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OECD countries' twin long-run challenge: The impact of aging dynamics and increasing natural disasters on savings ratios

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Abstract

There has been a long-standing debate over the development of savings rates in developed economies, and an emphasis has been placed on aging societies and a global savings glut. Meanwhile, with rising global temperatures and more frequent extreme weather events becoming an increasingly visible economic and ecological global challenge, the concern of climate-related risks could indeed be an important issue in monetary and real economic analysis. This study aims to investigate the dual long-term challenge of sustainable economic development. By constructing an enhanced growth model and investigating empirically, using a panel approach which employs data from OECD countries between 1980 and 2020, the question as to the extent to which the savings rate is affected by aging populations and environmental degradation will be addressed in a broad macro perspective. This study explores for the first time the impact of natural disasters on OECD countries and the main findings indicate that aging populations and natural disasters have significant negative impacts on savings rates. Moreover, the analyses using sub-samples suggest a diminishing role of the real long-term interest rate regarding savings behaviour.

Keywords Savings rate · Aging · Natural disaster · Economic growth · Panel analysis · OECD

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1 Introduction

There has long been a debate over the development of savings ratios in the context of aging societies in OECD countries. However, much emphasis has been placed on potentially increasing savings ratios in aging societies and the meagre long-run real interest rates explained by a global savings glut. With climate change problems becoming an increasingly visible economic and ecological global challenge, and with the phenomenon of extreme weather events becoming more frequent, the question of climate-related risks indeed could be a pressing issue in monetary and real economic analysis (IPCC 2021).

Global warming brings about more frequent extreme weather events so that natural disaster phenomena associated with climate change problems need to be analysed in a broad macro perspective. One key empirical aspect concerns the question as to the extent to which the savings ratio is influenced by natural disasters, e.g. flooding and hurricanes - the latter two obviously partly related to climate change problems and the rather slow global progress in terms of bringing about a strong and controlled decline of CO2 emissions; even if policymakers in G20 countries would adopt many ambitious climate policy programmes, one will have to anticipate more extreme weather challenges in the coming decades, not to mention events such as earthquakes which also come as shocks to so many countries in the world economy. The empirical evidence suggests that the savings rate falls if natural disasters are rising in terms of the number of days duration. Thus, successful climate policy – with lower frequencies of natural disasters – will raise the global (OECD) savings ratio and thus could affect the cost of capital and the cost of the global modernization necessary to achieve sustainability and climate neutrality, respectively.

Occurrences of many consecutive days of extreme rainfall and resulting flooding and hurricanes have become new problems in North America, Europe, Asia and Australia since about 1990 (IPCC 2013). The empirical results show clear evidence of the impact of demographic changes as well as natural disasters on the savings ratios – where longer spells of serious disasters bring about lower savings ratios: possibly because people witness to the physical destruction brought about by natural disasters feel discouraged with respect to the accumulation of physical assets or because the negative income shocks associated with natural disaster shocks undermine the ability of people to maintain high savings ratios in OECD countries and other country groups. Aging and declining fertility rates as well as the frequency of natural disasters affect the savings ratios in many countries and it is not clear whether or not the 21st century will be characterized by very high savings ratios in the long run unless a rapidly developed, successful and global climate change policy could help bringing down the frequency of natural disasters rather quickly.

High-income nations, in particular, face the burden of a declining demographic resulting from falling fertility rates and rising longevity (UN 2015). Figure 1 illustrates the dependency ratios of different selected age groups for OECD countries. The vertical axis is the ratio of the elderly group (aged 65+) to per hundred

