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Prospective Ageing and Economic Growth in Europe*

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Abstract

We assess empirically the role played by prospective ageing measures as a predictor of income growth in Europe. We show that prospective ageing measures which move beyond chronological age and incorporate changes in life expectancy are able to explain better the recent long-run growth experience of European economies. The improvement in explanatory power of prospective ageing indicators as compared to standard measures based on chronological age is particularly relevant for long-run economic growth horizons.

JEL codes: I15, O15, O52.
Keywords: Economic growth, ageing, prospective age, old age dependency ratio.

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1 Introduction

In the last decades, population ageing has been recognized as one of the most challenging demographic developments in the developed world in terms of its potential effects on income growth and fiscal sustainability. Lutz et al. (2008) document the global ageing trends over the last century and show that the speed of ageing is likely to increase over the coming decades and to decelerate in most world regions by mid-century. Bloom et al (2010) identify three main factors behind the changes in population ageing – declining fertility rates that reduced the share of young people on total population and pushed up the share of the elderly, increases in life expectancy and the past variations in birth and death rates. Among other studies, Chawla et al. (2007) and Gill and Raiser (2012) stress the importance of ageing trends in Europe. Such developments have led to an increasing interest in the economic consequences of ageing in terms of its implications for future economic growth (see for example Lindh and Malmberg, 2009 or Bloom et al, 2010) and as a burden for public finances (see Meijdam and Verbon, 1997, or Borsch-Supan, 2003).

The recent literature has developed theoretical arguments that focus on the different channels through which demography may influence economic growth, as well as empirical evidence on the potential effects of such demographic changes on several macroeconomic variables. A recent survey of endogenous growth models and semi-endogenous models that explicitly incorporate demographic change in their framework can be found in Prettner and Prskawetz (2010). Prettner (2013) proposes generalizations of economic growth models with age-specific heterogeneity and studies the long-term consequences of population ageing on economic development. From the life-cycle perspective (that is, based on the fact that economic needs and contributions vary over the various stages of life), Bloom and Williamson (1998) and Bloom et al (2001, 2003) assess the transitory and permanent effects of changes in age structure and argue that changes in age structure explain up to one third of the economic miracle in East Asia between 1965 and 1990.[1] Freyer (2007) shows that workforce demographics are strongly correlated with productivity and output developments and his results suggest that roughly one-quarter of the productivity gap between the OECD and low-income countries may be related to differences in their demographic structures.

Cervellati and Sunde (2011) address the effect of life expectancy on economic growth and highlight the importance of accounting for the non-linearities and non-monotonic features of the demographic transition when modelling such a link. They document a hump-shaped relationship between life expectancy and population growth and show that increases in life expectancy accelerate income per capita in countries that have already experienced the onset of the transition by 1940, while the effect does not exist in pre-transitional countries. This is in line with the analysis of Gomez and Hernandez de Cos (2008), who show that the process of population ageing produces intermediary changes in the age structure of populations that can actually improve economic performance rather than dampen it. The fact that increases in the youth dependency ratio reduce total factor productivity growth is supported by the results in Kogel (2005), who argues that the effect works through lower aggregate savings that turn into lower expenditures in research and development and thus lower total factor productivity growth. The severity of the effects of such demographic developments can be mitigated through behavioural changes in several ways. With better health and increased life expectancies, individuals will be expected to work longer and increase their savings over the working life in order to finance a

[1] See Crespo Cuaresma et al. (2013) for a different view on such *demographic dividend* effects, where changes in educational attainment are seen as the driving force between such income growth effects.

continued high standard of life in retirement (see for example Bloom et al, 2010). Smaller number of children per woman, on the other hand, should lead to more women entering the labour market and therefore to increased labour force participation, as well as a higher investment in education by child.

The growing interest in population ageing has created new discussions in the academic literature concerning its measurement (see Sanderson and Scherbov, 2005, or Sanderson and Scherbov, 2010). While measures based on standard chronological definitions of age, such as old age dependency ratio or median age, provide evidence of ageing populations in developed countries but less so in developing economies, new measures that take into account changes in longevity and health status show a much more heterogeneous pattern between as well as within these groups of countries. As pointed out above, demographic change operates through different channels that are connected with changes in life expectancy and health. New measures of ageing, such as the *prospective old age dependency ratio* or *prospective median age*, take these changes into account and therefore should explain the relation between ageing and economic growth better than chronological measures and thus predict the influence of demographic changes on economic growth better than standard measures.

