Does Population Ageing Affect Government Environmental Expenditure?

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1 Introduction

The demographic transition refers to the mechanism by which pre-industrial societies exhibiting high levels of fertility and mortality eventually transit to developed economies with low fertility and mortality. This demographic transition continues to fuel the largely irreversible trend of population ageing. Indeed, the world proportion of persons over the age of 60 was 8 percent in the year 1950, 10 percent in 2000, and is projected to reach 21 percent by the year 2050. Throughout the more developed regions of the world, nearly one fifth of the population was 60 years or older in the year 2000. This proportion is expected to reach one third by the year 2050. In less developed regions, approximately 8 percent of the population is currently over the age of 60, however by 2050, this proportion is projected to rise to 20 percent. The number of individuals in the world aged 60 years and older will exceed the number aged under 15 years by 2050 (United Nations Population Division 2002).

Population ageing has profound social, political and economic implications. Socially, population ageing affects health and health care, family composition and living arrangements, housing and migration. In the political sphere, population ageing may induce changes in representation and voting patterns. In the economic arena, population ageing will affect economic growth, savings, investment and consumption, labour markets, pensions, taxation and intergenerational transfers (United Nations Population Division 2002).

In addition to the demographic transition and the resulting trend of population ageing, the alarming pace of climate change poses significant public policy challenges. According to the 2007

Assessment of the Intergovernmental Panel of Climate Change (IPCC), the climate system is unequivocally warming, with increases in global sea and air temperatures, extensive melting of snow and ice and rising global average sea levels. Most of the observed increase in global average temperatures since the middle of the 20th century is attributable to increases in anthropogenic greenhouse gas emissions. In addition, anthropogenic warming throughout the previous three decades has likely contributed to changes in global physical and biological systems. Given current sustainable development practices and climate change mitigation policies, global greenhouse gas emissions will continue to increase over the next few decades, giving rise to potentially irreversible climate change. The impact of climate change may be partially reduced, delayed or avoided by investment in mitigation over the next two to three decades. In particular, IPCC stabilisation scenarios may be achieved via a range of technologies which are currently available or expected to be commercially available in the future, assuming that the necessary technological innovation and diffusion incentives are in place (IPCC 2007).

Though the requirement for immediate and sustained investment in climate change mitigation is well understood, the impact of population ageing on government environmental expenditure has been virtually completely ignored. In an attempt to address this gap in the literature, this paper investigates two distinct - though interelated - aspects of population ageing: increased longevity and a rise in the proportion of individuals aged 65 years and above. This paper theoretically and empirically explores the potential impact of both of these facets of population ageing on government environmental expenditure. I present an overlapping generations (OLG) model which illustrates the divergent policy preferences of the young and old generations. The younger generation supports government environmental expenditure while the older generation seeks to minimise environmental expenditure such that they receive a maximum elderly care transfer payment from the government. An increase in the proportion of older individuals in the population therefore places political pressure on the public planner to shift the composition of expenditure away from environmental maintenance and towards elderly care. However, rising longevity simultaneously increases the younger generation's demand for environmental care expenditure, given that increased longevity generates a higher return from such investment owing to a longer remaining lifespan. Assuming that the public planner seeks to maximise the aggregate utility of all of the individuals alive at a particular time, the latter effect - that is, the increased preference among the young for environmental care expenditure - dominates the preferences of the older generation for higher transfer payments and lower environmental expenditure. To test this theoretical result, I exploit a panel data set specifically constructed for this research project which contains observations on a diverse set of 47 countries. Fixed effect regression results provide clear support for the theoretical hypothesis that population ageing may have contradictory e·ffects on government environmental expenditure. In particular, though the proportion of individuals in the population aged 65 years and over negatively affects public spending on the environment, this effect is overwhelmed by the statistically significant positive impact of both longevity and the proportion of the population aged between 15 and 64 years.

The remainder of this paper is organised as follows. Section 2 presents some stylised facts motivating this investigation of the impact of population ageing on public environmental expenditure. Section 3 contains a theoretical and empirical literature review. Section 4 details an overlapping generations model where the two facets of population ageing - longevity and an increase in the proportion of older individuals in the population - have opposing effects on government environmental care expenditure. These theoretical implications are tested empirically in Section 5. Section 6 concludes.

2 Stylised Facts

Detailed below are a number of stylised facts which motivate this macro-level theoretical and empirical analysis of the relationship between population ageing and government environmental protection expenditure.

Stylised Fact 1: Population ageing induces government budgetary pressure.

A recent World Bank (Whitehouse 2007) analysis of retirement systems found that of the 53 countries analysed, 32 have publicly financed defined-benefit plans, making the pay-as-you-go (PAYG) system the most common form of pension-insurance provision. For economies operating a PAYG retirement system, the dramatic increase in the dependency ratio fuelled by the demographic shift will pose enormous government budgetary challenges. Table 1 illustrates the acceleration in world population age dependency for a cross-section of countries. Almost without exception, the annual rate of increase is projected to be higher between the years 2000 and 2030 than between 1950 and 2000. Indeed, the proportion of older individuals in countries such as Malaysia, Mexico and South Africa are expected to increase as rapidly as the elderly populations in many economically advanced countries. This increase in the dependency ratio will place significant budgetary pressure on governments in countries with PAYG retirement funding systems (Nyce and Schieber 2005).

Stylised Fact 2: Population ageing increases government health care expenditure.

