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## Abstract

Pension expenditure is a concern for the sustainability of public finances in the European Union. Therefore, assessing pension expenditure determinants is crucial. This study aims to disentangle the impact of demographic and economic variables, such as ageing, productivity, and unemployment, on pension expenditure. Using Portuguese time-series data, from 1975 to 2014, statistical evidence was found of co-integration between unemployed people aged between 15 and 64 years old, apparent productivity of labour, the old-age dependence index and pension expenditure as a share of gross domestic product. The use of a vector error correction model, with impulse-response functions and variance decomposition, showed that ageing has an almost insignificant impact in the long-run, when compared with unemployment and productivity.

**JEL Classification:** C32, C51, C52, H55

**Keywords:** pension expenditure, determinants, linear regression analysis

**Introduction**

There is worldwide increasing interest in the analysis of the impact of ageing, productivity, and unemployment on pension expenditure. European social security systems are concerned with the rise of pension expenditure which motivated several reforms including adjusting the age eligibility for a pension benefit and adjusting the size of the pension benefit (Eurogroup 2016; Eurogroup 2017; European Commission, 2014). However, public pension systems are expected to experience a pattern of increasing expenditures from the early years of its existence and until a pension scheme reaches a state of maturity (Plamondon et al. 2002). After a period of 65 to 70 years, under stable conditions, the expenditure of a scheme expressed as a percentage of insured earnings normally stabilizes, since the first generation of young new entrants to the scheme has passed through the various stages of participation. Indeed, pension schemes mature very slowly, that is, over many decades (Cichon et al. 2004). Moreover, increasing pension expenditures are a perfectly normal phenomenon during the maturation phase of national pension schemes, which lasts several decades. Rising pension expenditures per se are not necessarily indicative of a financial sustainability issue. Therefore, the design of pension financing systems should accommodate this expected growth of pension expenditure. Indeed, pension privatization policies, implemented in a number of countries, as a consequence of the concern with the pattern of increasing pension expenditure (World Bank, 1994), did not deliver the expected results, as coverage and benefits did not increase, systemic risks were transferred to individuals and fiscal positions worsened (Beattie and McGillivray, 1995; ILO, 2018). Consequently, several countries are reversing privatization measures and returning to public solidarity-based systems.

In addition, recent austerity or fiscal consolidation trends affected the adequacy of pension systems and general conditions of retirement, putting at risk the fulfilment of the minimum standards in social security and, consequently, the contribution of public pension systems to the Sustainable Development Goals (SDGs) (ILO, 2017; ILO, 2018).

Few studies are available regarding the factors that influence the evolution of Portuguese pension expenditure, and whether there is a link between pension expenditure as a dependent variable and other relevant explanatory variables, including the most recent developments on relevant variables, covering the current environment and data.

This paper aims to understand which variables have a relevant influence on social security pension expenditure using econometric techniques that include a vector error correction model (VECM).

In the next section we describe the Portuguese public pension system. Next we review the literature covering the impact of ageing on several macroeconomic variables especially pension expenditure. In the methods section, we present our data and method. In the following section, we show our estimation results. Last sections provide the discussion and the conclusion.

**The Portuguese Pension System**

The Portuguese pension system is an earnings-related public pension scheme with a means-tested safety net (OECD, 2015), which is financed both by contributions from employees, employers, and by transfers from the State budget.

Throughout its existence, several measures have been enacted to allegedly reinforce the pension system's financial sustainability, such as the creation of the public pension reserve fund in 1989, and the convergence of the civil servants' scheme with the public pension system that covers the private sector in 2005.

In 2007, a sustainability factor was introduced for the calculation of the old age pension benefit, reducing it so that it takes life expectancy into account. This was further changed in 2013, with a decrease in the pension benefit, although this only covered early retirement. This reform, whose effects will mainly be felt in the medium and long term, also intended to promote the financial sustainability of the public finances, reducing the expected value of future pension expenditure and replacement rates. Simultaneously, as a consequence of the Portuguese bailout in 2011 (European Commission, 2011), a extraordinary solidarity contribution was also introduced which decreased all pension income.

In 2013, the normal retirement age was established 66 years in 2014, but increased to 66 years and two months in 2015, following the automatic process of adjusting the normal age of retirement by two-thirds of gains in life expectancy from age 65, measured as the average of the previous two years (Garcia, 2017).