The aim of our study is to analyse the dynamics of prospective ageing measures in Europe and to assess quantitatively their role as predictors of economic growth. We construct such prospective ageing indicators for European countries and address their role as income growth determinants in the framework of panel regressions. As far as we know, this is the first attempt to quantify the explanatory power of prospective ageing for European countries and to compare it to that of measures based on chronological age. Using panel regression models, we show that the old age dependency ratio based on prospective ageing has better properties than the standard old age dependency ratio based on chronological age in terms of explaining differences in income growth and predicting income developments. In particular, the properties of the prospective old age dependency ratio as a predictor of income growth are significantly better for explaining long-run income developments that go beyond the usual business cycle frequencies.

The paper is organized as follows. Section 2 presents the measures and analyses their development in Europe over the last decades. Section 3 presents the results of panel data regressions linking economic growth in European economies to changes in prospective ageing indicators. Section 4 concludes.

2 Ageing and prospective ageing in Europe: An overview

In this section we present the key features of population ageing trends in the European Union using different ageing measures. In the last decades, developed economies and in particular European countries have experienced a rapid change in the age structure of their populations caused by a decrease in fertility, a decrease in mortality and a higher life expectancy. According to United Nations projections, population in Europe faces significant changes regarding to the change of age structure. The number of people aged 65 and older has tripled in the last sixty years and the number of people of ages 80 and more is six times higher than in 1950 (see Figure 1). On the other hand, there are about 18% less children under age 15. According to the medium scenario of the UN population projections, population ageing will continue in future decades. By 2050, the number of people older than 65 is expected to be 55% higher than today and the number of people older than 80 is expected to double. Although such a trend has been experienced by all European countries, some differences within the region can be highlighted.

For instance, in France, as of 2010, 26% of the population was older than 65, while the share of this age group was 13% in Ireland.

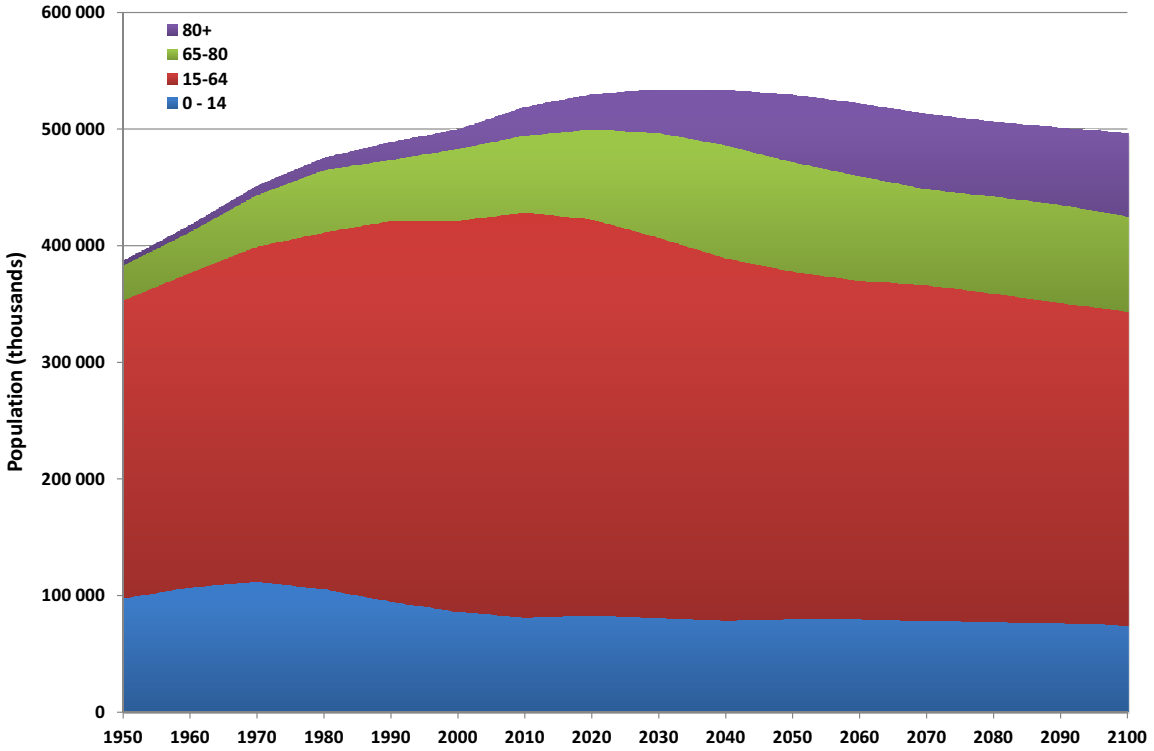

Figure 1: Population by age group, 1950-2100, European Union (source: United Nations)

