	9.777*** (1.701)	4.286*** (0.819)
obs	700	700	700	700	700	700
Wald X^2 (p-value)	36.95 (0.0000)	86.40 (0.0000)	40.83 (0.0000)	4.84 (0.1839)	109.92 (0.0000)	25.23 (0.0000)
Root Mean Squared Error	0.0321	0.0255	0.0318	0.0681	0.0494	0.0617

[*] for the CCEMG estimator (columns I, II and III), cross-section averaged regressors were not reported.
*, **, *** denote significance at 10%, 5% and 1% respectively. Standard errors in parenthesis.
Source: *own compilation*

The alternative estimates for robustness checks using the CCEMG estimator are presented in *Table 2* in columns (I-III). The estimated effect of the old-age dependency ratio was positive and significant regardless of whether it was employed alone or with the young-age dependency ratio. The long-run elasticity of the young-age dependency ratio was not significant. In the specification with age dependency ratio (Model I), the estimated coefficient was positive and significant (in AMG, it was insignificant – see *Table 1*).

Columns (IV-VI) show results using the Pesaran and Smith (1995) mean group (MG) estimator, confirming a significant and positive long-run relationship between the old-age dependency ratio and social protection expenditure. The relationship between the young-age dependency ratio and the dependent variable was significant and negative. The effect of total age-dependency ratio was positive and significant; however, the specification for the MG estimator does not have an appropriate set of independent variables, as indicated by a p-value higher than 10% for the Wald test.

Finally, the estimates for the FMOLS and DOLS are presented. These approaches were applied as effective estimators to control the problem of endogeneity, heteroscedasticity, and serial correlation (see, e.g., Yahyaoui and Bouchoucha, 2021). The estimated elasticities are presented in *Table 10A*, showing that the results for the group-mean estimator were robust, and the coefficient for the old-age dependency ratio was positive and significant. The effect of total dependency ratio was consistent with the results presented in *Table 2*, positively and significantly affecting social protection expenditure to GDP ratio. The effect of the young-age dependency ratio for FMOLS and DOLS was significant, and the long-term coefficients were negative. The real GDP per capita negatively affected social protection expenditures. The coefficients for the relationship between trade openness and the dependent variable, while significant, were negative.

These results are in line with studies concerning the non-cointegration approach and provide evidence to support the dominance of the "efficiency" hypothesis in the context of globalization. If statistically significant, the estimated coefficient was negative. Moreover, the relationship between real GDP per capita and social spending to GDP ratio was negative. The primary focus was to examine the long-run relationship between social protection spending and the share of the dependent population in the working-age population. The results indicate that the old-age dependency ratio was significantly related to social spending in the long term, and this effect was robust regardless of the estimator used. The result highlights the significance of population ageing in shaping social protection spending dynamics.

4. Discussion, policy implications and limitations

This study makes important contributions to the existing literature. Firstly, it evaluated the long-term relationships between social protection expenditure and the proportion of the dependent population. The findings provide strong evidence of the significant burden that population ageing imposes on government spending. This contribution is also confirmed in the literature. For example, Piekut and Rybaltowicz (2024) concluded about the dominance of old age expenditures (due to ageing of population) within the social protection expenditures. Second, trade openness was not investigated as an important factor affecting social protection spending; however, the "efficiency" hypothesis seems to prevail. The important contribution is the significant and negative long-term relationship between income and social protection. The paper also analyzed the long-term elasticities in the regression for social protection expenditure, suggesting that government policies should consider the effects of population ageing and its impact on social protection expenditure as the estimated long-term coefficients were positive. The effect of the old-age dependency ratio was not reduced by the youngest generation. In most cases, the relationship between the young-age dependency ratio and the dependent variable was not significant. Since EU countries are generally advanced economies, the long-run relationship between income and social protection was negative, thereby impacting the social policies of individual EU countries or even at the supranational level.

The study offers a comprehensive analysis of the relationship between the dependent population and social protection expenditures. The study revealed a statistically significant relationship between population at age 65+ and analyzed expenditures. The findings are in line with Haelg et al. (2022) or Gugushvili and Meuleman (2022).