In summary, Portugal essentially has a pay-as-you-go pension scheme (World Bank, 2006), which represents the major source of retirement income, with occupational and personal pension funds only existing to a minor extent (Blake, 2006; European Parliament, 2011; Garcia, 2017). The Portuguese system is also a defined-benefit system (European Commission, 2015), offering pensioners more measurable post-employment income benefits (Ramaswamy, 2012). Pensions are indexed to prices and gross domestic product (European Commission, 2015).

## Literature Review

Demographic aging and its impact on pension expenditure brought to the debate the need to reform public pension systems (EC, 2012; EC, 2015; ECB, 2015; OECD, 2015).

Roach and Ackerman (2005) show that a wide range of existing policy options could be used to secure the finances of the U.S.A. social security programme over the next 75 years without major structural changes, whereby it will continue to provide beneficiaries with a stable and predictable source of retirement income. These authors believe that the system is not in crisis and that it cannot go bankrupt as long as revenues continue to be collected.

Ramaswamy (2012) stress the ideas that lower payroll tax revenues during a period of high unemployment and rising fiscal deficits are a test of the sustainability of pay-as-you-go public pension schemes, as well as poor financial market returns and low long-term real interest rates, which create challenges for the defenders of defined benefit pension schemes.

To limit public expenses, pension benefits might be decreased, however retirement income adequacy is a concern (European Parliament, 2011; Chybalski and Marcinkiewicz, 2014). Orenstein (2011) calls attention to the fact that, from 1981 to 2007, more than thirty countries worldwide fully or partially replaced their pre-existing pay-as-you-go pension systems with ones based on individual, private savings accounts in a process often labelled "pension privatisation". However, pension privatization did not deliver the expected results (ILO, 2018), revealing limited effects on capital markets and economic growth. In fact, coverage rates and pension benefits decreased, the risk of financial market fluctuations was shifted to individuals, and administrative costs increased. Moreover, the high costs of transition created large fiscal pressures. In addition, private pension fund administration did not improve governance as, frequently, the regulatory and supervisory functions were captured by economic groups responsible for managing the pension funds, allowing concentration in pension industry.

Cipriani (2014) uses an overlapping generations model with a pay-as-you-go pension system to conclude that population ageing due to increased longevity implies a reduction in pension benefits. However, the effects of aging on pensions may not be negative if the elderly are free to choose their retirement age, while they are always negative in the case of full retirement (Cipriani, 2016).

Halmosi (2014) emphasises that the study of the pension systems of developed countries is a priority issue in light of the 2008 economic crisis. Grech (2015) presents evidence that the impacts of the crisis were different for continental and Mediterranean systems, where pension benefits of the later were cut back significantly.

Natali and Stamanti (2014) analyse pension reforms in Greece, Italy, Portugal, and Spain, between, 1990 and 2013, concluding that all countries encouraged the spread of private pensions and harmonised their fragmented public schemes. In addition, cost containment was massive, putting future adequacy at risk.

Natali (2015) provides a summary of reforms in Europe since the onset of the Great Recession, showing that evidence proves that austerity has hit both public pay-as-you-go schemes and private pre-funded schemes alike. Indeed, both have been subject to measures to contain costs (e.g., a higher pensionable age, the introduction of automatic stabilisers of future spending, reduced indexation, and higher taxes and/or contributions). Indeed, Diamond (1996), much earlier, suggested the indexation of normal retirement age to life expectancy, and the investment of part of the public reserve funds in the private economy as being good measures to solve the social security pension system problem.

Bloom *et al.* (2010) analyse the implications of population ageing for economic growth, concluding that the results suggest that OECD countries are likely to see modest - but not catastrophic - declines in the rate of economic growth, emphasising that policy

reforms (including an increase in the legal age of retirement) can mitigate the economic consequences of an ageing population.

In order to disentangle the macroeconomic impacts on the pay-as-you-go Portuguese social security system, Garcia and Lopes (2009) conclude that some cumulative measures such as a changing of indexing rules, a better actuarial match between pensions and contributions, and measures to increase the effective age of retirement, could have a bigger impact on reducing the expected increase in pension expenditure than applying a systemic pension reform. Using a macroeconomic model of the Portuguese economy, the estimations suggest that the elimination of early retirement schemes, combined with an increase in the effective contribution rate could be a good alternative to promote the financial sustainability of the system. Economic growth strengthened by the pension reserve fund (which had an average annual nominal rate of return of 5.17% during the period 1989-2014, and relatively low administrative costs compared with funded systems), brings more advantages to the system when compared with a fully pre-funded system, which has high transition costs, with current tax payers being responsible for paying both their own and the existing pensioners benefits (European Parliament, 2011).

This paper analyses the factors that influence the evolution of Portuguese pension expenditure, including the most recent developments on relevant variables.