The most commonly used ageing indicator, the old age dependency ratio (OADR), is usually defined as the ratio of the number of people 65 and older to the number of people in age between 20 and 64.[2] When analysing the dynamics of such an indicator, the maintained hypothesis is that a person aged 65 today has the same characteristics as a person aged 65 50 years ago. The role played by the increase in life expectancy in the global ageing process, however, implies that comparing persons of the same chronological age across periods may be misleading. In this context, Sanderson and Scherbov (2005, 2008, 2010) propose to consider remaining lifetime (*prospective age*) instead of chronological age in order to construct measures of ageing that take into account the improvements in life expectancy to define old age. The *prospective old age dependency ratio* (POADR) is defined as the ratio of the population whose age is such that the remaining life expectancy is 15 years or less (the old-age threshold) to the number of people of age 20 to that old-age threshold. It should be noted that, in spite of their obvious appeal, ageing indicators based on prospective age have also been subject to criticism. Bloom et al (2010) argue that despite the increase in life expectancy people do not, in general, work to later ages and that instead they spend more time in retirement. In addition, according to Bloom et al. (2010), the dramatic rise in the prevalence of obesity limits the extent to which older people are able to work productively.

Combining data sourced from Eurostat on life expectancy by age and population information from the United Nations, we compute both ageing indicators for the European Union from 1980 to 2010. Figure 2 presents scatterplots relating the OADR to the POADR for all EU countries

[2]Alternative definitions of the OADR use population above 15 years of age or total population in the denominator.

