Do ageing economies save less? Evidence from OECD data

Benjamin Wong
Center for Applied Macroeconomic Analysis, Research School of Economics, Australian National University, Canberra, Australia, and
Kam Ki Tang
School of Economics, University of Queensland, Brisbane, Australia

Abstract

Purpose – The purpose of this paper is to re-examine the effect of population ageing on private saving, taking into account the fact that ageing is brought about by not only rising old-aged dependency but also expanding longevity.

Design/methodology/approach – The study uses panel data of 22 OECD countries from 1961 to 2010. Linear and non-linear panel regression methods are used. The study takes into account the time series characteristic of the data, such as the deterministic trend present in old-age dependency ratio.

Findings – Longevity consistently has a significant positive impact on savings, while old-aged dependency rate has no discernible impact once country-specific time trends in the data are accounted for. The general finding within the literature where old-age dependency exerts a negative impact on savings is sensitive to the manner in which the data is handled and/or the sample selected.

Originality/value – First, the authors jointly consider rising old-aged dependency and expanding longevity on savings, thus avoiding potential omitted variable bias in previous studies. Second, they explore non-linearity in the savings-ageing relationship which was ignored previously. Third, they identify whether saving rate and demographic measures are sharing common stochastic trends or driven by individual deterministic trends to avoid spurious regression results.

Keywords Ageing, Longevity, Old-age dependency, Savings, Elderly people, Ageing (biology)

Paper type Research paper

1. Introduction

Within a few decades, the demographic structures of most, if not all, economies will be vastly different from today. Advances in medical science will conceivably result in continual increases in life expectancy. The rise in longevity will see a greater proportion of people entering higher age brackets. This phenomenon, coupled with the trend of falling fertility rates, implies that demographic structures will tend towards the aged.

Ageing can bring about substantial macroeconomic impacts. One of the channels through which demographic ageing can exert its influence is aggregate savings; this has been well established in the literature. However, the literature has hitherto focused on the effect of rising age dependency on savings, while largely ignoring that of extended life expectancy. This omission of life expectancy can have serious adverse consequences. Theoretically, the impacts of life expectancy on savings are opposite to those of an aged population structure; however, as life expectancy and age dependency

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are highly correlated, analysing the impact of one without due consideration of the other is likely to result in bias.

The life-cycle hypothesis (LCH)[1] suggests that individuals save during their economically active years to finance their consumption during retirement. Accordingly, increases in the dependency ratio, be it youth or age dependency, will increase the number of non-savers relative to savers in the economy, thereby reducing private saving rates in aggregation. As national savings are largely made up of private savings, *ceteris paribus*, increases in dependency ratios are also expected to reduce national savings. Empirical validation of this was demonstrated in the seminal work of Leff (1969). Two main early criticisms of Leff's results centred on data quality (Goldberger, 1973) and the pooling of developing and developed countries in the same sample (Gupta, 1971; Ram, 1982). The latter point is relevant, in so far as Leff's results appear to be entirely driven by the developed countries in his sample. The more recent literature tends to support Leff's conclusions, e.g. see Edwards (1996), Masson *et al.* (1998), Loayza *et al.* (2000) and de Serres and Pelgrin (2003). However, it is still common practice to pool developed and developing countries in a same sample. In other words, despite more recent empirical validation of Leff's results, it appears the earlier criticisms have not been been sufficiently addressed.

Previous work, however, has largely ignored the fact that population ageing is brought about not only by rising age dependency, but also by longer life expectancy. The link between life expectancy and savings was only brought to attention very recently by Li *et al.* (2007) and Kinugasa and Mason (2007). Longevity-driven ageing can have an opposite effect on aggregate saving rates as compared to dependency rate-driven ageing[2]. Increases in longevity can prompt working age adults to save more in preparation for a longer retirement. Even the elderly can be motivated to continue to save, or at least to run down their assets more slowly, as longevity brings about both higher uncertainty of future medical expenses and the risk of outliving one's assets (De Nardi *et al.*, 2009). Furthermore, the retirement age may not stay constant as life expectancy increases. Ando *et al.* (1995), for example, find that the elderly in Japan have a high probability of maintaining employment, and tend not to dissave as much as theory predicts. Work by Ehrlich and Lui (1991), Lee *et al.* (2003a, b) and Sheshinski (2009) provide theoretical support for the positive impact of longevity on private savings. Bloom *et al.* (2003) and Kinugasa and Mason (2007) provide empirical evidence in reaffirming this theoretical proposition.

Since higher age dependency and rising longevity exert opposite effects on private savings, the overall impact of ageing is therefore equivocal. This paper follows the very recent development in the literature by setting forth to investigate the joint effects of higher age dependency and rising longevity on savings. The empirical analysis of this paper is based on a panel dataset covering 22 OECD countries over 1961-2010.