Based on the findings of the study, several policy implications emerge for EU economies. The study suggests that the dependent population, especially the older adults proxied by the old-age dependency ratio, significantly influences social spending. The considerable long-run elasticity highlights the pressure of population ageing on social support, emphasizing the need for governments to incorporate the effects of ageing into development strategies. Additionally, governments should be aware of the long-term effects of aging on expenditure and demographic trends. While the average elasticity regarding older people is generally less than 1%, the estimates of the coefficient measuring the relationship between the old-age dependency ratio and social protection spending to GDP for some countries are higher. In addition, the improved standard of living (proxied by real GDP per capita) reduces the social expenditure share of GDP. These considerations should inform the development of a common social policy for the EU in the context of population ageing and a shrinking labor supply.

An important study limitation is the length of the time series and data availability. As presented in the beginning of the study, the Covid-19 pandemic temporary influenced the scale of social support. The time series utilized in the paper cover the effect of the Covid-19 period in a moderate range. The extension of the analysis is valuable for further research regarding the impact of Covid-19 on social protection spending and the dependent population, especially the older adults, the most vulnerable group in society. Moreover, the results suggest the need for further research to expand the long-run elasticities of social spending, in particular, the effects of population ageing, expressed by an increase in the old-age dependency ratio.

Conclusions

This study investigated the effects of the dependent population on social protection expenditure in 25 EU countries between 1995 and 2022. It confirmed that population ageing proxied by the old-age dependency ratio was significantly related to social protection spending in EU economies. The coefficients for the long-term relationship between the old-age dependency ratio and the dependent variable were positive, and this was robust for all estimation techniques used (i.e., AMG, CCEMG, and MG, as well as the grouped-weighted DOLS and FMOLS). The estimated elasticities for panels ranged from 0.4% in the case of the AMG approach to higher than 1% when the FMOLS or MG approaches were utilized.

The total dependency ratio was insignificant when the coefficient was estimated using the AMG approach, however, a significant effect was revealed for 19 out of 25 countries examined. However, the significance varied, with 13 positive and six negative coefficients estimated. Therefore, the overall effect was not significant. The effect of the young-age dependency ratio was negative but insignificant in baseline approaches (AMG, CCEMG). However, the use of MG estimator and group-mean DOLS and FMOLS allowed for negative and significant elasticities.

The long-run relationship between trade openness and social protection spending if statistically significant was generally negative.

In conclusion, governments should be aware of the long-term effects of population ageing on expenditure and demographic trends. The average elasticity regarding older adults is generally less than 1% but the estimates of the coefficient measuring the relationship between the old-age dependency ratio and social protection spending to GDP for single countries are higher. In addition, the improving standard of living reduces the social expenditure share of GDP. These issues should be considered to develop a common social policy for the EU in the context of population ageing and a shrinking labour supply.

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Appendix

Table 1A. Selected descriptive statistics of variables used in regressions

variable	Obs.	Mean	Std. dev.	Min	Max
$ln\_soc\_p_{it}$	700	2.762	0.265	1.960	3.303
ln_adr_{it}	700	3.902	0.092	3.653	4.134
ln_oadr_{it}	700	3.205	0.190	2.791	3.624
ln_yadr_{it}	700	3.195	0.128	2.944	3.666
$ln\_gdp\_pc_{it}$	700	9.990	0.729	6.202	11.630
ln_trade_{it}	700	4.624	0.477	3.614	5.962

Source: *own compilation*

Table 2A. The Pesaran (2004) CD test results

Variable	CD-statistic (p-value)
$ln\_soc\_p_{it}$	23.81 (0.000)
ln_adr_{it}	50.94 (0.000)
ln_oadr_{it}	78.07 (0.000)
ln_yadr_{it}	51.93 (0.000)
$ln\_gdp\_pc_{it}$	69.78 (0.000)
ln_trade_{it}	71.76 (0.000)