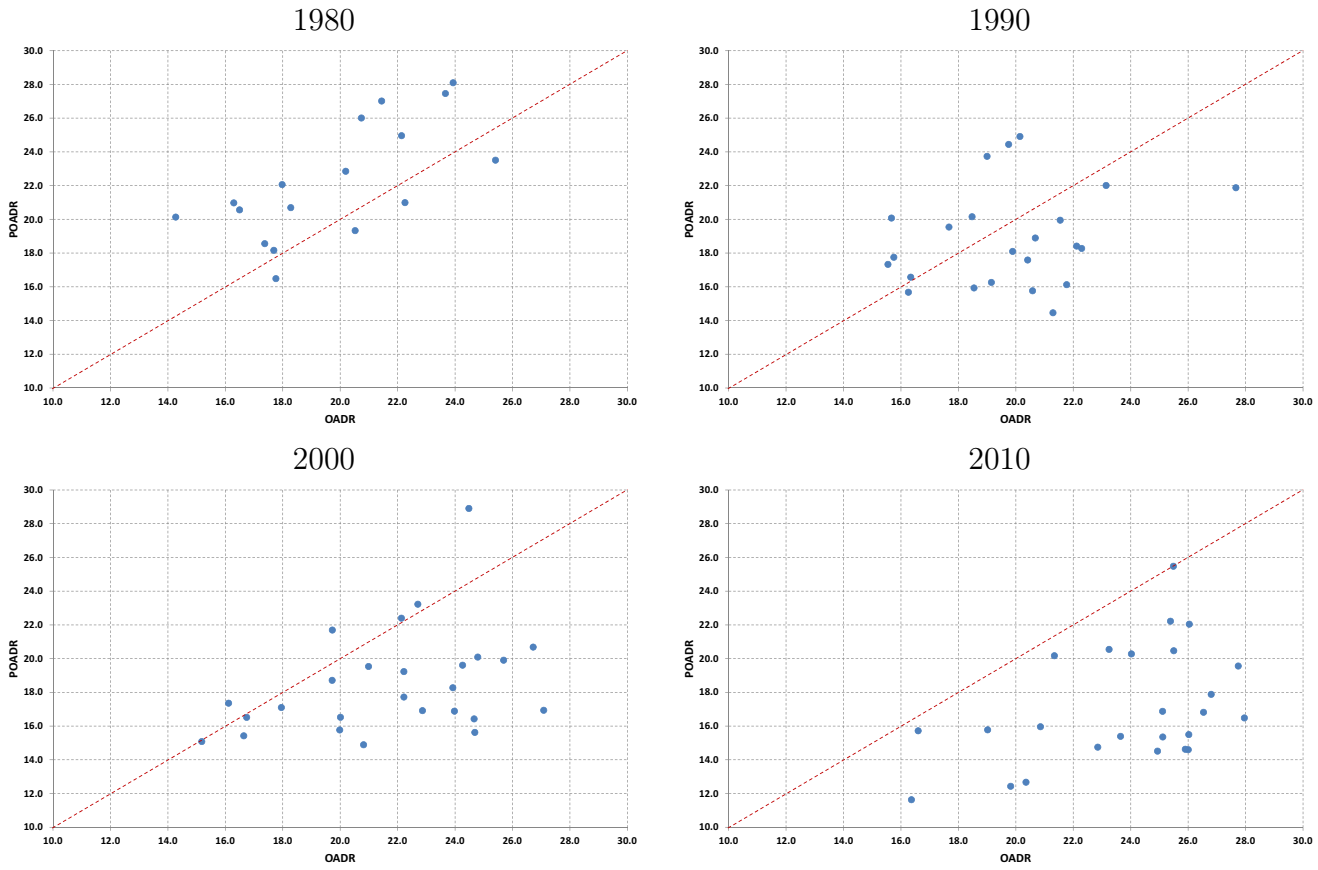

Figure 2: EU-28 countries: Old age dependency ratio (OADR) against prospective old age dependency ratio (POADR); 1980, 1990, 2000 and 2010

for which data are available. The increase in life expectancy over the last three decades has created an increasing divergence between the two measures of ageing. The continuous increase in the OADR has not been accompanied by a parallel rise in the POADR, thus leading to sizeable differences between the two indicators by the end of our observation period. The dynamics of the POADR and OADR for the whole set of EU countries in the period 1980-2010 is depicted in Figure 3. While in 1980 the average POADR was higher than the OADR, starting with the mid-eighties the strong increase in the OADR has not taken place in parallel to similar dynamics of the POADR, which has remained roughly stable around a slightly decreasing trend.

These aggregate changes in both ageing indicators hide strong differences across EU regions and in particular between Western and Eastern European economies. We define a Western EU region (formed by Denmark, Finland, Sweden, Greece, Portugal, Spain, Austria, Belgium, Germany and Luxembourg) and an Eastern EU region (including Bulgaria, Czech Republic, Hungary, Romania, Slovakia and Lithuania) and compute the respective OADR and POADR indicators, whose dynamics are shown in Figure 4. While the overall EU dynamics are driven by the group of Western economies, the change in the prospective ageing measure for Eastern Europe appears qualitatively different from the Western European counterpart. The differences in life expectancy levels across countries, as well as in the dynamics of this variable over the period, are able to explain the patterns shown in Figure 4. For instance, while life expectancy for 65 year-old French women in 1990 was 19.8 years, a 65 year-old woman from the Czech Republic was expected to live for 15.3 years in the same year. In 1990 the old-age threshold