The contributions of this paper are threefold. First, our model jointly considers the effects of higher age dependency and greater life expectancy on savings, thus avoiding the potential bias present in previous studies that neglect one of these interrelated factors. Second, we explore non-linearity in the savings and ageing relationship, a feature that the previous literature has ignored. The consideration of non-linearity is motivated by the fact that the saving rate is bounded; as such, ignoring the non-linear terms may risk omitted variable bias. Third, given that both saving rate and demographic measures are all trending over time, identifying whether they share common stochastic trends (i.e. trend non-stationary but cointegrated) or driven by individual deterministic trends (i.e. trend stationary) is crucial in avoiding spurious regression results. However, previous studies that draw on panel data largely ignore this concern. In this paper, we carefully investigate the time series characteristics of our data and model them accordingly.

Our findings are summarised as follows. The longevity effect on savings is rather robust in many different specifications for our 22 OECD country sample. In contrast, the effect of old-age dependency, which acts as the main measure of ageing in much of the literature, appears to have no discernible effect on savings once the country-specific time trends of savings are accounted for. It is also found that the coefficient estimates for the demographic variables become unstable when the analysis is extended to larger samples that are less homogeneous than the 22 OECD country sample.

The rest of the paper is organised as follows. Section 2 lays out the empirical framework of the analysis. Section 3 presents the findings. The last section concludes the paper with discussion of the overall findings.

2. Empirical specification

Data

All data for this paper was sourced from the World Development Indicators, a dataset maintained by the World Bank. The series used for the main empirical exercise are national saving as a percentage of GDP, the old-age dependency ratio, life expectancy at birth, and GDP per capita in constant 2000 US dollars. In addition, the fertility rate is included in robustness tests.

Sample selection

A pertinent issue with regard to panel data estimation relates to the stability of parameters across different cross-sectional units. Haque *et al.* (1999), for example, demonstrate that ignoring cross-country slope heterogeneity – especially when pooling countries at different stages of economic development in saving regressions – can lead to quite misleading inferences. Indeed, criticisms of panel data techniques tend to focus on the potential misinformation regarding the estimated average marginal effects and resulting (misguided) inference, which can still exist even after controlling for unobserved heterogeneity with fixed effects. Given that population ageing is a phenomenon that mainly affects the developed world[3], it is sensible to limit the analysis to countries befitting that description. This also relates to the early criticisms of pooling together developed and developing countries, a point which has perhaps been lost on the more recent literature. The OECD countries are obvious candidates in this regard.

Besides experiencing a more rapid ageing process than other country groups, OECD countries also have more reliable data than developing countries, as well as relatively similar social, economic and institutional settings. However, since its inception in 1957, membership of the OECD has been expanding – especially since the early 1990s. This enlargement sees the group now including not only traditional advanced nations, but also some emerging economies, such as Chile and Mexico. This reignites the aforementioned concern regarding slope coefficient stability across non-homogeneous groups. Since a 21-year gap exists between the acceptance of New Zealand to the OECD in 1973 and that of the next member, Mexico, in 1994, we use this as a natural cut-off point for sample selection. As such, those OECD countries whose memberships commenced before or at 1973 are included in the sample for the main empirical exercise. In a robustness test, we examine whether the main findings change when the sample is extended to include those OECD countries that were admitted after 1973. As a further robustness test, we also examine a sample of 114 countries, which includes emerging and developing countries as well as the OECD countries[4].

In line with this area of the literature, two other natural exclusions are small countries with populations less than one million, and large oil producers, like OPEC members, since excessive volatility in their saving rates cannot be explained by demographic factors. This reduces unnecessary noise in the data. Iceland and Luxembourg are excluded from the sample based on the former condition, but no further exclusions arise due to the latter one.

The 22 OECD countries that are included in the main empirical analysis are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the UK, and the USA.

Stationarity tests

Figures 1-4 show time series plots of the main variables used in the empirical work for the period 1961-2010, on an annual basis. There are obvious upward trends in old-aged dependency and life expectancy for almost all 22 OECD countries[5], reflecting the population ageing process that the developed world undergone over the last 50 years. As expected, log real income[6] also exhibits an upward trend over time, but with more short term vacillations than the demographic variables. The national saving rate is the most volatile amongst the four series. Although saving rates for many countries exhibit a long-term upward or downward trend, this trend is not at all uniform across