**Methods**

*Sample*

In order to study the determinants of pension expenditures, we adopt the ratio between pension spending and gross domestic product at current prices as the dependent variable (pensions to gross domestic product ratio).

The independent variables consider eight factors that might influence pension expenditure. The first group of factors follows the related literature concerning the macroeconomic and demographic characteristics:

(1) Unemployment consists of unemployed people defined as someone aged 15 to 64 without work during the reference week, available to start work within the next two weeks (or has already found a job to start within the next three months), and has actively sought employment at some time during the last four weeks. In pay-as-you-go systems, the unemployment shrinks the contribution base, negatively affecting the pension system balance.

(2) Apparent labor productivity denotes apparent productivity of labor that relates the wealth created to the labor factor. The apparent labor productivity is the real gross domestic product in terms of expenditure, at constant prices of 2011, per annual hours worked by employed people. Apparent labor productivity presents the potential to overcome the negative effects of ageing, positively affecting the pension system balance.

(3) Old age dependency ratio is the ratio between elderly people at an age when they are generally economically inactive (i.e. aged 65 and over) and the number of people of working age (i.e. 15 - 64 years old). This variable is expected to have a positive effect on the dependent variable.

The second group tries to disentangle the impact of the main pension system laws since 1975 (Garcia, 2017). Therefore, five dummy variables were set, each of which refers to a specific period, that is to say, the variable's value will be 1 if included in that specific period, and 0 otherwise. The events are:

(4) Revolution of April 1974, which led to important social and economic changes during the second half of the '70s. This variable is expected to have a positive effect on the dependent variable.

(5) The first Social Security Act of 1984, which established pension benefit payments in the private sector. This variable is also expected to have a positive effect on the dependent variable.

(6) The Social Security Reform of 1993, which made changes to the social security system of the Public Administration (civil servants), in order to be similar with that of the private sector. This reform considers a new formula for the calculation of public employees' pensions, which is the same as that of the private sector workers' scheme. This variable is expected to have a negative effect on the dependent variable.

(7) The Third Social Security Act of 2002, which considered parametric changes to the old age pension benefit formula, including the accrual rate and life-time earnings. This variable is expected to have a negative effect on the dependent variable.

(8) The Fourth Social Security Act of 2007, which introduced the sustainability factor and the voluntary public regime of capitalisation. The sustainability factor is the ratio between average life expectancy at the age of 65 in 2000 and average life expectancy at the age of 65 for the year prior to the year for which the pension benefit is calculated. This Act also increases the penalty for early retirement to 6% per year. This variable is also expected to have a negative effect on the dependent variable.

We conduct linear regression analysis using annual time series data from 1974 to 2015. The equation of the model is:

$$(1) Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \delta_0 D_{1t} + \delta_1 D_{2t} + \delta_2 D_{3t} + \delta_3 D_{4t} + \delta_4 D_{5t} + \varepsilon_t$$

Where $Y$ is the ratio between pension spending and gross domestic product; $X_1$ is the unemployment in logarithmic form; $X_2$ is the apparent labor productivity in logarithmic form; $X_3$ is the old age dependency ratio; and $D_1$ to $D_5$ represent dummy explanatory variables used to indicate the occurrence of the events described above.

$$(1) \frac{pensions}{gross\ domestic\ product}_t$$

$$= \beta_0 + \beta_1 \log\ unemplyment_t + \beta_2 \log\ apparent\ labor\ productivity_t$$

$$+ \beta_3 old\ age\ dependency\ ratio_t + \delta_0 Rev1974_t + \delta_1 R1984_t$$

$$+ \delta_2 R1993_t + \delta_3 R2002_t + \delta_4 R2007_t + \varepsilon_t$$

The data sources are PORDATA and OECD.

Descriptive statistics for the variables used in the analysis are presented in the appendix (Table A1).

*Analysis*

To test for stationarity, unit root tests were undertaken (Wooldridge, 2009). Following the methodology adopted by Brooks (2014), the tests used were the Augmented Dickey-Fuller test and Phillips-Perron test. The p-values analysis of both tests suggests that the null hypothesis of the presence of a unit root cannot be rejected in all variables at 10% significance level, and that stationarity is achieved with first differences through the rejection of the same null hypothesis at 5% significance level, highlighting their strong persistence (I(1) process).

The finding of non-stationarity may render the potential econometric results statistically invalid. Typically, the linear combination of I(1) variables will be I(1), but it

is desirable to obtain I(0) residuals, which are only achieved if the linear combination of I(1) variables is I(0), that is to say, if the variables are co-integrated (Brooks, 2014).