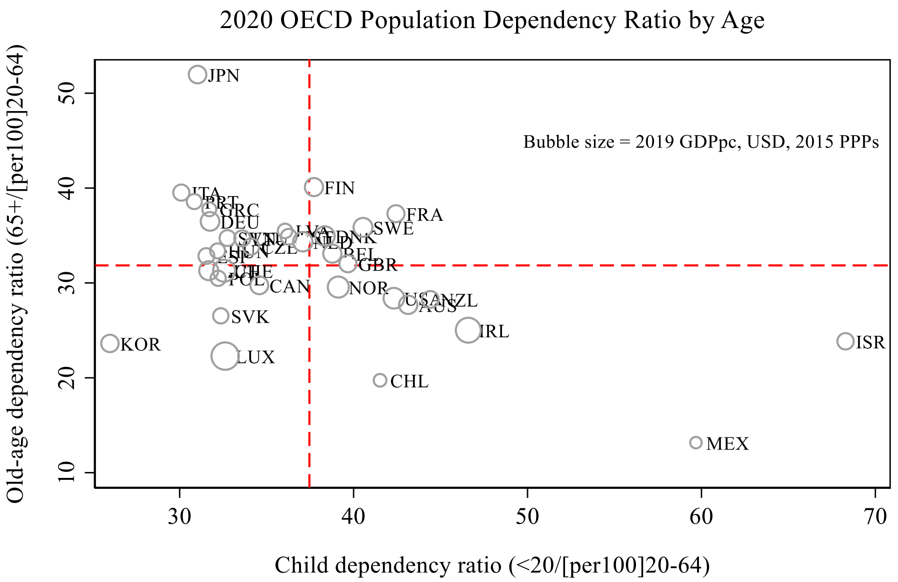

Fig. 1 2020 OECD population dependency ratio by age

working-age population between 20 and 64 years of age. The horizontal axis indicates the child dependency ratio (i.e., those aged 0–19 years / 20–64 year olds). The size of the bubble refers to the GDP per capita of each country using data from 2019 in USD at 2015 constant prices at Purchasing Power Parity (PPP), and the bubbles get larger as the amount of the GDP per capita gets bigger. The horizontal and vertical red dotted lines show the group-mean of the two dependency ratios individually. By looking at the graph, we can see that the cross-country average child dependency ratio is higher than the old-age average dependency ratio, but the difference is minor, and a major group of countries is clustered in the quadrants which have either a high/low ratio of old-age dependency and a low child dependency. Interestingly, the percentage of people above 65 years of age relative to the working population is above 50% in Japan, far ahead of other OECD countries, while at the same time, Japan obtains a much lower child dependency ratio. By contrast, Mexico and Israel have a considerably high proposition of young people and a low old-age dependency.

According to United Nations' projections using the medium-fertility variant of these two dependency ratios for OECD until 2080 in Fig. 2, both dependency ratios appear to have an opposite developing trend. The year-average forecasted child dependency ratio (long dash-dotted line) will face a slight decline and remains relatively constant at around 39% over time. Instead, the gap between the two estimated ratios is continuously rising. For the old-age dependency ratio (solid line), the figure is expected to double within the next half-century from ca. 30–60%.

The paper is organized as follows: After the introduction follows Section 2, which reviews the relevant literature. In Sections 3 and 4, the theoretical modelling and

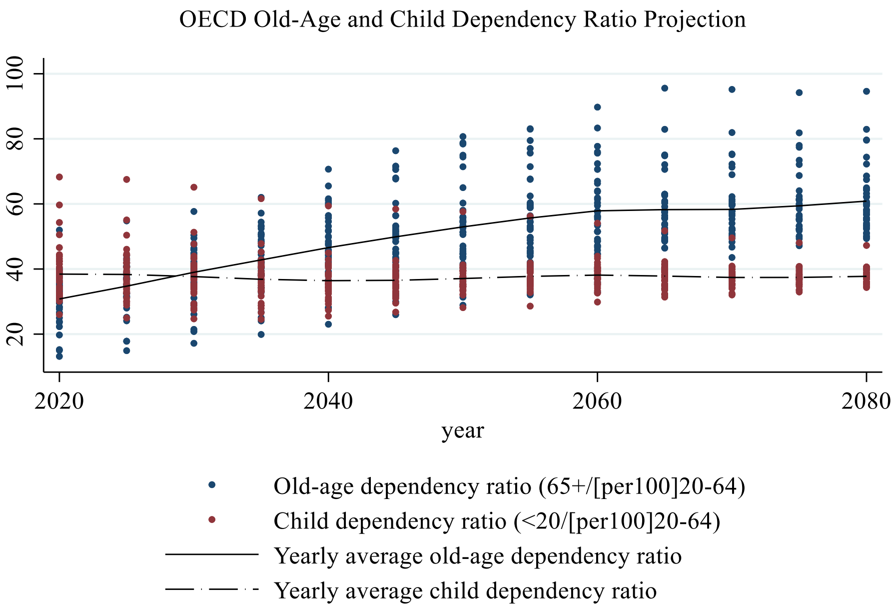

Fig. 2 OECD old-age and child dependency ratio projection

empirical analysis are included. Section 5 incorporate the conclusions and future research recommendations.