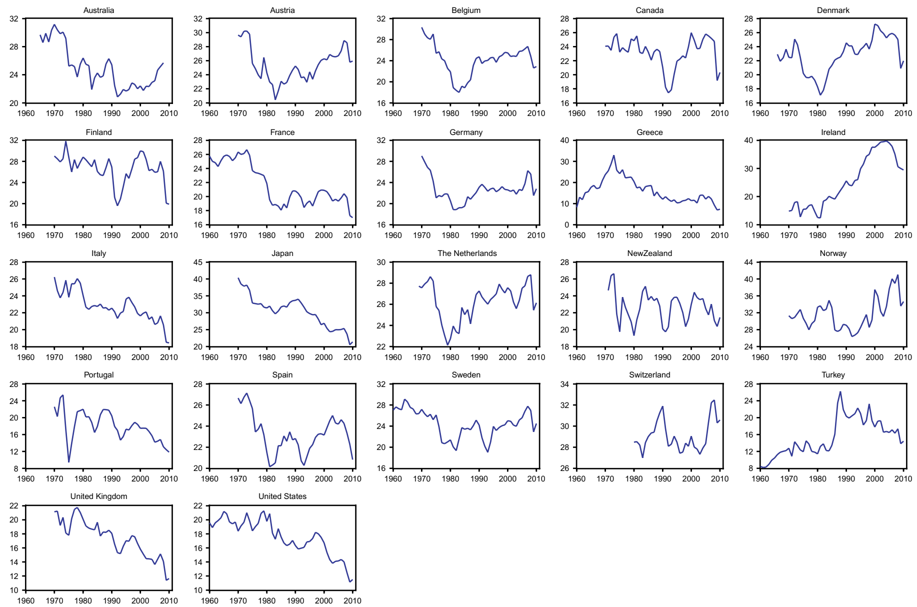


Figure 1.
Plots for national savings as a percentage of GDP

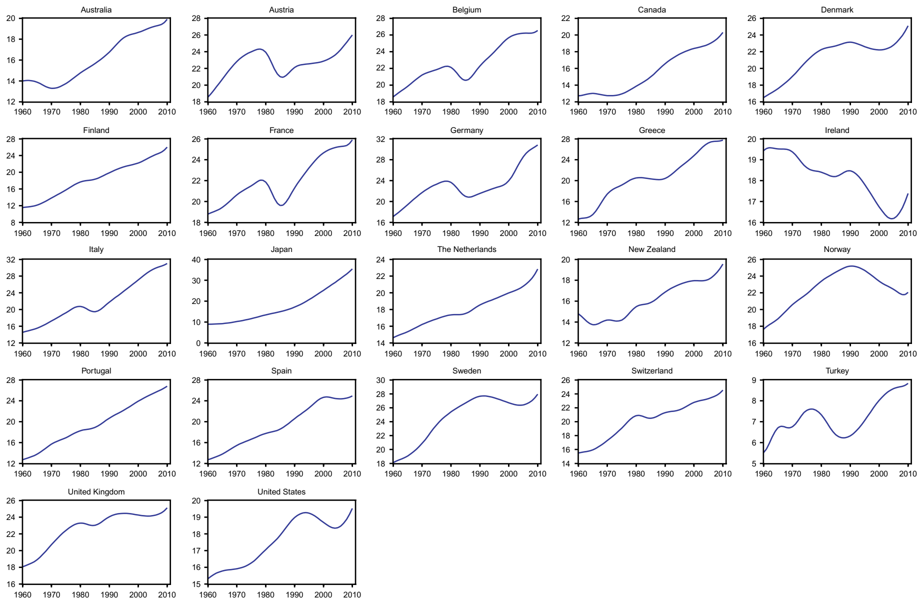


Figure 2.
Plots for old-age dependency ratio

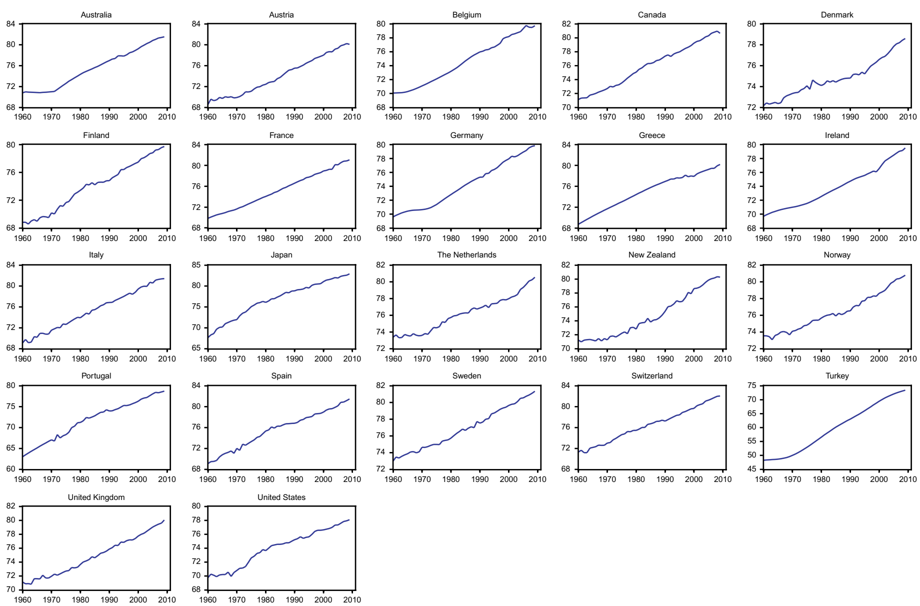
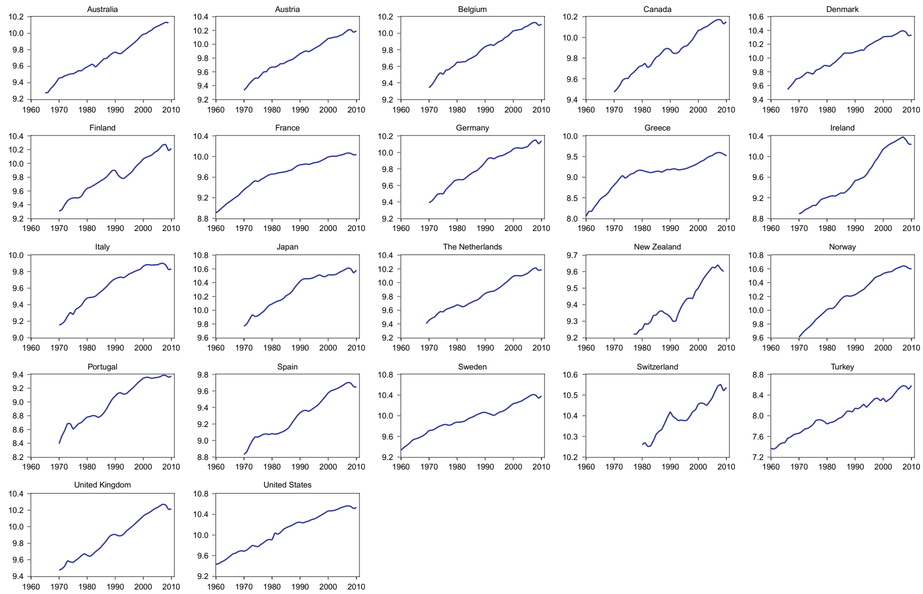


Figure 3.
Plots for life expectancy at birth

the 22 countries. These differences in trending patterns of saving rates are important to the model specification, as discussed later.

Given that all the variables are trending to different degrees, there is a distinct possibility that the data are generated by unit root processes. If that is the case, standard



Note: Constant 2000 US$

Figure 4.
Plots for log GDP per capita

least square regression will be spurious unless the variables are cointegrated, i.e. unless the variables share a common stochastic trend. To explore this possibility, we first test for stationarity of each of the series using panel augmented Dicky-Fuller unit root tests. Observing the trends in the data, all unit root test specifications include a trend, except for income growth per capita.

As show in Table I, all the variables – with the exception of GDP per capita – are found to be trend stationary. The results thus rule out the scenario that the variables are cointegrated. A corollary of these findings is that we need to model the deterministic trend component of the time series, as well as use the first difference of GDP per capita (i.e. income growth per capita) in the regression.

Furthermore, the observation that the saving rate is a much more volatile series than the demographic variables clearly suggests that its short-run dynamics are more likely driven by business cycles than by the slowly evolving demographic structure.

Variable	