With regards to the hypothesis of the existence of more than one linearly independent co-integration relationship between more than two variables, it is appropriate to stress the issue of co-integration using the Johansen VAR test. To develop the Johansen VAR framework, the selection of the optimum number of lags is needed to avoid problems of residual autocorrelation, using the VAR Lag Order Selection Criteria procedure. The Likelihood Ratio Criteria (LR), the Final Predictor Error (FPE), and the Hannan-Quinn Information Criteria (HQ) selected two lags as an optimum limit, against the evidence of the Akaike Information Criteria (AIC) and the Schwarz Information Criteria (SC), which presented the optimum selection of three and one lag, respectively.

The Johansen co-integration test allows for the selection of the appropriate lag length and model to choose. The test result suggests that the number of appropriated lags is two (as referred before), with one co-integrating vector, and the model to adopt consists of the allowance of a quadratic deterministic trend, with intercept and trend in the co-integration equation and intercept in VAR, following Akaike Information Criteria (Brooks, 2014).

Therefore, it was decided to use an error correction model "incorporated" into a VAR framework in order to model the short and long-run relationships between variables: a Vector Error Correction Model (VECM). The VECM can be set up in the following form (Brooks, 2014):

$$(2)\ \Delta\gamma_t = \Pi\gamma_{t-k} + \Gamma_1\Delta\gamma_{t-1} + \cdots + \Gamma_{k-1}\Delta\gamma_{t-(k-1)} + u_t$$

where $\Pi = \left(\Sigma_{i=1}^{k}\beta_i\right) - I_g$ and $\Gamma_i = \left(\Sigma_{j=1}^{i}\beta_j\right) - I_g$.

This VECM contains g variables in first-differenced form on the LHS, and k-1 lags of the dependent variables (differences) on the RHS, each with a $\Gamma$ short-run coefficient matrix. $\Pi$ consists of a long-run coefficient matrix, as being in equilibrium, all the $\Delta\gamma_{t-i} = 0$, and setting $E(u_t) = 0$ will leave $\Pi y_{t-k} = 0$. $\Pi$ illustrates the speed of adjustment back to equilibrium, that is to say, it measures the proportion of last period´s equilibrium error that it is corrected for (Brooks, 2014).

The VECM model estimation is depicted in Table 1 and encompasses the co-integration equation with dummy variables.

Table 1. VECM estimation

| Cointegrating Eq: | CointEq1 | | |
|---|---|---|---|
| Pensions to gross domestic product ratio (-1) | 1.000000 | | |
| Log unemployment (-1) | -0.934243 (0.08485) [-11.0107] | | |
| Log apparent labor productivity (-1) | -3.450917 (0.61569) [-5.60500] | | |
| Old age dependency ratio (-1) | -0.114074 (0.07355) [-1.55089] | | |
| @TREND(75) | 0.024757 | | |
| C | 18.19483 | | |

Sample (adjusted): 1978 to 2014
Included observations: 37 after adjustments
Standard errors in ( ) & t-statistics in [ ]
Determinant residual covariance (dof adj.) 9.01E-11
Determinant residual covariance 9.35E-12
Log likelihood 259.8113
Akaike information criterion -10.36818
Schwarz criterion -7.407571

| Error Correction: | D(Pensions to gross domestic product ratio) | D(Log unemployment) | D(Log apparent labor productivity) | D(Old age dependency ratio) |
|---|---|---|---|---|
| CointEq1 | -0.823727 (0.25145) [-3.27589] | 0.355044 (0.27994) [1.26830] | -0.085035 (0.02454) [-3.46495] | -0.229154 (0.19648) [-1.16627] |
| D(Pensions to gross domestic product ratio (-1)) | 0.048722 (0.23937) [0.20354] | -0.134046 (0.26649) [-0.50301] | 0.037997 (0.02336) [1.62640] | 0.216371 (0.18705) [1.15678] |
| D(Pensions to gross domestic product ratio (-2)) | -0.023504 (0.19428) [-0.12098] | -0.327028 (0.21629) [-1.51196] | 0.023747 (0.01896) [1.25233] | 0.140985 (0.15181) [0.92867] |
| D(Log unemployment (-1)) | 0.402031 (0.24351) [1.65098] | 0.652833 (0.27110) [2.40812] | -0.002592 (0.02377) [-0.10904] | 0.147807 (0.19028) [0.77679] |
| D(Log unemployment (-2)) | -0.006098 (0.24210) [-0.02519] | 0.136222 (0.26952) [0.50542] | -0.054351 (0.02363) [-2.30024] | -0.148583 (0.18918) [-0.78542] |
| D(Log apparent labor productivity (-1)) | -0.221389 (2.35803) [-0.09389] | 3.246082 (2.62517) [1.23652] | -0.463845 (0.23014) [-2.01547] | -1.234411 (1.84257) [-0.66994] |
| D(Log apparent labor productivity (-2)) | 0.580083 (1.60695) [0.36098] | 0.776474 (1.78900) [0.43403] | -0.055980 (0.15684) [-0.35693] | -0.496768 (1.25567) [-0.39562] |