Source: *own compilation*

Table 3A. Results for slope heterogeneity test for specifications

	$ln\_dependencies_{it}$ as an independent variable replaced by:					
	ln_adr_{it} (model I)		ln_oadr_{it} and ln_yadr_{it} (model II)		ln_oadr_{it} (model III)	
	Delta	p-value	Delta	p-value	Delta	p-value
Standard	23.774	0.000	26.702	0.000	25.925	0.000
adj.	26.231	0.000	30.123	0.000	28.604	0.000

Source: *own compilation*

Table 4A. Pesaran CIPS panel unit root outcomes

	Level	first difference	order of integration
$ln\_soc\_p_{it}$	-1.578	-3.798***	I(1)
ln_adr_{it}	-1.221	-2.596***	I(1)
ln_oadr_{it}	-1.661	-2.638***	I(1)
ln_yadr_{it}	-0.948	-2.300***	I(1)
$ln\_gdp\_pc_{it}$	-2.056	-4.463***	I(1)
ln_trade_{it}	-1.614	-3.842***	I(1)

Source: *own compilation*

Table 5A. Westerlund cointegration test results

Model I – dependencies controlled by ln_adr_{it}			
Statistic	Value	Z-value	p-value
Gτ	-2.132	-2.066	0.019
Gα	-3.267	3.638	1.000
Pτ	-11.677	-3.885	0.000
Pα	-3.626	0.510	0.695
Model II – dependencies controlled by ln_oadr_{it} and ln_yadr_{it}			
Statistic	Value	Z-value	p-value
Gτ	-2.111	-0.643	0.260
Gα	-3.491	4.491	1.000
Pτ	-9.932	-1.459	0.072
Pα	-3.755	1.613	0.947
Model III – dependencies controlled by ln_oadr_{it}			
Statistic	Value	Z-value	p-value
Gτ	-2.149	-2.149	0.016
Gα	-2.978	3.869	1.000
Pτ	-8.656	-1.581	0.057
Pα	-2.830	1.140	0.873

Source: *own compilation*

Table 6A. Results for cointegration tests (Westerlund's (2005) test)

Model I – dependencies controlled by ln_adr_{it}	
Statistic	p-value
-1.7245	0.0423
Model II – dependencies controlled by ln_oadr_{it} and ln_yadr_{it}	
Statistic	p-value
-1.2948	0.0998
Model III – dependencies controlled by ln_oadr_{it}	
Statistic	p-value
-1.4419	0.0747

Source: *own compilation*

Table 7A. Estimates for individual countries in the AMG approach (Model I)