Savings (percent of GDP)	0.011
Aged dependency ratio	0.000
Life expectancy at birth	0.005
Log (real income per capita)	0.620
Income growth per capita	0.000
Fertility	0.000

Notes: All series were tested with trend and intercept, except income growth per capita; null – series is non-stationary; p-values reported

Table I.
ADF panel unit root test

To filter out such short-term noise, we follow the approach of Carroll and Weil (1994), Bloom *et al.* (2003) and Li *et al.* (2007) and use non-overlapping five-year averages of the data[7]. There are thus ten separate five-year average time periods in the dataset, starting with 1961-1965 and ending with 2006-2010.

Model specification

A suggested baseline specification, in the spirit of Li *et al.* (2007), could take the form of equation (1):

$$SAVING_{i,t} = \beta_1 AGED_{i,t} + \beta_2 LIFE_{i,t} + \beta_3 GROWTH_{i,t-1} + u_i + v_t + \varepsilon_{i,t} \quad (1)$$

where *SAVINGS*, *AGED*, *LIFE* and *GROWTH* are, respectively, savings as a percentage of GDP, the old-age dependency ratio, life expectancy at birth, and real income growth per capita; u_i and v_t are the country and time fixed effects, respectively; and ε is the error term. The country fixed effects, u_i, are included to capture time-invariant country heterogeneity that is likely to affect saving, income growth and demographic structure, such as culture, environment and endowment. To the extent that such heterogeneity is correlated with the regressors, the omission of country fixed effects will lead to bias estimation for the coefficients of interest. Likewise, the time fixed effects, v_t, are to capture time-varying but country-common factors that are correlated with both the regressand and regressors, such as global business cycles.