2 Literature review

While analysing differences between the savings rates in EU countries, Stierle and Rocher (2015) show that besides the income level, age dependency and uncertainty (here, the variation in inflation and unemployment levels are taken as proxies) are also factors explaining savings behaviour. Results in Bloom et al. (2007) and Bloom et al. (2011) also indicate that higher old-age dependency rates tend to lower savings rates and that there is a positive relationship between life expectancy and savings rates. As regards uncertainty, results from Engen and Gruber (2001), Flodén (2006) undermine the positive link between savings rates and (labour-) income and employment risks. Besides the income risk, Eeckhoudt and Schlesinger (2008) find that interest-rate risk is also a main driver of savings rates. In a nutshell, the literature provides strong evidence that savings behaviour is related to risks and uncertainty, which threatens the welfare of the economy. From this perspective, uncertainties arising from both the demographic change towards an aging society and climate-related risks – which are difficult to assess – could have a significant impact on savings behaviour. In this context, it is not unreasonable to assume that not only physical but also transitory climate risks are important factors in savings behaviour.

At the beginning of the millennium, Boersch-Supan and Winter (2001) predicted that after initial higher savings rates between 2015 and 2025, savings rates will decline as the population ages. Due to the changes in savings behaviour, the authors argue that, especially in Europe, the attractiveness and necessity of one's own savings with respect to retirement is becoming more and more important. According to the study, this trend will affect the portfolio structure of households and deepen capital markets. Especially for European countries with relatively low stock market capitalization (e.g., France, Germany and Italy) this is associated with an improvement in corporate governance and capital allocation. De Haas and Popov (2019) show that equity markets play an important role as regards the transition to a low carbon economy, since they shift investments to less polluting sectors and urge carbon-intensive sectors to develop and implement greener technologies. Moreover, their study indicates that more developed stock markets produce more green patents (De Haas and Popov 2018). Thus, a higher market capitalisation due to an aging population could have a positive impact on green innovation and the decarbonization of the economy. Furthermore, in a panel data analysis of 25 OECD member countries, Hassan and Salim (2015) show that an increase of the share of the aged population reduces the per capita CO2 emission in the long run.

On the other hand, aging could hinder the greening of the economy as shrinking labour supply and employment levels (European Commission 2021), lower labour productivity growth (Aiyar and Ebeke 2016) and the decline in savings (Börsch-Supan and Ludwig 2009) could lead to lower corporate profits, increasing interest rates capitalization. Moreover, Andor et al. (2018) find in their analysis of household data that older people tend to be less willing to pay for environmental policies. This finding could also be an indication of the investment behaviour of the aging population, namely that less consideration is given to climate-friendly investments during private pension savings.

The ongoing problem of global warming has reinforced the challenge of extreme weather problems in the US, Canada, Europe, Asia and Australia. Nevertheless, the effects of disasters and physical climate risks on savings behaviour have been rather understudied. Earlier studies have focused more on the effect of adverse shocks on the savings rate. Moreover, existing studies looking at the impact of disasters on savings have focused on individual countries – most notably Japan. Udry (1995) finds evidence that agricultural households in Nigeria save less in case of adverse shocks and save more when they are favoured with a positive shock. He argues that the picture could change if economic entities could foresee negative shocks (Udry 1995, p. 1295): "*If shocks are predictable, then standard intertemporal models imply that the household would have saved in advance of the occurrence of the shock*".[1] Skidmore (2001) uses a life cycle model to examine the effects of natural catastrophes on savings behaviour in Japan and finds that geologic and climatic catastrophes are positively correlated with household saving rates. In accordance to that, Horioka and Watanabe (1997) point out that Japanese households hold substantial amounts of precautionary savings. Since Japan is relatively vulnerable to natural disasters

[1] Especially with respect to climate change, this observation is very crucial, since the increase of climatic catastrophes on the one hand, and the statements of climatologists on the other hand, raise the expectations of further climate-related disasters.