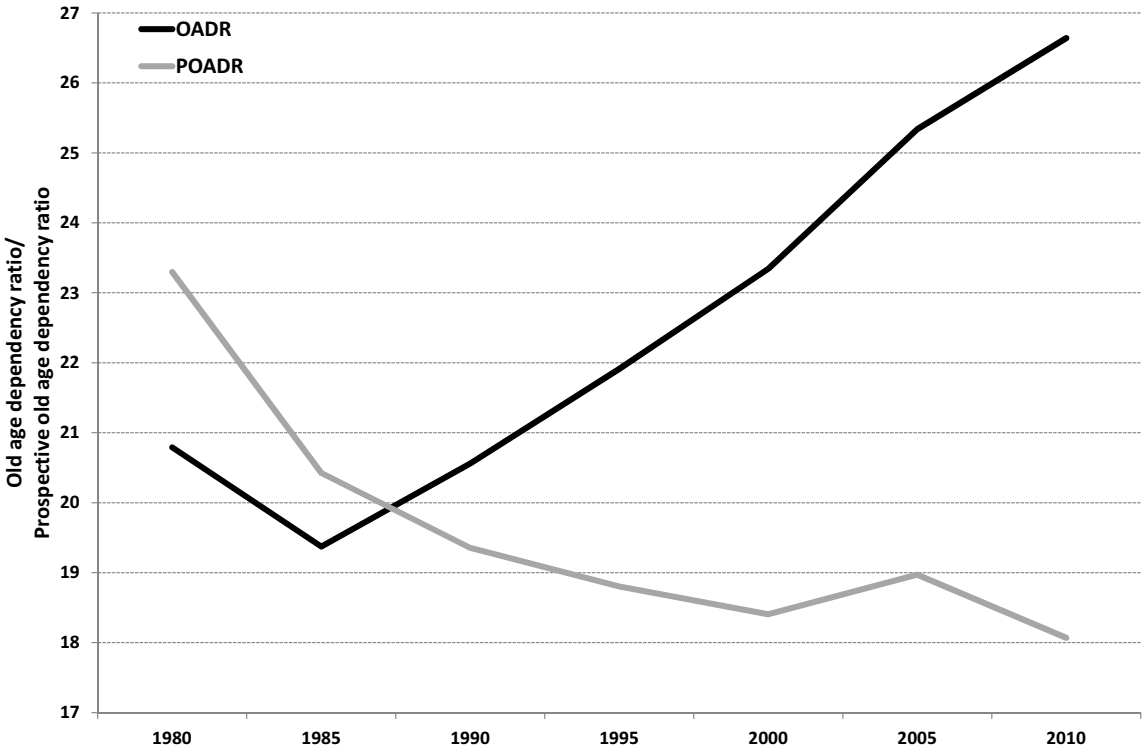

Figure 3: EU-28: Old age dependency ratio (OADR) and prospective old age dependency ratio (POADR), 1980-2010

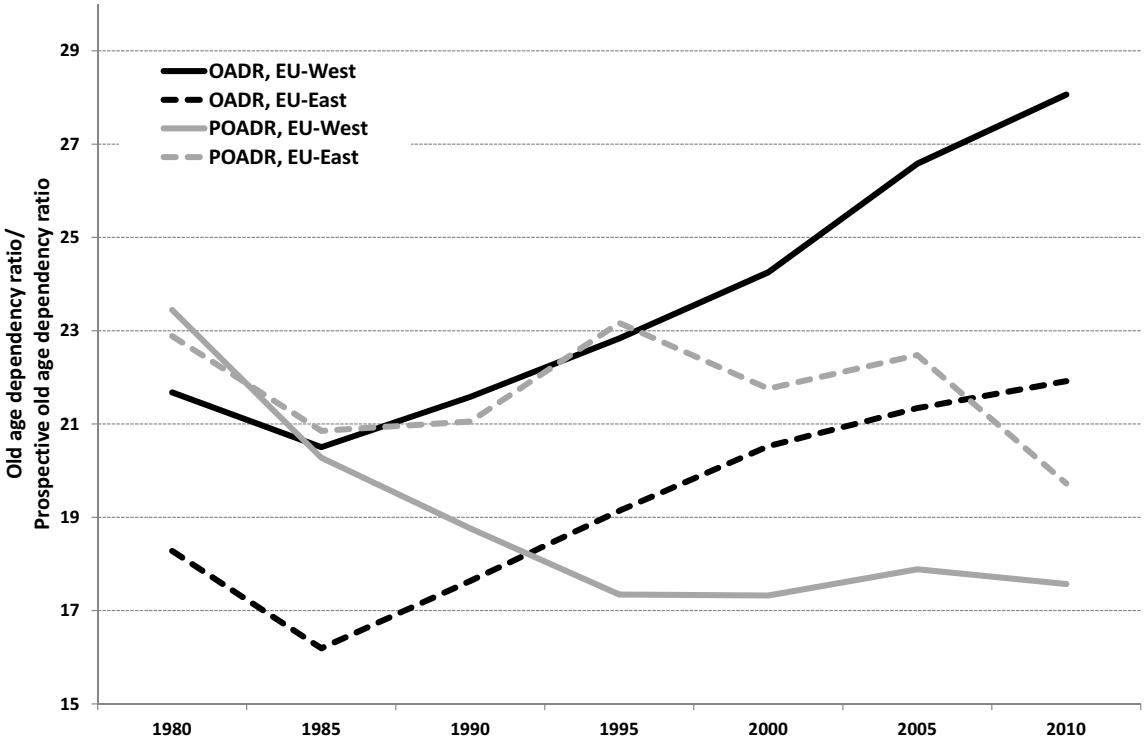

Figure 4: Western and Eastern EU regions: Old age dependency ratio (OADR) and prospective old age dependency ratio (POADR), 1980-2010

used to compute the POADR (that is, the age at which remaining life expectancy is 15 years) in France was 70 years, while in the Czech Republic it was six years lower.