Nonetheless, an inspection of Figure 1 shows that saving rates in different countries exhibit different long-term trends, indicating that a country-common time-varying variable is insufficient to account for the time series properties of the data. Therefore, we improve equation (1) by adding country-specific time trends:

$$SAVING_{i,t} = \beta_1 AGED_{i,t} + \beta_2 LIFE_{i,t} + \beta_3 GROWTH_{i,t-1} + \lambda_i t + u_i + v_t + \varepsilon_{i,t} \quad (2)$$

where $\lambda_i t$ is a country-specific time trend, as indicated by the fact that the coefficient, λ_i, is allowed to vary across countries.

The incorporation of country-specific time trends is important in avoiding spurious regression. This is because, as saving, old-age dependency and life expectancy are trending, the latter two could be found to have "explanatory power" on the former when the trend property of saving is not accounted for.

3. Results

Baseline specifications

The first column of Table II reports the results for equation (1). Newey-West standard errors are used to account for autocorrelation and heteroskedasticity in the error terms[8]. Consistent with theoretical predictions, old-age dependency and life expectancy have, respectively, a positive and negative effect on saving rates. Growth is also found to be an important determinant of saving rates, as expected. In the absence of the country-specific time trend, it is found that a one percentage point rise in the old-age dependency ratio decreases the saving rate by nearly 0.7 percentage points, and a one-year rise in life expectancy increases it by close to 0.3 percentage points. The estimates are extremely similar to those obtained by Li *et al.* (2007)[9].

When country-specific time trends are added to the model, as shown in column (2) of Table II, old-age dependency is no longer statistically significant at any standard level. On the other hand, the longevity effect on saving becomes much larger, in that a one-year

Table II.
Regression with and without country-specific time trend and between estimator

	Without country-specific time trend	With country-specific time trend	With country-specific time trend	Between estimator
AGED	−0.696***	−0.115	−0.331**	−0.21
	(0.144)	(0.183)	(0.190)	(0.342)
LIFE	0.289*	2.220**		0.634*
	(0.205)	(0.846)		(0.410)
$GROWTH_{t-1}$	0.630**	0.586**	0.437**	1.398
	(0.263)	(0.232)	(0.212)	(1.737)
No. of obs.	164	164	164	164
R^2	0.390	0.764	0.741	0.483

Notes: Significant at: *10, **5 and *** 1 percent levels; Newey-West standard errors in parentheses; time fixed effects in all specifications; country fixed effects in all except for between estimator

rise in life expectancy now increases the saving rate by over 2 percentage points. This demonstrates that even after accounting for trends in the variables, movements in life expectancy around the trend are still important in the determination of savings. Also, given that the life expectancy trend is very smooth, the fluctuations from the trend are very small; therefore, a large coefficient is needed to "compensate" for the effect of the country-specific time trends. To illustrate, in our data, life expectancy seldom deviates more than 0.5 years from its trend, which means that in general the longevity effect adds only about one percentage point to the national saving rate. Results from column (2) suggest that previous studies that have identified an old-age dependency effect on savings in the absence of country-specific time trends might suffer from omitted variable bias.

Column (3) reports the results of an auxiliary regression in which life expectancy is omitted from equation (2). The coefficient for old-age dependency has now become statistically significant. Given the high level of correlation between old-age dependency and life expectancy (0.7 in our dataset), it is clear that omitting life expectancy has caused a downward bias on the estimate of old-age dependency, overstating its effect on savings. This finding is sober because, with a few exceptions, studies on the macroeconomic effects of population ageing tend to focus solely on old-aged dependency as the measure of the population ageing process.

Although the results thus far have confirmed the importance of controlling for country-specific time trends, it is equally important to consider the possibility that their inclusion may risk "over fitting" the data. For instance, if we include country-time fixed effects (i.e. country and time-varying dummies) in the model, then every other variable will drop out due to multicollinearity; this is because the overly flexible country-time fixed effects will "account for" all variations in the regressand, leaving nothing for the regressors to explain. By the same token, if the (deterministic) trend in saving rates were indeed driven by the (deterministic) trend in old-age dependency, then including country-specific time trends would wrongly remove the explanatory power of old-age dependency. In fact, in column (1) we do find old-age dependency to be statistically significant in the absence of country-specific time trends. So how can we tell if country-specific time trends are necessary or counterproductive? To answer this question, we estimate the model using the between effects estimator, the results of which are presented in column (4) of Table II. Since the between effects estimator removes the trend properties of all variables, it focuses squarely on the cross-country variations. The rationale is that, if old-age dependency truly has explanatory power over saving rates, there should be at least some tentative evidence in cross-sectional data. From column (4) it can be seen that although all variables retain the correct signs, old-age dependency and income growth are not individually significant at any standard level, while life expectancy is significant at the 5 percent level. This suggests that, in the absence of country-specific time trends, there is a high risk of obtaining spurious regression results for old-age dependency (and even income growth). This therefore further vindicates the inclusion of country-specific time trends in our models.