	ln_adr_{it}		$ln\_gdp\_pc_{it}$		ln_trade_{it}		*CDP*		*const*	
Belgium	1.015***	(0.195)	-0.375**	(0.153)	0.117	(0.116)	1.036***	(0.087)	2.177*	(1.237)
Bulgaria	-0.002	(0.319)	-0.115	(0.193)	0.128	(0.179)	1.482***	(0.486)	2.755**	(1.211)
Czechia	-0.136*	(0.081)	0.125	(0.114)	-0.095	(0.066)	0.915***	(0.161)	2.232***	(0.653)
Denmark	0.039	(0.417)	-0.966***	(0.305)	0.047	(0.126)	0.572***	(0.190)	13.208***	(2.090)
Germany	0.742***	(0.263)	0.004	(0.007)	-0.332***	(0.058)	0.044	(0.142)	1.459*	(0.823)
Estonia	0.811***	(0.181)	-0.119***	(0.045)	-0.380***	(0.123)	1.967***	(0.229)	2.127**	(0.826)
Greece	1.001**	(0.404)	0.263***	(0.101)	0.064	(0.094)	1.899***	(0.246)	-4.141**	(1.759)
Spain	1.282***	(0.273)	-0.315***	(0.123)	0.053	(0.121)	1.687***	(0.155)	0.622	(1.532)
France	0.528***	(0.114)	0.081	(0.135)	-0.137	(0.088)	0.807***	(0.077)	0.642	(1.229)
Italy	0.800***	(0.227)	-0.903***	(0.137)	0.207**	(0.094)	0.488***	(0.157)	8.286***	(1.269)
Cyprus	-1.911***	(0.450)	0.062	(0.171)	0.444**	(0.173)	0.700*	(0.416)	6.905***	(2.566)
Latvia	1.035***	(0.239)	-0.367***	(0.072)	-0.150	(0.166)	2.102***	(0.338)	2.332**	(0.938)
Lithuania	0.046	(0.443)	0.199*	(0.108)	-0.556***	(0.188)	2.163***	(0.376)	3.039*	(1.772)
Luxembourg	-0.622	(0.496)	-0.165	(0.173)	0.060	(0.139)	0.495***	(0.237)	6.740***	(1.966)
Hungary	-2.192***	(0.297)	0.239*	(0.137)	-0.321***	(0.121)	0.561***	(0.210)	10.507***	(0.871)
Malta	-1.035***	(0.160)	-0.382***	(0.041)	-0.061	(0.083)	0.623***	(0.201)	10.577***	(0.826)
Netherlands	0.596**	(0.248)	-0.927***	(0.091)	0.114	(0.099)	0.785***	(0.103)	9.726***	(0.892)
Austria	0.174	(0.141)	-0.583***	(0.141)	0.105	(0.086)	0.587***	(0.057)	8.039***	(1.403)
Poland	0.515***	(0.108)	-0.340*	(0.188)	0.200	(0.194)	0.244	(0.202)	3.054***	(0.701)
Portugal	-0.469	(0.712)	0.545**	(0.241)	0.231	(0.242)	1.885***	(0.262)	-1.191	(2.504)
Romania	0.865***	(0.253)	0.004	(0.068)	-0.234**	(0.111)	1.502***	(0.219)	-0.087	(0.796)
Slovenia	-0.340***	(0.073)	-0.248***	(0.068)	0.117*	(0.070)	0.946***	(0.087)	5.985***	(0.500)
Slovak Republic	0.371***	(0.051)	-0.193***	(0.064)	0.071	(0.072)	1.083***	(0.117)	2.659***	(0.358)
Finland	0.856***	(0.152)	-0.264***	(0.079)	-0.368***	(0.129)	0.605***	(0.177)	4.055***	(0.783)
Sweden	-0.187*	(0.102)	-0.161	(0.099)	-0.446***	(0.110)	-0.167	(0.111)	7.504***	(0.750)

CDP- stands for common dynamic process

*, **, *** denote significance at 10%, 5% and 1% respectively. Standard errors in parenthesis.

Source: *own compilation*

Table 8A. Estimates for individual countries in the AMG approach (Model II)