| | | | | |
|---|---|---|---|---|
| D(Old age dependency ratio (-1)) | 0.170345 | -0.345219 | 0.035069 | 0.468223 |
| | (0.26139) | (0.29100) | (0.02551) | (0.20425) |
| | [0.65169] | [-1.18632] | [.37463] | [2.29241] |
| D(Old age dependency ratio (-2)) | 0.371367 | -0.035296 | 0.046423 | 0.150022 |
| | (0.20938) | (0.23310) | (0.02044) | (0.16361) |
| | [1.77363] | [-0.15142] | [2.27169] | [0.91694] |
| C | -0.066069 | -0.010129 | 0.001324 | -0.066055 |
| | (0.13892) | (0.15466) | (0.01356) | (0.10855) |
| | [-0.47559] | [-0.06550] | [0.09766] | [-0.60851] |
| @TREND(75) | 0.007064 | 0.012654 | -0.001357 | 0.003988 |
| | (0.01497) | (0.01667) | (0.00146) | (0.01170) |
| | [0.47172] | [0.75905] | [-0.92828] | [0.34082] |
| REV1974 | -0.268243 | -0.002228 | 0.053747 | 0.162941 |
| | (0.13658) | (0.15206) | (0.01333) | (0.10673) |
| | [-1.96393] | [-0.01465] | [4.03186] | [1.52670] |
| R1984 | 0.077589 | -0.199898 | 0.054140 | 0.244170 |
| | (0.11939) | (0.13292) | (0.01165) | (0.09329) |
| | [0.64988] | [-1.50395] | [4.64628] | [2.61728] |
| R1993 | -0.383299 | 0.032310 | -0.040317 | -0.117924 |
| | (0.17433) | (0.19408) | (0.01701) | (0.13622) |
| | [-2.19869] | [0.16648] | [-2.36955] | [-0.86567] |
| R2002 | -0.099864 | -0.004149 | 0.002105 | -0.144916 |
| | (0.16839) | (0.18746) | (0.01643) | (0.13158) |
| | [-0.59306] | [-0.02213] | [0.12808] | [-1.10136] |
| R2007 | 0.169199 | -0.040558 | 0.000708 | 0.179928 |
| | (0.10280) | (0.11445) | (0.01003) | (0.08033) |
| | [1.64589] | [-0.35438] | [0.07054] | [2.23988] |
| R-squared | 0.685045 | 0.413290 | 0.802777 | 0.842369 |
| Adj. R-squared | 0.460078 | -0.005789 | 0.661903 | 0.729776 |
| Sum sq. resids | 0.304910 | 0.377908 | 0.002904 | 0.186175 |
| S.E. equation | 0.120497 | 0.134148 | 0.011760 | 0.094157 |
| F-statistic | 3.045086 | 0.986188 | 5.698563 | 7.481515 |
| Log likelihood | 36.27442 | 32.30368 | 122.3691 | 45.40105 |
| Akaike AIC | -1.095914 | -0.881280 | -5.749681 | -1.589246 |
| Schwarz SC | -0.399301 | -0.184667 | -5.053068 | -0.892633 |
| Mean dependent | 0.124324 | 0.023130 | 0.020237 | 0.367568 |
| S.D. dependent | 0.163987 | 0.133761 | 0.020226 | 0.181129 |

As all inverse roots of characteristic polynomial are inside the unit circle, the model is stable. The residuals assumptions were tested, and it is possible to conclude that the mean of the residuals is zero. The White Heteroscedasticity test p-value does not allow for the rejection of homoscedastic residuals. In addition, the covariance between residuals and explanatory variables is zero, thus satisfying the assumption of there being no relationship between them and that the residuals are normally distributed. Finally, the null

hypothesis of no residual serial correlation is not rejected at 5% significance level with the use of two lags.

As such, the estimators are efficient, and the confidence intervals and hypothesis tests using t and F-statistics are reliable.