Non-linear specifications

In this section we introduce non-linearity to the hitherto linear model. There are good reasons to expect that the relationship between saving rate and demographic structure might be non-linear in nature. First, given that, at the national level, consumption and savings must sum to total income, savings as a share of GDP must be bounded above at unity. Second, although a country can have negative savings when it consumes more than what it produces, it is inconceivable that international lenders would fund its current account deficit without any limit; as such, savings a share of GDP must also be bounded below at some level. This implies that the marginal effects of its determinants must diminish as the national saving rate approaches its bounds. In other words, even with a continuously increasing burden (dividend) of old-age dependency (longevity), it is unlikely that the national saving rate would be driven to zero (unity) and beyond in a monotonic fashion. In fact, the potential non-linearity in the demographic relationship to savings was briefly suggested by Loayza *et al.* (2000), though they stopped short of explicitly exploring this issue.

To explore the non-linear effects of the demographic variables, we consider a quadratic model that includes the squared terms of old-age dependency and life expectancy, respectively. The results are reported in Table III. Again, all estimations include time and country fixed effects, and country-specific time trends. To facilitate comparison, the first column repeats the linear estimation from Table II.

AGED	−0.115	−1.072	−0.061	0.178
	(0.183)	(1.225)	(0.175)	(1.035)
LIFE	2.220**	2.194**	7.180***	7.480***
	(0.846)	(0.805)	(1.849)	(2.118)
GROWTH $_{t-1}$	0.586**	0.575**	0.527**	0.526**
	(0.232)	(0.221)	(0.216)	(0.219)
AGED^2		0.020		−0.005
		(0.024)		(0.020)
LIFE^2			−0.036***	−0.038***
			(0.013)	(0.015)
No. of obs.	164	164	164	164
R^2	0.764	0.768	0.782	0.782

Notes: Significant at: *10, **5 and *** 1 percent levels; Newey-West standard errors in parentheses; country and time fixed effects, country-specific time trends in all specifications

Table III. Non-linear specification

A number of consistent findings are observed. First, old-aged dependency and its square term are insignificant in all estimations. Second, life expectancy and its squared terms are always significant at the 1 or 5 percent level, and of the correct signs. Third, income growth remains significant and retains the same sign as before in all estimations. Overall, the results confirm the proposition that the effect of longevity on national saving rate is positive but diminishing as life expectancy increases. In terms of magnitude, the estimates from the last column suggest that a one-year rise in life expectancy increases the national saving rate by 1.8 percentage points when evaluated at the sample mean value of life expectancy (74.94), which is slightly smaller than but still comparable to the estimate of 2.2 percentage points from the linear model.

Robustness tests

A variety of alternative specifications are considered to test the sensitivity of the previous results. As suggested by Li *et al.* (2007), the fertility rate can also be considered an important demographic driver of savings. Using the lag of fertility rate as per their specification, this variable was added to both the linear and non-linear models with country-specific time trends and both time and country fixed effects. The results are reported in Table IV. It is found that the fertility rate is statistically insignificant in all four estimations. Given that the fertility rate never improved the goodness-of-fit of any of these models, it is not surprising that the coefficients of other regressors are very similar to the previous ones.

We now turn our attention to two alternative samples. The first one is includes post-1973 admissions to the OECD club, such as Mexico, the Czech Republic and Chile. This increases the sample to 32 countries. The second one is a sample of 114 countries consisting of developed, emerging, and developing economies. Mixed samples like this are commonly used in the literature. The purpose of considering these two samples is to investigate whether the previous findings continue to hold for less homogenous groups of countries. The results are presented in Table V.

To focus the discussion, we only present results for one linear and one non-linear model. Again, in all estimations we include the time and country fixed effects and country-specific time trends. It can be seen that there are substantial changes in the

AGED	−0.113	−1.077	−0.063	0.240
	(0.186)	(1.212)	(0.178)	(0.965)
LIFE	2.221**	2.195***	7.303***	7.705***
	(0.853)	(0.812)	(1.905)	(2.002)
$GROWTH_{t-1}$	0.596***	0.587***	0.508**	0.504**
	(0.239)	(0.229)	(0.222)	(0.225)
$FERTILITY_{t-1}$	0.230	0.287	−0.410	−0.477
	(1.159)	(1.187)	(1.328)	(1.223)
$AGED^2$		0.020		−0.006
		(0.024)		(0.019)
$LIFE^2$			−0.037***	−0.040***
			(0.014)	(0.014)
No. of obs.	164	164	164	164
R^2	0.764	0.768	0.782	0.782