	ln_oadr_{it}	$ln\_gdp\_pc_{it}$	ln_trade_{it}	*CDP*	*const*
Belgium	0.773***(0.132)	-0.428***(0.148)	0.118 (0.116)	1.040*** (0.094)	4.255*** (1.080)
Bulgaria	0.863** (0.339)	-0.435** (0.219)	0.078 (0.161)	1.339*** (0.465)	2.485*** (0.818)
Czechia	-0.079 (0.087)	0.176 (0.140)	-0.050 (0.098)	0.913*** (0.187)	1.278 (0.807)
Denmark	-0.090 (0.100)	-0.788***(0.269)	0.067 (0.127)	0.719*** (0.175)	11.642*** (2.300)
Germany	0.380** (0.192)	0.007 (0.127)	-0.384***(0.107)	0.027*** (0.179)	3.293*** (0.240)
Estonia	1.458*** (0.248)	-0.521***(0.096)	-0.311***(0.106)	1.645*** (0.240)	4.154*** (0.594)
Greece	1.198*** (0.283)	0.215** (0.098)	-0.133 (0.127)	1.603*** (0.302)	-2.868*** (0.991)
Spain	1.048*** (0.256)	-0.439***(0.137)	-0.011 (0.169)	1.851*** (0.217)	3.739*** (1.133)
France	0.328*** (0.068)	0.104 (0.143)	-0.138 (0.094)	0.845*** (0.091)	1.471 (1.192)
Italy	0.567*** (0.097)	-0.904***(0.121)	0.153* (0.083)	0.482** (0.137)	9.753*** (1.169)
Cyprus	1.472*** (0.282)	0.095 (0.178)	-0.916***(0.169)	1.427*** (0.318)	1.458 (1.726)
Latvia	2.305*** (0.385)	-0.949***(0.113)	-0.277* (0.151)	1.310*** (0.343)	4.953*** (0.418)
Lithuania	-0.319 (1.195)	0.411 (0.467)	-0.590***(0.191)	2.345*** (0.531)	2.454*** (0.514)
Luxembourg	0.346 (0.755)	-0.213 (0.183)	0.208* (0.110)	0.769*** (0.227)	3.019 (3.378)
Hungary	-2.126*** (0.236)	0.883***(0.171)	-0.170* (0.092)	1.346*** (0.227)	2.079*** (0.649)
Malta	-0.539** (0.231)	-0.035 (0.147)	0.075 (0.132)	0.900*** (0.337)	4.069*** (1.083)
Netherlands	0.287*** (0.084)	-0.840***(0.089)	0.070 (0.097)	0.757*** (0.111)	10.457*** (0.732)
Austria	0.156* (0.082)	-0.589***(0.142)	0.107 (0.090)	0.539*** (0.082)	8.285*** (1.117)
Poland	0.770*** (0.100)	-0.708***(0.161)	0.186 (0.134)	0.432*** (0.159)	6.201*** (0.697)
Portugal	0.498 (0.392)	0.408 (0.355)	-0.110 (0.281)	1.539*** (0.407)	-2.529 (3.009)
Romania	0.746*** (0.287)	-0.203 (0.1473)	-0.126 (0.115)	1.250*** (0.249)	2.372*** (0.406)
Slovenia	-0.314*** (0.097)	0.003 (0.085)	0.111 (0.081)	1.083*** (0.117)	3.250*** (0.544)
Slovak Republic	0.367*** (0.045)	-0.320***(0.063)	0.090 (0.067)	1.068*** (0.110)	4.141*** (0.254)
Finland	0.478*** (0.085)	-0.298***(0.086)	-0.444***(0.111)	0.486** (0.235)	6.595*** (0.740)
Sweden	-0.161** (0.094)	-0.150 (0.097)	-0.442***(0.125)	-0.132 (0.125)	7.150*** (0.583)

CDP - stands for common dynamic process

*, **, *** denote significance at 10%, 5% and 1% respectively. Standard errors in parenthesis.

Source: *own compilation*

Table 9A. Estimates for individual countries in the AMG approach (Model III)