## Results

The results suggest that the long-run relationship between pensions to gross domestic product ratio and old age dependency ratio is negative, whereas the long-run relationship between pensions to gross domestic product ratio and the other two variables (log unemployment and log apparent labor productivity) is positive. In fact, the normalised co-integrating model estimation (Table A.2 in the appendix), without dummy variables, allows one to obtain the following equation:

(3) Pensions to gross domestic product ratio = 1.320370 log unemployment + 1.818858 log apparent labor productivity - 0.221652 old age dependency ratio

The presence of a co-integrating vector illustrates an equilibrium phenomenon, as it is possible that co-integrated variables may deviate from their relationship in the short run, but that their association would return in the long run (Brooks, 2014).

## Discussion

The positive long-run coefficient of log unemployment suggests that unemployment has a positive impact on pension system expenditure, which is in line with the literature. High unemployment leads to negative migratory balances (mostly affecting young people), aggravating the ageing process, and consequently the declining demographics. With less people, investment decreases, shrinking the economic growth. The causality from ageing and unemployment to productivity are confirmed by a VEC Granger Causality Test, at 5% and 10% significance level, respectively.

The positive long-run coefficient of log apparent labor productivity on pensions to gross domestic product ratio is not in line with the European Commission (2015).

Concerning the negative coefficient of old age dependency ratio, this might be the consequence of the parametric changes introduced to the system since 2000 (Garcia, 2017), especially the one that changed the normal retirement age (NRA) to 66 years old, in 2013, becoming life expectancy-dependent after 2014. Therefore, an increase of old age dependency ratio does not compulsorily imply an increase of pension expenditure as a share of gross domestic product in the long-run. This measure is strongly supported by the literature as a crucial measure to guarantee the financial sustainability of pension systems, smoothing the impact of an ever-increasing number of pensioners (Diamond, 1996; Clements *et al.*, 2015). The introduction of a sustainability factor into the benefit calculation formula, which is related to the evolution of average life expectancy (ALE), also represents a significant decrease in the pension benefit.

With regards to the short-run coefficients of the dummy variables, only the revolution of April 1974 (at 10% significance level) and the 1993 Social Security Reform (at 5%) present statistical significance, and the negative coefficients illustrate each contribution to the decrease of pension expenditure as a share of gross domestic product, where the possible causes can be the high average real gross domestic product growth rate after 1976 until 1979 of 5.4% in the first case (PORDATA), and in the latter case, the implementation of the same official retirement age between men and women, as well as the increase of the minimum contributory period from 10 to 15 years.

Finally, the impulse-response functions were stressed, as well as the variance decomposition for pensions to gross domestic product ratio, which is strongly dependent of the Cholesky ordering, which does not follow a specific requirement (Brooks, 2014).

In order to guarantee some consistency and reasonability of the results, the order considered was from the most exogenous variable to the most endogenous one, determined by a VEC Granger Causality Test. The higher the p-value, the greater the exogeneity of the variable. The adopted order is as follows: old-age dependency ratio, log unemployment, pensions to gross domestic product ratio and log apparent productivity of labour.
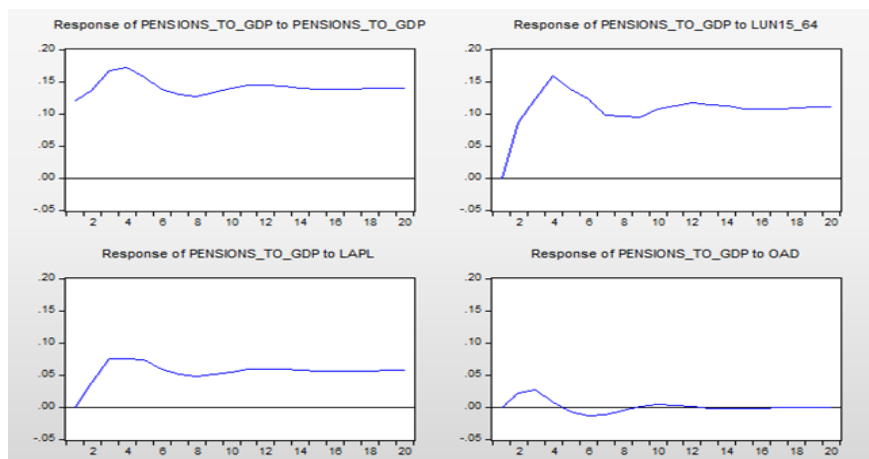


Figure 1. Response to cholesky one standard deviation innovation

Following Brooks' (2014) methodology, Figure 1 gives the impulse responses for pensions to gross domestic product ratio, regarding several unit shocks to old-age dependency ratio and log unemployment and their impact during 20 periods (years) ahead. Considering the signs of the responses, innovations to old-age dependency ratio have a positive impact until the 5th year, achieving its peak in the 3rd year. After this, the impact is negative, although the effect of the shock ends up dying down. A standard deviation shock to log unemployment and log apparent productivity of labour always has a positive impact on pensions to gross domestic product ratio, reaching its peak in the 4th and 3rd years, respectively, and stagnating in the long-run. Finally, the own innovations to pensions to gross domestic product ratio register a similar impact in relation to log

unemployment, that is to say, it reaches its peak in the 4th year, and then stagnation thereafter.