Notes: Significant at: *10, **5 and *** 1 percent levels; Newey-West standard errors in parentheses; country and time fixed effects, country-specific time trends in all specifications

Table IV.
Robustness test including fertility rate

	32 OECD countries		114 OECD and non-OECD countries	
AGED	− 0.615**	− 2.017*	− 0.725***	− 1.656**
	(0.253)	(1.067)	(0.273)	(0.785)
LIFE	0.259	3.436*	0.209*	0.341
	(0.733)	(2.587)	(0.138)	(0.626)
GROWTH $_{t-1}$	0.416**	0.328**	0.488***	0.484***
	(0.187)	(0.177)	(0.083)	(0.082)
AGED^2		0.033		0.024
		(0.022)		(0.016)
LIFE^2		− 0.026		− 0.001
		(0.017)		(0.006)
No. of obs.	227	227	825	825
R^2	0.704	0.728	0.658	0.659

Notes: Significant at: *10, **5 and *** 1 percent levels; Newey-West standard errors in parentheses; country and time fixed effects, country-specific time trends in all specifications

Table V. Robustness test for alternative country groupings

results compared to the 22 OECD countries sample. First of all, in all four estimations, old-aged dependency is significant and of the expected negative sign. On the contrary, life expectancy, although it retains the positive sign, is only significant at the 10 percent level in two of the estimations. The squared terms of both old-aged dependency and life expectancy are not individually significant at any standard level. As a result, we focus on the linear model estimates in what follows. Interestingly, the magnitudes of the coefficients on old-aged dependency and life expectancy for both alternative samples resemble those of the linear model without country-specific time trends for the 22 OECD countries sample (column (1) of Table II). This dramatic change in the results is likely due to the fact that the larger samples incorporate countries that have not only very different demographic dynamics as compared to the original 22 OECD countries, but also vastly different levels of development, cultures (e.g. thriftiness) and institutions (e.g. social security)[10]. The increasing country heterogeneity is also reflected in the fact that the explanatory power of the same linear model reduces from 0.764 for the 22 OECD countries sample, to 0.704 for the 32 OECD countries sample, and further down to 0.658 for the mixed country sample.

4. Discussion

While a general observation is the OECD is experiencing falling savings rates with increased aged dependency ratios in the last two to three decades, the results of this paper challenge the typical view that the oncoming ageing of their populations will necessarily drive the saving rates down further. This is because longevity appears to be a very important (and robust) determinant of savings and there is no reason to expect the growth of longevity to come to a halt in the near future. This suggests some scope for savings within the OECD to maintain (or not to fall as fast as what would have been suggested based solely on the old-aged dependency rate) as long as life expectancy continues to rise.

It is conceivable that the response of savings to changes in old-aged dependency rate and longevity will differ across countries with different social security systems. The differences in the results between the OECD samples and the OECD plus non-OECD sample may well be hinting at the importance of institution and public policy setting.

For instance, the generosity of pension systems in Europe is believed to discourage private savings, which currently stays well below 20 percent. In comparison, saving rates in China typically exceed 40 percent, partly attributing to its underdeveloped social security system. Furthermore, as pointed out by Blöndal and Scarpetta (1998), retirement duration in much of the developed world has increased from a few years in the early twentieth-century to almost 30 years nowadays, while retirement ages stay stubbornly below 60. The implication here is that future research in this area needs to more explicitly account for differences in social security systems across countries.

In terms of aiding the public policy debate, an often-brought up issue is that of propping up private savings in anticipation of ageing. This idea stems from the fact that saving rates in some developed countries have been steadily falling in the last 50 years, as already shown in Figure 1. While it is a legitimate public policy concern that private savings can fall further with ageing, limiting capital supply and retarding future living standards, the evidence revealed in the analysis challenges this notion. Based on this evidence, a public policy aimed at propping up private savings in anticipation of ageing could be redundant at best and counter-productive at worst if the policy has any adverse side effects. Nonetheless, we strongly advocate that population ageing should be recognized as a multi-faceted phenomenon. As such, analysis of the economic impacts of population ageing should consider various dimensions of the population ageing process, not just an increase in the old-aged dependency rate. Future research should be directed to further separating the economic effects of various elements of population ageing.