To the extent that the additional information about changes in life expectancy which is included in the POADR is related to productivity and labour market participation of older individuals, it is expected that changes in this indicator serve as a better predictor than OADR for economic growth. We assess such a question quantitatively by including these indicators in simple economic growth panel regressions in the following section.

3 Economic growth and (prospective) ageing

In this section we assess empirically the extent to which ageing measures can explain differences in income growth across and within European countries for the last decades. We address the role played by the ageing measures using a panel regression model linking income growth in country i at period t ($\Delta \log y_{it}$) to the change in the ageing measure, as well as other explanatory variables. In particular, our most general specification is given by

$$\Delta \log y_{it} = \beta_1 \Delta \log POP_{it} + \beta_2 \Delta \log K_{it} + \beta_3 \log y_{0,it} + \gamma \Delta AGE_{it} + \theta \Delta AGE_{it} \times \log y_{0,it} + \varepsilon_{it}, \quad (1)$$

where $\Delta \log POP_{it}$ denotes population growth, $\Delta \log K_{it}$ is the growth rate of physical capital, $\log y_{0,it}$ is the initial value of (log) income per capita (evaluated at the first year of the corresponding period) and ΔAGE_{it} is the change in the ageing indicator. The specification given by equation (1) allows for different effects of ageing depending on the level of income per capita of the country through the inclusion of an interaction term formed by the product of the ageing measure and initial income per capita. The error term, ε_{it} is assumed to be composed by a country-specific time-invariant component, a period fixed effect and a disturbance, assumed to be homoskedastic and uncorrelated over time. Therefore ε_{it} can be written as $\varepsilon_{it} = \mu_i + \lambda_t + \nu_{it}$, with $\nu_{it} \sim \text{IID}(0, \sigma^2)$. The specification can be thought of as emanating from a simple production function where aggregate income depends on labour and capital input and the initial income per capita variable accounts for convergence dynamics to a country-specific equilibrium.

We construct a dataset spanning information for the period 1970-2010 on the variables mentioned above as well as the OADR and the POADR for all European countries for which data are available. The original source for the income and population data is the Penn World Table 7.1 (Heston et al., 2009), the capital stock data are sourced from Berlemann and Wesselhöft (2012). The OADR is constructed using data from the United Nation's Population Division and the construction of the POADR uses also data on life expectancy by age sourced from Eurostat. Using all the data available from countries belonging to the European continent, we are able to construct an unbalanced dataset that contains information on all these variables for 23 EU countries (Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Malta, Netherlands ,Poland, Portugal, Slovenia, Spain, Sweden and United Kingdom), as well as Iceland, Norway, Switzerland and TFYR Macedonia.

In order to gain some insights into the temporal dimension of the relationship between income growth developments and ageing indicators, we estimate three different versions of equation (1) based on 5-year periods, 10-year periods and 20-year periods. The estimates of the different models are presented in Table 1. The top part of Table 1 refers to estimates based on the panel dataset defined on 5-year intervals. The first column presents the estimates of model (1) for the