When analysing this approach, the main highlight is the fact that old-age dependency ratio registers an almost irrelevant contribution for the evolution of pensions to gross domestic product ratio in the long-run, when compared with the other variables, which is surpassed by the contributions of log unemployment and log apparent productivity of labour, this reinforcing the doubts about the contribution of ageing on pension expenditure. It is also possible to verify the relevance of unemployment in the presence of a positive shock immediately in the first years (as stressed by the European Commission (2015)), over a 20-year forecasting horizon (positive but constant impact), shrinking the contributory base and the economic growth, with a similar pattern in relation to the apparent productivity of labour, guaranteeing higher pension entitlements.

The results of the variance decomposition for the pensions to gross domestic product ratio residuals show that, for the 20-year forecasting horizon, the old-age dependency ratio shocks account for only 2.86%, in the first year, and 5.35%, in the 20th year, of the variance of the pensions to gross domestic product ratio, while log unemployment contributes between 57.87% and 85.83%, reinforcing the huge importance of unemployment on pension expenditure and the reduced impact of ageing when compared with the other variables. It is also important to stress the own shocks of pensions to gross domestic product ratio, which accounts for between 39.76% and 0.93% of its movements.

*Limitations*

The negative relationship between pensions to gross domestic product ratio and old age dependency ratio supports the hypothesis of a spurious result. Therefore, the Johansen

co-integration test with dummy variables was carried out, although there is a problem in that the critical values may not be valid with exogenous series, such as dummy variables.

With this test, the old age dependency ratio long-run coefficient becomes positive and the sign of the other two coefficients does not change. However, it is important to take into account the econometric limitations of this change. To derive the VECM p-values, the VECM model with the coefficients as C(1) until C(16) was developed. C(1) is the coefficient of the co-integration equation (as well as the speed of adjustment back to equilibrium), C(10) is the constant, C(2) up to C(9) are the short-run coefficients of the lagged variables (until the second lag), and C(12) until C(16) are the coefficients of the dummy variables. C(11) is the trend coefficient (Brooks, 2014).

Looking at C(1), which is negative and statistically significant at 5%, this confirms the long-run relationship between pensions to gross domestic product ratio, log unemployment, log apparent labor productivity, and old-age dependency ratio, as well as the existence of a correction mechanism of deviations (Wooldridge, 2009). When carrying out the Wald Tests, it is not possible to reject the null hypothesis of C(4)=C(5)=0, C(6)=C(7)=0 and C(8)=C(9)=0, and the conclusion that needs to be stressed is the absence of short-run causality running from log unemployment, log apparent labor productivity, and old age dependency ratio to pensions to gross domestic product ratio.

In addition, the results need to be analysed carefully: if the order of variables changes, then the results of impulse-response functions and variance decomposition can change drastically, mainly the variance decomposition between pensions to gross domestic product ratio and log unemployment. Nevertheless, it is noticeable that unemployment strongly influences pension expenditure behaviour.

**Conclusion**

The results of the estimation, after taking into consideration certain aspects such as non-stationarity, co-integration, and residuals testing, suggest that unemployment, apparent productivity of labour, and old-age dependency ratio all jointly present a long-run relationship with pension expenditure as a share of gross domestic product, but not in the short-run.

Unemployment is crucial to explain the increase of pension expenditure as a share of gross domestic product, as reinforced by the review of the literature on pensions. This interpretation is confirmed by the variance decomposition of pensions to gross domestic product ratio and also the impulse-response functions.

The apparent productivity of labour also seems to have a positive impact on pension expenditure to gross domestic product, which is not in line with the European Commission (2015), supporting the assumption that gross domestic product growth is larger than pension expenditure growth in Portugal, due to the fact that pensions are not fully indexed to wages after retirement.

The most intriguing result concerns the old-age dependency ratio. In fact, after the development of the Johansen co-integration tests, both without dummy variables and with dummy variables, the old-age dependence ratio long-run coefficient presents different signs, giving rise to the hypothesis that ageing may not be the most relevant factor which jeopardises the financial sustainability of the Portuguese public pension system. This fact is corroborated by the irrelevant influence of old-age dependency ratio (in the long-run) on the impulse-response-functions.