like earthquakes or tsunamis, a certain share of precautionary savings could reflect that self-insurance plays an important role for Japanese households. Skidmore and Toya (2002) use a cross-country empirical analysis and show for the long-run, that physical capital investment decreases with higher disaster risks, while human capital increases. In contrast to the previous findings, Sawada and Shimizutani (2008) analyse the coping strategies of victims of the great Hanshin-Awaji (Kobe) earthquake in 1995 using a household dataset and find that households dissaved and raised loans after the shock. The authors explain this finding by the ineffectiveness of the insurance system, which highlights the need for Japanese households to self-insure. Raschky and Weck-Hannemann (2007) analyse the "charity hazard" as regards the European flood of 2002 and conclude that government financial assistance following a catastrophic event can lead to further distortions in the insurance market as households anticipate that government assistance will also follow future disasters. In accordance to that, the study by Berlemann et al. (2015) examines the impact of the European flood of 2002 on savings behaviour and conclude that the flood dampened the savings motive of victims, mainly due to the generous state compensation. Using a panel dataset for China's Sichuan province, Filipski et al. (2019) find that the closeness of individuals to the epicentre of the 2008 earthquake significantly reduced their savings rate in the short and middle term. Luo and Kinugasa (2018) also analyse the impact of the 2008 Sichuan earthquake on saving behaviours. Using a counterfactual method, the authors find that "in the short-run, the earthquake has caused drastic declines in household saving rates—from 24–7% and from 23–21% for rural and urban populations, respectively".

In a nutshell, the existing literature on the impact of aging on savings rates provides broadly similar findings, that higher old-age dependencies cause lower savings rates. Only in periods during which a relatively large cohort approaches retirement age could the savings rate rise despite a rising old-age dependency ratio. Regarding the effects of natural disasters on the savings rate, the literature does not allow to draw clear conclusions about the direction of the impact. The reason for this could be the country- and event-specific analyses in the existing literature. In terms of natural disaster savings behaviour, Japan in particular, about which there are many natural disaster-related studies, could be an outlier due to its cultural and demographic characteristics. Therefore, there is an urgent need to go beyond the country-specific perspective and expand empirical knowledge on disaster-related savings behaviour across countries.

3 Theoretical aspects of key influences of the savings ratio - savings plus investment and innovation dynamics in an enhanced growth model

Using an enhanced neoclassical Solow model, this section discusses the steady-state relationship between the savings rate, per-capital income and the old-age dependency ratio. The total population N is assumed to be divided into a young population N_y and an old population N_o $\left(N = N_y + N_o\right)$. Hence, the old-age dependency ratio is $= \frac{N_o}{N_y}$

($\in (0,1)$). Since only the young population participates in the labour market, we can state the following for labour L:

$$L = N_y = N\frac{1}{1+d} = \frac{N}{\Phi}, \tag{1}$$

where $\Phi := 1 + d$ ($\in (1,2)$) with an exogenous growth rate φ: $\Phi = e^{\varphi t}$, where t denotes time. Assuming that the exogenous growth rate of the total population is n, the following labour supply can be noted.

$$L(t) = \frac{N_0}{\Phi(t)}e^{nt} = N_0 e^{(n-\varphi)t}, \tag{2}$$

where N_0 denotes the initial value of N. We also assume that a is the growth rate of the level of technology A, with the initial level A_0: $A(t) = A_0 e^{at}$. As usual, we use a Cobb-Douglas production function with constant returns to scale.

$$Y = K^{\beta}(AL)^{1-\beta} \text{with } 0 < \beta < 1, \tag{3}$$

where Y and K denote total production and capital, respectively, and β is the elasticity of production with respect to capital. Given that $S = s(1 - t')Y$, where t' denotes the tax rate, the differential equation is

$$S = \frac{dK}{dt} + \delta K, \tag{4}$$

where δ is the depreciation rate of capital. Defining capital and output relative to effective labour ratio as $k' = \frac{K}{AL}$ and $y' = \frac{Y}{AL}$, respectively, we obtain.

$$y' = k'^{\beta}. \tag{5}$$

The derivative of k' with respect to time is

$$\frac{dk'}{dt} = \frac{dK}{dt}\Big/AL - (a + n - \varphi)k'. \tag{6}$$

Dividing Eq. (4) by AL and using the production function in (5), we obtain

$$\frac{dk'}{dt} = s(1 - t')k'^{\beta} - (a + n - \varphi + \delta)k'. \tag{7}$$

Solving the differential equation gives as steady state

$$k'^{*} = \left(\frac{s(1 - t')}{a + n - \varphi + \delta}\right)^{\frac{1}{1-\beta}} \tag{8}$$

$$y'^{*} = \left(\frac{s(1 - t')}{a + n - \varphi + \delta}\right)^{\frac{\beta}{1-\beta}}. \tag{9}$$

$$y''^{*} = A_0 \left(\frac{s(1 - t')}{a + n - \varphi + \delta} \right)^{\frac{\beta}{1-\beta}} e^{at}, \tag{10}$$

and the per-capita output $y = \frac{Y}{N}$ in the steady state is

$$y^{*} = A_0 \left(\frac{s(1 - t')}{a + n - \varphi + \delta} \right)^{\frac{\beta}{1-\beta}} e^{(a-\varphi)t}. \tag{11}$$