5-year periods								
Pop. Growth	-0.108	-0.105	0.0705	0.149	-0.262	-0.302	-0.0543	-0.113
	[0.356]	[0.349]	[0.763]	[0.751]	[0.348]	[0.331]	[0.806]	[0.792]
Phys. Cap. Growth	0.257**	0.248**	0.564**	0.512**	0.276***	0.280***	0.574**	0.554**
	[0.0999]	[0.101]	[0.238]	[0.246]	[0.0957]	[0.0939]	[0.237]	[0.237]
Initial Income	-0.0358**	-0.0337**	-0.416***	-0.395***	-0.0334**	-0.0453***	-0.418***	-0.419***
	[0.0149]	[0.0143]	[0.0921]	[0.0862]	[0.0145]	[0.0171]	[0.0903]	[0.0895]
Change in OADR					-2.041***	-16.02	-1.169	-20.08**
					[0.732]	[11.49]	[0.844]	[9.474]
Change in OADR						1.402		1.904*
× Initial Income						[1.125]		[0.958]
Change in POADR	-1.229***	-7.991	-0.673	-15.00*				
	[0.462]	[7.949]	[0.503]	[8.572]				
Change in POADR		0.688		1.462*				
× Initial Income		[0.797]		[0.849]				
Observations	152	152	152	152	152	152	152	152
R-squared	0.399	0.402	0.541	0.554	0.4	0.406	0.542	0.552
Number of countries	27	27	27	27	27	27	27	27
Country fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
10-year periods								
Pop. Growth	-0.14	-0.149	-0.722	-0.441	-0.306	-0.337	-0.963*	-0.817
	[0.373]	[0.357]	[0.556]	[0.549]	[0.339]	[0.348]	[0.558]	[0.531]
Phys. Cap. Growth	0.348***	0.342***	0.606**	0.477*	0.364***	0.369***	0.637**	0.557**
	[0.121]	[0.117]	[0.268]	[0.260]	[0.118]	[0.116]	[0.271]	[0.252]
Initial Income	-0.0844**	-0.0731**	-0.745***	-0.685***	-0.0779**	-0.108**	-0.731***	-0.753***
	[0.0331]	[0.0322]	[0.128]	[0.121]	[0.0305]	[0.0500]	[0.108]	[0.109]
Change in OADR					-2.635**	-19.61	-1.485	-28.59
					[1.044]	[19.93]	[1.010]	[20.03]
Change in OADR						1.696		2.719
× Initial Income						[1.947]		[1.997]
Change in POADR	-1.695**	-14.4	-0.818	-19.13**				
	[0.786]	[10.57]	[0.798]	[9.197]				
Change in POADR		1.294		1.870*				
× Initial Income		[1.075]		[0.940]				
Observations	71	71	71	71	71	71	71	71
R-squared	0.399	0.413	0.679	0.703	0.408	0.417	0.686	0.705
Number of countries	26	26	26	26	26	26	26	26
Country fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
20-year periods								
Pop. Growth	0.164	0.24	0.312	-2.012**	0.0238	0.145	0.201	-0.0688
	[0.313]	[0.306]	[1.539]	[0.835]	[0.324]	[0.329]	[1.504]	[1.566]
Phys. Cap. Growth	0.242**	0.237**	-0.0236	-0.540*	0.244**	0.228**	-0.174	-0.00297
	[0.105]	[0.0935]	[0.149]	[0.266]	[0.0900]	[0.0834]	[0.204]	[0.305]
Initial Income	-0.211***	-0.271***	-0.938***	-1.232***	-0.203**	-0.111	-0.979***	-0.894**
	[0.0721]	[0.0797]	[0.276]	[0.264]	[0.0729]	[0.118]	[0.303]	[0.380]
Change in OADR					-2.060***	24.93	-0.261	38.73
					[0.586]	[21.52]	[0.796]	[50.06]
Change in OADR						-2.699		-3.899
× Initial Income						[2.147]		[5.026]
Change in POADR	-1.605***	29.10*	-0.619	62.66**				
	[0.458]	[16.87]	[0.656]	[22.46]				
Change in POADR		-3.142*		-6.340**				
× Initial Income		[1.718]		[2.269]				
Observations	31	31	31	31	31	31	31	31
R-squared	0.607	0.648	0.825	0.894	0.582	0.603	0.816	0.824
Number of countries	22	22	22	22	22	22	22	22
Country fixed effects	No	No	Yes	Yes	No	No	Yes	Yes

* (**) [***] stands for significance at the 10% (5%) [1%] level. Period fixed effects included in all specifications, country fixed effects when indicated. The panel spans information for the period 1970-2010 for 120 countries. The dependent variable is the growth rate of GDP per capita over the corresponding period.

Table 1: Estimation results: Economic growth panel regression models

POADR without country fixed effects and without the inclusion of the interaction term, that is, assuming that the effect of the ageing variable is homogeneous across European economies. Since the model does not include country fixed effects, the effects found are to be interpreted as explaining differences both across and within countries. The parameter estimates imply that physical capital accumulation and income convergence dynamics are able to significantly explain differences in income per capita growth in Europe. The highly significant negative parameter attached to the change in POADR indicates that, after controlling for the rest of the covariates, countries whose population got relatively older as measured by this index tended to have slower economic growth. An increase of 1 percentage points in the POADR over a five year period, which roughly corresponds to the 85th percentile of the distribution of changes in POADR observed in the sample at hand, is associated with a decrease of economic growth by approximately 1.23 percentage points in the same period. A similar qualitative result is obtained if the OADR is used as a measure of population ageing, with a correspondingly larger elasticity, which is in line with the relatively smaller variance of the variable as compared to POADR. For the panel dataset based on 5-year periods in the setting without country fixed effects, the interaction term of POADR or OADR with income per capita does not deliver significant results that would point towards parameter heterogeneity across countries depending on their level of income per capita.