	ln_oadr_{it}	ln_yadr_{it}	$ln\_gdp\_pc_{it}$	ln_trade_{it}	*CDP*	*const*
Belgium	1.127*** (0.259)	-1.521** (0.776)	-1.026*** (0.279)	0.157 (0.108)	0.879*** (0.106)	13.650*** (4.355)
Bulgaria	1.840*** (0.236)	-1.068***(0.159)	-0.892*** (0.138)	-0.082 (0.097)	1.236*** (0.256)	7.686*** (0.864)
Czechia	0.884*** (0.199)	-1.050** (0.212)	-0.482*** (0.158)	-0.232*** (0.076)	0.476*** (0.150)	8.786*** (1.553)
Denmark	0.916***(0.174)	1.855***(0.307)	-1.515*** (0.198)	-0.062 (0.078)	0.165 (0.132)	10.772*** (1.354)
Germany	0.312* (0.163)	0.758***(0.231)	0.003 (0.007)	-0.197* (0.105)	0.200 (0.157)	0.421 (0.902)
Estonia	3.154*** (0.718)	-0.888** (0.377)	-1.374*** (0.345)	-0.145 (0.117)	0.885** (0.354)	8.865*** (1.946)
Greece	1.122*** (0.318)	-0.174 (0.384)	-0.241*** (0.069)	0.016 (0.116)	1.750*** (0.198)	5.209*** (1.458)
Spain	0.939*** (0.255)	0.501 (0.306)	-0.356* (0.184)	0.009 (0.160)	1.691*** (0.187)	1.591 (2.332)
France	0.310*** (0.073)	0.396 (0.382)	-0.125 (0.192)	-0.143 (0.092)	0.816*** (0.082)	-0.008 (2.759)
Italy	0.451*** (0.081)	-0.981*** (0214)	-0.851*** (0.090)	0.113* (0.064)	0.373 (0.394)	10.772*** (1.546)
Cyprus	0.401 (0.249)	-1.040***(0.183)	-0.304** (0.127)	-0.246 (0.152)	0.170 (0.291)	8.898*** (1.653)
Latvia	4.282*** (1.081)	-0.792* (0.425)	-1.748*** (0.417)	-0.374** (0.150)	0.249 (0.620)	8.925*** (2.065)
Lithuania	-0.495 (1.310)	0.240 (0.345)	-0.494 (0.544)	-0.574*** (0.193)	2.480*** (0.624)	1.349 (2.162)
Luxembourg	-1.279* (0.724)	-0.951***(0.325)	0.260 (0.235)	-0.287 (0.194)	0.443** (0.217)	0.660 (3.025)
Hungary	-2.316***(0.462)	0.448 (0.645)	0.998*** (0.310)	-0.126 (0.128)	1.515*** (0.413)	-0.042 (3.678)
Malta	-0.312* (0.167)	-0.931***(0.212)	-0.645*** (0.166)	-0.156 (0.103)	0.377 (0.2701)	13.690*** (2.219)
Netherlands	0.210 (0.168)	-0.260 (0.418)	-0.882*** (0.092)	0.080 (0.095)	0.735*** (0.102)	11.939*** (1.542)
Austria	0.168** (0.086)	-0.079 (0.205)	-0.708*** (0.204)	0.122 (0.095)	0.484*** (0.110)	9.688*** (2.440)
Poland	1.199***(0.182)	-0.345** (0.136)	-0.947*** (0.168)	0.041 (0.130)	0.495*** (0.142)	8.840*** (1.172)
Portugal	-0.131 (0.613)	-1.665 (1.649)	-0.049 (0.511)	-0.046 (0.256)	1.370*** (0.412)	9.008 11.192)
Romania	0.667** (0.276)	0.481** (0.209)	-0.089 (0.156)	-0.187 (0.115)	1.118*** (0.258)	0.281 (1.070)
Slovenia	0.277 (0.183)	-0.497***(0.152)	-0.644*** (0.190)	0.105 (0.067)	0.740*** (0.125)	9.346*** (1.749)
Slovak Republic	0.493***(0.123)	-0.122 (0.154)	-0.458*** (0.134)	0.099 (0.067)	1.052*** (0.110)	5.398*** (1.261)
Finland	0.400***(0.075)	2.260***(0.660)	-0.110 (0.092)	0.041 (0.188)	1.411*** (0.342)	-4.674 (3.393)
Sweden	0.039 (0.229)	-0.278 (0.281)	-0.221* (0.127)	-0.455*** (0.113)	-0.271 (0.194)	8.229*** (1.303)

CDP - stands for common dynamic process

*, **, *** denote significance at 10%, 5% and 1% respectively. Standard errors in parenthesis.

Source: *own compilation*

Table 10A. Results for group-mean FMOLS and DOLS estimators.

	FMOLS			DOLS		
	I	II	III	IV	V	VI
	Model I	Model II	Model III	Model I	Model II	Model III
ln_adr_{it}	0.383***(0.083)			0.227* (0.120)		
ln_oadr_{it}		1.168*** (0.088)	0.732***(0.079)		0.557***(0.147)	0.493***(0.080)
ln_yadr_{it}		-0.896***(0.114)			-1.085***(0.325)	
$ln\_gdp\_pc_{it}$	-0.133***(0.042)	-0.691***(0.047)	-0.306***(0.049)	-0.156**(0.063)	-0.567***(0.110)	-0.193***(0.065)
ln_trade_{it}	0.027 (0.041)	-0.196***(0.031)	-0.131***(0.037)	-0.153**(0.071)	-0.048 (0.080)	-0.077 (0.071)
Obs.	675	675	675	625	625	625

*, **, *** denote significance at 10%, 5% and 1% respectively. Standard errors in parenthesis.
Source: *own compilation*