After taking the logarithm of Eq. (11), we obtain the following

$$\ln\ y * = \ln \left[A_0 \left(\frac{s(1 - t')}{\alpha + n - \varphi + \delta} \right)^{\frac{\beta}{1-\beta}} \right] (\alpha - \varphi)t\ . \tag{12}$$

According to Eq. 12, the variables inside the square brackets change the level of the growth path: an increase in the savings rate s, a decrease in the growth rate of knowledge a, a decrease in the tax rate t', a decrease in the growth rate of population n, a decrease in the depreciation rate of capital δ, and an increase of the old-age dependency ratio φ raise the level of the growth path. With respect to the trend growth of output, only two variables are significant: a higher growth rate of knowledge a increases trend growth, whereas increasing growth rates for the old-age dependency ratio φ has a negative effect on growth.

Demographic change will most likely affect the above variables, so that in the context of the extended Solow model, both the level of the growth path and trend growth will be affected. In line with the findings in the literature, the savings ratio s is expected to decline and, in addition, the tax ratio t' is expected to rise due to the increase in the share of the pension ratio financed by taxes. Both assumptions would have a negative impact on the level of the growth path. It is assumed that the growth rate of the population n will decrease, which would lead to an increase in the level of the growth path. In the absence of economic policy countermeasures – for instance, in the area of (more) life-long learning - the aging of society is likely to lead to a decline in the growth rate of knowledge and technical progress a. Moreover, the old-age dependency rate is expected to increase. The decrease in a and the increase in $a - \varphi$ have a twofold effect; the level of the growth path will be positively affected by these changes, whereas trend growth is clearly negatively affected. As also shown in Fig. 3, the result is that demographic change will lead to a flattening of the growth path, but the effect on the level of the path depends on the strength of the individual variables.

With respect to the model described, it is arguable that the savings rate, per-capita income and the old-age dependency ratio show interdependencies. The higher per capita income y is, the higher will be the savings rate - a typical finding in economic history: with higher incomes, the interest of individuals in accumulating wealth is raised. Moreover, the higher the real interest rate r, the higher the incentive for saving on the one hand, on the other hand the income generating effect of a higher yield of return (here, the real interest rate) is dampening the savings incentive; furthermore, the higher

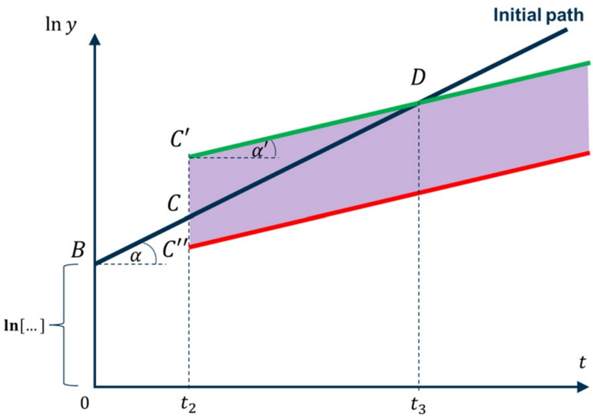

Fig. 3 Aging effects in the Solow Model. Note: An exogenous decrease of *a*, *s*, *n* and an increase of *t'* and *φ* in *t*2 due to aging leads to a flattening of the growth path (from tan——1(*a* - *φ*) = *α* to *α'* < *α*); however, depending on the strength of the exogenous changes, the level of the growth path may decrease (*C''*) or increase (*C'*). Source: own illustration

the real interest rate, the higher the growth rate in a golden rule growth model perspective so that the savings rate could decline if a higher anticipated real income growth rate dampens the interest in savings. Climate risks could also affect savings behaviour: the higher the number of days of natural disaster occurrences, the more aware individuals are about the risk of the physical destruction of the capital stock (broadly defined) and hence the interest of individuals in the accumulation of capital will decline. If climate problems result in more extreme weather events – and hence more disaster days *D* (possibly also with rising damages per disaster day) – the enhanced climate change problems could bring about a lower savings ratio. Furthermore, increasing climate disaster days and damages are likely to cause a higher depreciation rate of capital δ. In a standard neoclassical growth model, both a lower savings rate and a higher depreciation rate would cause the level of the growth path to fall.