In a next step, we include fixed country effects in our specification and thus concentrate on variation within countries, which is the most relevant dimension for gaining insights directed towards policy conclusions. Once that the country fixed effects are added to the model (see columns 3 and 7 in Table 1), the ageing indicators remain negative but lose statistical significance, thus indicating that the significant parameter estimates in the models presented in columns 1 and 5 are driven by the link between differences in economic growth and the ageing measures across countries, but that such a robust link is not existing when concentrating exclusively on changes over time in a given country. Including the interaction with income per capita in this model results in significant interaction terms in both of the specifications (see column 4 and 8). The results indicate that the negative effects of ageing on economic growth appear to be more important in economies with a relatively lower income per capita level.[3] The model estimates give thus evidence that ageing is a particularly serious challenge to sustainable income growth in Eastern European economies, whose income per capita level is below EU average and which are precisely expected to experience further increases in old age dependency ratios (see for example World Bank, 2013).

In the middle panel we repeat the same exercise concentrating on larger time horizons by estimating the same models using a panel based on 10-year periods. In this case, the estimation results of the models without country fixed effects and with an ageing variable are qualitatively similar to those obtained for the panel based on 5-year periods. The chronological ageing variable, however, does not appear statistically significant in any of the models once that country fixed effects are included in the specification. The use of the prospective ageing index, on the other hand, leads to similar conclusions as those found in the 5-year panel. Similar insights are gained from estimating panel regression models based on 20-year periods, whose results are presented in the bottom panel of Table 1. In spite of the small sample size of 31 observations, changes in the POADR and their interaction with initial income in the corresponding period appear as robust determinants of income growth even when controlling for time-invariant

[3]The level of income corresponding to a zero economic growth effect of the ageing variable is approximately equal to the income per capita level of the UK in 2000 for the case of POADR and slightly larger in the case of OADR. The observed sample is thus dominated by significant negative economic growth effects of ageing.

country-specific unobservables. The OADR, on the other hand, does not have a significant effect in any of the two estimated specifications once that fixed country effects are part of the model.[4]

In order to assess the robustness and stability of the relationships found, we perform a simple out-of-sample prediction exercise based on the estimated models. Using data spanning the period 1970-1995, we estimated models based on the two alternative specifications given by columns 4 and 8 in Table 1, including the corresponding lagged change in the ageing variable instead of the contemporary change in the OADR and the POADR. Using the estimated models, we perform forecasts of income per capita growth for the period 1995-2000 and compute the prediction errors of the two alternative specifications. We repeat the exercise estimating the models for 1970-2000 and predicting the period 2000-2005, and for the in-sample period 1970-2005 and the out-of-sample period 2005-2010. The same exercise is performed for the 10-year panel, using 2000-2010 as the out-of-sample prediction period. While the prediction errors are relatively similar across models with different ageing measures for the 5-year horizon (with a root mean squared error of 0.16 in both cases), the predictions of the model using the POADR perform extremely better than those obtained using the OADR for the 10-year horizon (root mean squared error of 0.25 versus 0.66), and the results of a Diebold-Mariano test for equality of predictive accuracy (Diebold and Mariano, 1995) gives significant evidence concerning the superiority of the model built on the POADR.

4 Conclusions

The trends in population ageing observed in the developed world over the last decades have been often argued to constitute a serious challenge for economic growth and income convergence in Europe. We evaluate empirically for the first time whether prospective ageing measures are better able to explain the effect of such demographic changes on economic growth than chronological age indicators.

The results of our panel regressions provide clear empirical evidence concerning the superiority of measures based on prospective ageing as predictors of future economic growth at long horizons. As opposed to the standard OADR, which is built upon chronological age, changes in the POADR are able to explain changes in income per capita growth in a robust manner at 5-year, 10-year and 20-year horizons, while the OADR is only a significant determinant of such economic growth horizons when using data measured at 5-year intervals. Our results indicate that the effect of ageing on income dynamics is heterogeneous across countries and that the negative consequences of ageing societies are stronger in relatively poorer economies. The conclusions of our analysis indicate that monitoring prospective ageing measures should be a priority in the framework of designing policies aimed at combating the negative consequences of ageing for the macroeconomy.

[4]As a robustness exercise, we also estimated alternative models including other potential determinants of economic growth such as trade openness and educational attainment. The results described in the text remain robust to such changes in the specification. Detailed results for these robustness checks can be obtained from the authors upon request.

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