It is also worth pointing out some general limitations of the paper. The first issue concerns endogeneity. It is well known that countries with higher income often have lower fertility rates and higher life expectancy. This suggests the possibility of some form of reverse causality from savings (which is a source of future income) to old-age dependency and life expectancy. Over a short window, say a year or two, this is not likely to be an issue since it takes time for savings to impact on living standards sufficiently to influence life expectancy and fertility rates. However, in specifying the window length, the concept of "short" is seldom clear. The five-year averages are taken based on the convention of the literature, as age dependency and life expectancy change very slowly. While assumed to be exogenous in the previous literature, it is never clear whether five years is a sufficiently short window to make such an assumption. Guidance from prior work will suggest it is safe to make such an assumption. Even if such an assumption does not hold, it is worth pointing out that finding an instrument to control for the endogeneity is never a straightforward issue. It is a well known result from the instrumental variables literature where the use of weak instruments is perhaps more pernicious compared to accepting a little bias from an OLS estimator. Therefore, it is not quite clear how to proceed in instrumenting for old-aged dependency and life expectancy even if one drops the conventional assumption of exogeneity of these variables. For this reason, it is perhaps advisable to use the current empirical specification.

Lastly, we have considered life expectancy at birth and the fertility rate as well. Despite that, one should be cautioned that life expectancy at birth may only capture some aspects of longevity. For instance, reduction in under-five mortality rates and old-aged mortality rates will both result in an increase in life expectancy at birth, but their impacts on savings could be very different. As such, future research should be directed to further separating the economic effects of various elements of population ageing.

5. Conclusion

Demographic changes, such as population ageing, have the potential to alter macroeconomic outcomes. However, the standard singular focus on age structure in the literature might risk oversimplifying the multifaceted phenomenon of population ageing. In particular, rising old-aged dependency tends to be accompanied by rising longevity. Yet, as the two factors are expected to have opposite effects on savings, the omission of one could lead to bias in estimation of the impact of the other on savings. The empirical evidence presented in this paper – in general – supports this proposition.

For the 22 OECD countries examined in this paper, it is found that, once we have accounted for country heterogeneity using country fixed effects and country-specific time trends and global shocks using time fixed effects, old-aged dependency does not have any discernible effect on saving rate anymore, while life expectancy has significant positive effect. This implies that an ageing population does not necessarily save less, as is commonly asserted, when the longevity effect is sufficiently large.

There is also evidence that demographic changes have non-linear effects on saving rates. This finding is consistent with the fact that, in reality, saving rates are bounded. While incorporating non-linearity can refine the estimation, it does not change the qualitative results of the linear model.

The empirical findings of the paper highlight that the trend properties of the data require careful treatment. It is demonstrated that, at least for the smaller OECD sample used here, one might find a spurious relationship between old-aged dependency and saving rates when country-specific time trends are omitted.

Lastly, there is a lack of coefficient stability across non-homogeneous country groups. The use of an enlarged OECD sample covering some emerging economies, or a mixed sample of both developed and developing countries, leads to both qualitative and quantitative changes in the findings. In particular, the results resemble those of the previous literature, in that old-aged dependency has a significant, negative effect on savings. This calls into question the practice of pooling countries at vastly different stages of development into the same panel data set – a strategy often used in the literature to boost the number of observations.

Notes

1. See Modigliani's (1986) Nobel Prize lecture for more details of LCH. The permanent income hypothesis gives essentially the same predictions as the LCH; for simplicity, we only refer to the LCH in this paper.
2. An interesting exception to this might be the situation analysed in Feldstein (1974). If we assume longevity increasing but retirement ages staying constant, Feldstein's analysis indeed admits the possibility of decreasing private savings. The evidence provided by Blöndal and Scarpetta (1998), though, indicates that OECD retirement ages have become increasingly lower. The theoretical predictions provided by Feldstein about private savings become somewhat ambiguous when confronted by the evidence of the latter.
3. Even though exceptions like China exist.
4. The 114 countries include 32 OECD countries. The other 82 countries include 80 countries that are not classified as "advanced economies" by the IMF.
5. The only exception is that old-age dependency in Ireland has been declining.
6. Using the natural log of income rather than income is typical in applied work for two reasons. First, within a regression framework, we can interpret marginal effects from a 1 percent

change in income rather than dollar change, which is more intuitive. Second, as increases in income over time are typical non-linear, taking the natural log linearizes the variable and the slope can be regarded as a percentage change.

7. The five-year average of income growth takes five-year averages of the annual growth rates in the relevant time periods rather than taking the first difference of the five-year averages of the levels.
8. A bandwidth of two is chosen for the computation of Newey-West standard errors. This is consistent with the rough rule of thumb of $\sqrt[3]{T}$ or $\sqrt[4]{T}$ and ten non-overlapping five-year averages in our sample.
9. In Li *et al.* (2007), the corresponding figures are 0.6-0.7 percentage point and 0.2 percentage point in a variety of specifications.
10. This should be viewed in the context that we have already controlled for country (and time) fixed effects and country-specific time trends.

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Corresponding author
Kam Ki Tang can be contacted at: kk.tang@uq.edu.au