To verify the theoretical findings, we use the following empirical model:

$$s = \gamma_0 + \gamma_1 r + \gamma_2 d + \gamma_3 \ln y + \gamma_4 D. \tag{13}$$

4 Empirical analysis of savings ratios

Based on the theoretical framework developed, we have employed a panel data analysis with fixed-effects to estimate the enhanced growth equation using data from 34 OECD countries over the period from 1980 to 2020. We excluded five countries from the data sample due to missing values. The list of countries included in each model can be found in the Appendix (Table 4)

4.1 Data and sample

The dependent variable, the savings rate, and the other two explanatory variables, the long-term interest rate and GDP per capita, are collected from the OECD database. The real values for the savings rate and the long-term interest rate are generated by adjusting depreciation using GDP deflator, the GDP per capita figures uses PPP data in constant 2015 prices. The old-age dependency ratio is taken from the UN. It is the share of the population aged65 years and above to the working population, i.e. those aged between 20 and 64 years of age. The number of days relating to all kinds of natural disasters are accumulated as a proxy for the potential impact of natural disasters. Data on this are collected from the EM-DAT, CRED/ UCLouvain. We aggregate the number of days containing complete information on the day, month, and year of a natural disaster from beginning to end. We also summed the total damages in US$ caused by natural disasters as an alternative measure, and a comparable result is presented as for the former variable. Therefore, the variable of days for natural disasters is kept in the reported regression results due to fewer missing observations compared to the total damages. Detailed information concerning the composition of the data can be found in Table 1 with the expected signs. The descriptive statistics and pairwise correlation for each variable are displayed in Table 2.

4.2 Estimation method

In this study, we have macro-panels of 34 OECD countries over the period 1980–2020. With relatively large T and N, and with N/T → 0, several issues might arise. For instance, panel series might be nonstationary, the regression parameters may be heterogeneous across countries, the regressors serially correlated, and cross-country dependence can exists in panels (Baltagi 2021, p.337). We firstly examine data for the existence of panel stationarity. The null hypothesis of a unit root can be rejected for most individual series using the CIPS panel unit root test developed by Pesaran, which allows for cross-sectional dependence (Pesaran 2007). The old-age dependency ratio and GDP per capita in logarithm are stationary at the first difference. Also, the null hypothesis of no cointegration is rejected using the residual-based DF test suggested by Kao (1999). The inclusion of year dummies could also capture much of the residual cross-correlation (Nickell et al. 2005). We then test the poolability of the data using a Chow test (Chow 1960), the null hypothesis of common slopes is rejected, thus, the individual-specific effect should be considered. By applying fixed or random effects techniques, the time-invariant individual heterogeneity can be captured. In addition, the statistics of the F-test significantly reject the null hypothesis in favour of the alternative hypothesis, according to which at least one dummy parameter is not equal to zero; thus, the fixed-effects model (FE) can be seen to have better goodness-of-fit to the data in comparison to a pooled ordinary least squares (OLS) estimator (Baltagi 2021, p.87). The model with random effects (RE) is also examined by a Lagrange multiplier (LM) test, the null hypothesis of the LM test which assumes that variances across entities are zero can be rejected based on a significant result, which indicates that the RE model is favoured over the pooled OLS model (Breusch and Pagan 1980). A highly significant result at a 5% significance level from Hausman's specification test rejects the null hypothesis that the model with RE is more efficient than FE (Hausman 1978). As the panels contain a long time series and the disturbances are indicated

Table 1 General information of used variables

Variables	Description	Source	Expected sign	Time period
Savings rate	The ratio of net saving (saving net of depreciation) to GDP	OECD		1980–2020
Real long-term interest rate	The long-term interest rate adjusted by GDP deflator	OECD	+/-	1980–2020
Old-age dependency ratio	Annual old dep. ratio [(65+) / 20–64] (%)	UN	-	1980–2020
LN_ Per capita income	GDP per head of population in logarithm (USD, constant prices, 2015 PPPs)	OECD	+	1980–2020
Days for natural disasters	Aggregated days for natural disasters by year	EM-DAT, CRED / UCLouvain, Brussels, Belgium	-	1980–2020