When designing a pension system policy to reinforce its financial sustainability, policy makers should take these findings into account. In other words, apparently, an

increasing demographic strain seems not to impact pension expenditure as critically as unemployment. Therefore, policies to reduce unemployment should be considered as policy options to control pension expenditure, which represents a brand new way to address the financial sustainability of public pension systems.

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## Appendix

Table A1. Descriptive statistics

| Variables | Mean | Median | Maximum | Minimum | Std. Dev | Skewness | Kurtosis | Jarque-Bera |
|---|---|---|---|---|---|---|---|---|
| *Dependent variable* | | | | | | | | |
| Pensions to gross domestic product ratio | 5.05 | 5.15 | 7.70 | 2.20 | 1.28 | 0.16 | 2.82 | 0.28 (0.89) |
| *Independent variables* | | | | | | | | |
| Log unemployment | 12.75 | 12.72 | 13.66 | 12.09 | 0.38 | 0.65 | 3.14 | 2.82 (0.24) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Log apparent labor productivity | 2.69 | 2.77 | 3.01 | 2.18 | 0.28 | -0.53 | 2.03 | 3.43 (0.18) |
| Old age dependency ratio | 22.35 | 22.00 | 30.70 | 16.30 | 4.09 | 0.33 | 1.94 | 2.61 (0.27) |
| Number of observations | | | | | 40 | | | |

The probability is between brackets

## Table A2. Johansen Co-integration Test without Dummy Variables

| Sample (adjusted): 1978 2014 |
|---|
| Included observations: 37 after adjustments |
| Trend assumption: Quadratic deterministic trend |
| Series: Pensions to gross domestic product ratio Log unemployment Log apparent labor productivity Old age dependency ratio |
| Lags interval (in first differences): 1 to 2 |

Unrestricted Co-integration Rank Test (Trace)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.584823 | 62.45298 | 55.24578 | 0.0102 |
| At most 1 | 0.442063 | 29.92813 | 35.01090 | 0.1580 |
| At most 2 | 0.155065 | 8.338298 | 18.39771 | 0.6481 |
| At most 3 | 0.055277 | 2.103951 | 3.841466 | 0.1469 |

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.584823 | 32.52485 | 30.81507 | 0.0306 |
| At most 1 | 0.442063 | 21.58983 | 24.25202 | 0.1082 |
| At most 2 | 0.155065 | 6.234347 | 17.14769 | 0.7936 |
| At most 3 | 0.055277 | 2.103951 | 3.841466 | 0.1469 |

Max-eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

| Unrestricted Co-integrating Coefficients (normalised by b'*S11*b=I): | | | |
|---|---|---|---|
| Pensions to gross domestic product ratio | Log unemployment | Log apparent labor productivity | Old age dependency ratio |
| 6.459502 | -8.528931 | -11.74891 | 1.431758 |
| 1.636999 | -6.766814 | -37.79332 | -1.097487 |
| 6.475763 | -3.688677 | -25.99676 | -0.853253 |
| -1.854818 | 3.512219 | 20.29810 | -2.584471 |

| Unrestricted Adjustment Coefficients (alpha): | | | |
|---|---|---|---|
| D(Pensions to gross domestic product ratio) | -0.049258 | 0.008812 | -0.016745 | -0.027399 |
| D(Log unemployment) | 0.049632 | 0.030766 | -0.012136 | -0.015591 |
| D(Log apparent labor productivity) | -0.007377 | 0.006679 | 0.000878 | 0.001188 |

| D(Old age dependency ratio) | -0.029153 | 0.014410 | 0.032894 | -0.001872 |
|---|---|---|---|---|

1 Co-integrating Equation(s): Log likelihood  216.0536

Normalized co-integrating coefficients (standard error in brackets)

| Pensions to gross domestic product ratio | Log unemployment | Log apparent labor productivity | Old age dependency ratio |
|---|---|---|---|
| 1.000000 | -1.320370 (0.163) | -1.818858 (0.936) | 0.221652 (0.082) |

Adjustment coefficients (standard error in brackets)

| | |
|---|---|
| D(Pensions to gross domestic product ratio) | -0.318180 (0.16656) |
| D(Log unemployment) | 0.320601 (0.12175) |
| D(Log apparent labor productivity) | -0.047652 (0.01652) |
| D(Old age dependency ratio) | -0.188316 (0.11411) |