Table 2 Descriptive statistics and pairwise correlations

	Variable	Obs	Mean	Std. Dev.	(1)	(2)	(3)	(4)
	Country	1394	18.85	10.55				
	Year	1394	2000	11.84				
(1)	Savings rate	1178	7.23	6.14	1.000			
(2)	Real long-term interest rate	962	2.62	3.21	-0.223*	1.000		
(3)	Old-age dependency ratio	1394	23.82	6.25	-0.261*	-0.245*	1.000	
(4)	LN_Per capita income	1292	10.36	0.45	0.159*	-0.247*	0.481*	1.000
(5)	Days for natural disasters	1024	5.22	18.12	-0.096*	-0.035	0.094*	-0.017

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

to be cross-sectionally dependent, groupwise heteroscedastic, and autocorrelated as suggested by the results using Pesaran's test, a modified Wald test, and the Wooldridge test (Pesaran 2004; Drukker 2003; Wooldrige 2010), Driscoll-Kraay standard errors are estimated to provide robust estimations (Driscoll and Kraay 1998).

4.3 Regression results

In this section, we report on the empirical findings of the changes in the savings rates in OECD countries over the 40 years since 1980. The regression results have been presented in the following Table 3. The savings rate is the outcome variable that is used in all models. The estimated effects using full samples are reported in columns 1 to 6, the results in columns 7 to 10 are predicted using sub-samples with different time periods and country groups. The countries included in the samples are listed in Table 4 in the Appendix.

As can be seen in columns 1 to 4, the estimates of individual variables show the expected signs, and all outcomes are significant at the 1% significance level. Two separate regressions are conducted in the following models, resulting in a high correlation between the old-age dependency ratio and per capita income. As shown in models 5 and 6, the real long-term interest rate is negatively associated with the savings rate. A 1% change of the real long-term interest rate is expected to lead to a decrease in the range of 0.2 and 0.3% in the savings rate ($P<0.01$) for the analysed OECD countries. A significant result is also identified for the old-age dependency ratio. In model 5, the estimated coefficient shows a one-percent increase of the old-age dependency ratio is associated with a 0.36% decrease of the savings rate, holding other variables constant. Per capita income in model 6 displays a positive and highly significant impact on the savings rate. In this study, natural disasters, as measured by the cumulated number of days of duration of said disasters, strongly influence the savings rate among selected countries. For each additional day increase in disasters, the savings rate is expected to reduce by 0.02 ($p<0.05$) and 0.01 ($p<0.05$) percent with the giving significance levels.

In the sub-samples, the results presented in models 7 and 8 show the change of savings rates between 2007 and 2020. The real long-term interest rate is still negatively associated with the savings rate, but the result is no longer statistically

Table 3 Regression results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Full-sample						Sub-sample			
DV: savings rate							2007–2020	2007–2020	EU	EU
Real long-term interest rate	-0.298***				-0.274**	-0.218**	-0.100	-0.017	-0.193	-0.110
	(0.092)				(0.106)	(0.107)	(0.103)	(0.129)	(0.118)	(0.110)
Old-age dependency ratio		-0.424***			-0.358***		0.336*		-0.264***	
		(0.084)			(0.098)		(0.173)		(0.089)	
LN Per capita income			7.422***			9.452***		10.856***		9.864***
			(1.750)			(1.465)		(2.473)		(1.666)
Days for natural disasters				-0.018***	-0.019***	-0.014***	-0.003**	-0.002	-0.017***	-0.012***
				(0.006)	(0.005)	(0.005)	(0.001)	(0.001)	(0.005)	(0.004)
Constant	7.811***	17.151***	-65.359***	7.542***	15.411***	-87.866***	-7.199	-110.702***	12.268***	-92.470***
	(0.200)	(1.771)	(17.431)	(0.184)	(2.287)	(14.732)	(5.677)	(26.296)	(2.099)	(16.702)
Observations	925	1,178	1,178	832	675	675	306	306	574	574
Number of groups	32	34	34	25	23	23	23	23	20	20
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Driscoll-Kraay standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

significant at the 5% significance level. Surprisingly, the sign of the coefficient of the old-age dependency ratio turned positive during and after the global financial crisis until more recently, but the result is only significant at the 10% level. In models 9 and 10, the result using 20 EU countries shows persistent outcomes when compared with the whole sample, although the significant impact of the interest rate disappears.

5 Conclusion and future research

The empirical analysis shows that the twin long-term challenges of climate change and an aging society have a significant impact on savings behaviour in the analysed OECD countries. In the overall sample from 1980 to 2020, results show a highly significant negative link between the old-age dependency ratio and the savings rate, which is consistent with previous findings in the literature. For the period 2007–2020, however, the coefficient reverses its sign and indicates a positive relationship between the old-age dependency ratio and the savings rate. Although this result may seem unexpected at first glance, it is in line with the study of Boersch-Supan and Winter (2001), who predicted higher savings between 2015 and 2025, as the need to save for one's own retirement becomes increasingly important. Thus, although in general a higher old-age dependency ratio brings about declining savings rates, an increasing old-age dependency ratio combined with a working age population stratum a relatively large share of which will retire in the foreseeable future can positively influence savings activity.

Moreover, the results indicate a negative link between the number of disaster days and the savings rate for OECD countries. This result fits to the theoretical consideration in Sections 2 and 3: firstly, after a natural disaster, households' increasing awareness of the risk of physical destruction could lead to a lower savings rate; secondly, dissaving could be the result of induced self-insurance following disasters. Regarding the latter, the usual scope of government support after natural disasters is likely to play an important role as the degree of household confidence about expected government aid could depress the savings rate. At this point, it is also important to mention that the governments' aid behaviour may also reduce households' willingness to insure against natural disasters. Although insurances against natural disasters are (precautionary) savings in a broader economic sense, they are not counted in the national accounts as savings. Therefore, an analysis of government aid activities, the savings rate, and insurance contracts against natural disasters could very well complement the present study and provide a broader picture.

As shown in Section 3, the twin long-term challenge is likely to hamper the economic growth path in the long run. To address this overall problem, OECD countries would need to focus more on innovation promotion – with a special focus on green innovation. Innovativeness could be particularly promoted through enhanced real and economic openness (Coe et al. 2009; Gräbner et al. 2021), more incentives for inward foreign direct investments (Cheung and Lin 2004), higher R&D subventions, and more spending on education. Higher savings in countries with rather low savings rates could also help to promote innovation. Considering the empirical results, successful climate policy – with a lower frequency of natural disasters – will raise the global (OECD) savings ratio and thus could affect the cost of capital and the cost of global modernization necessary for achieving sustainability and climate neutrality, respectively. Besides tackling climate change and moving to a carbon-neutral economy, the ongoing aging of the population also requires higher savings rates. All in all, it can be said that higher (tax) incentives for more private savings are not only necessary with respect to aging societies, but also have positive spillover effects in terms of greening the economy and economic prosperity.

The limitations of this study could also offer avenues for future research. Firstly, we have considered the case of a closed economy in the theoretical section. The authors will expand the model to analyse the open economy to address more practical issues in the next stage. Secondly, for the empirical part, one could further implement a dynamic panel analysis to account for the endogeneity problem. Lastly, the savings rate can be separated to identify the possible difference between public and private saving behaviours.

Appendix

Table 4 The countries in the regression samples (M = model)

Country	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Australia	Yes	Yes	Yes	No	No	No	No	No	No	No
Austria	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Belgium	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Canada	Yes	Yes	Yes	No	No	No	No	No	No	No
Chile	Yes	Yes	Yes	No	No	No	No	No	No	No
Colombia	No	No	No	No	No	No	No	No	No	No
Costa Rica	No	No	No	No	No	No	No	No	No	No
Czech Republic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Denmark	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Estonia	No	Yes	Yes	Yes	No	No	No	No	No	No
Finland	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
France	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Germany	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Greece	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hungary	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Iceland	No	No	No	No	No	No	No	No	No	No
Ireland	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Israel	Yes	Yes	Yes	No	No	No	No	No	No	No
Italy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Japan	Yes	Yes	Yes	No	No	No	No	No	No	No
South Korea	Yes	Yes	Yes	No	No	No	No	No	No	No
Latvia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lithuania	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Luxembourg	No	Yes	Yes	Yes	No	No	No	No	No	No
Mexico	Yes	Yes	Yes	No	No	No	No	No	No	No
Netherlands	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
New Zealand	Yes	Yes	Yes	No	No	No	No	No	No	No
Norway	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Poland	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Portugal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Slovak Republic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Slovenia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spain	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sweden	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Switzerland	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Turkey	No	No	No	No	No	No	No	No	No	No
United Kingdom	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
United States	Yes	Yes	Yes	No	No	No	No	No	No	No
N	32	34	34	25	23	23	23	23	20	20

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Declarations

Conflicts of interest/Competing interests Not applicable.

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