In addition to government budgetary pressure driven by increases in the dependency ratio, population ageing will likely cause additional budgetary pressure via significant increases in aggregate government health care expenditure. In developed countries, the insurance systems which finance health care are predominantly government funded and administered, and cover both the elderly and non-elderly populations, with the notable exception of the United States. Combined with current public health care financing arrangements, population ageing will generate significant health care financing challenges in all developed countries. Since older individuals consume a large proportion of publicly provided health care services relative to younger individuals, public health expenditure will likely substantially increase in all developed countries in the next decades. Figure 1 illustrates a clear bivariate positive correlation between public health expenditure as a proportion of gross disposable income and the proportion of the population over the age of 65 years.

This paper provides a theoretical and empirical framework which is motivated by these stylised facts. Taking into account a tightening government budget constraint and dramatically increased health care expenditure, population ageing may cause public spending to be diverted away from environmental care and towards social spending that favours the elderly. In this way, an increase

	Ratio of People Aged 60 Years and Over to People Ages 20 to 59 Years					Annual Growth Rate	
	1950	*1975*	*2000*	*2010*	*2030*	*1950-2000*	*2000-2030*
Argentina	0.13	0.23	0.27	0.27	0.33	1.41	0.67
Australia	0.23	0.25	0.29	0.35	0.51	0.48	1.91
Brazil	0.11	0.14	0.15	0.17	0.31	0.55	2.57
Canada	0.22	0.24	0.29	0.35	0.59	0.54	2.38
Chile	0.15	0.18	0.19	0.23	0.39	0.56	2.35
China	0.15	0.16	0.18	0.20	0.44	0.30	3.08
Egypt	0.11	0.15	0.13	0.14	0.23	0.31	1.79
France	0.30	0.37	0.38	0.43	0.63	0.45	1.71
Germany	0.27	0.40	0.42	0.46	0.77	0.91	2.04
Hungary	0.20	0.34	0.35	0.39	0.53	1.06	1.41
India	0.12	0.14	0.16	0.17	0.25	0.45	1.58
Ireland	0.31	0.35	0.28	0.31	0.43	-0.18	1.40
Italy	0.23	0.34	0.43	0.50	0.78	1.24	2.05
Japan	0.17	0.21	0.41	0.58	0.79	1.85	2.18
Malaysia	0.17	0.14	0.13	0.16	0.27	-0.51	2.34
Mexico	0.17	0.15	0.14	0.16	0.29	-0.42	2.44
Netherlands	0.22	0.30	0.32	0.40	0.65	0.70	2.44
Pakistan	0.19	0.13	0.14	0.14	0.16	-0.61	0.41
Poland	0.16	0.26	0.30	0.31	0.51	1.30	1.79
South Africa	0.13	0.12	0.11	0.14	0.22	-0.25	2.20
Spain	0.21	0.29	0.38	0.42	0.70	1.22	2.03
Sweden	0.27	0.41	0.42	0.51	0.72	0.88	1.86
Switzerland	0.25	0.33	0.38	0.49	0.84	0.80	2.73
Turkey	0.13	0.17	0.16	0.18	0.29	0.41	1.86
United Kingdom	0.28	0.40	0.38	0.43	0.66	0.62	1.86
United States	0.23	0.29	0.29	0.33	0.52	0.45	1.93

Table 1: Ratio of retirement age populations to working age populations. Source: United Nations Population Division, World Population Prospects: The 2000 Revision.

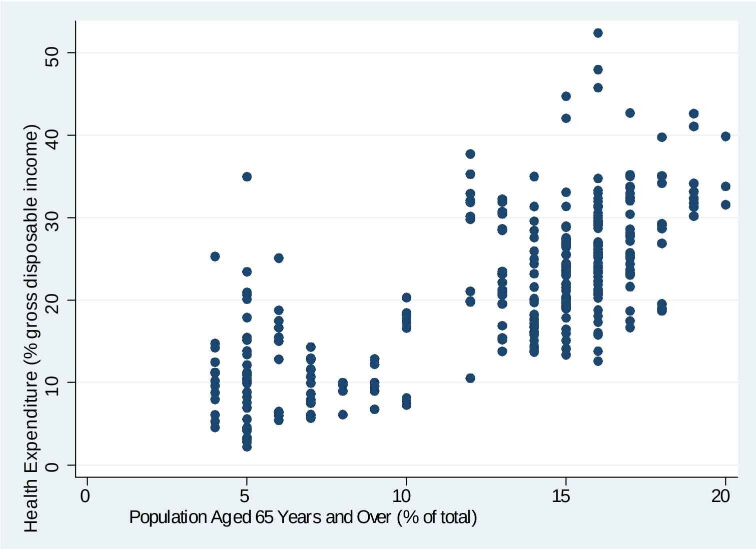

Figure 1: **Government Health Expenditure (% of gross disposable income) and Percentage of the Population Over the Age of 65.** *Source:* government health expenditure as a proportion of gross disposable income was calculated using national accounts official country data from the United Nations Statistics Division; data on the proportion of the population over the age of 65 is from the World Bank World Development Indicators (2009).

in the proportion of the population aged 65 years and over may have a negative impact on government environmental expenditure. The next section reviews empirical literature which suggests that elderly individuals may indeed exhibit a lower preference for environmental protection expenditure relative to younger individuals. A limited number of theoretical models additionally suggest that longevity may play an important role in determining the public environmental expenditure preferences of the younger generation.

3 Literature Review

3.1 A review of the empirical literature

Though the literature is completely silent regarding the macro-level impact of population ageing on government environmental protection expenditure, various micro-based analyses consistently find that on average an individual's support for environmental protection expenditure is inversely related to their age. Detailed below firstly are a set of empirical studies suggesting that age and willingness to pay for environmental preservation are negatively correlated. Second, contingent valuation surveys are detailed which arrive at analogous conclusions. Finally, analysis of political surveys and voting patterns additionally contribute evidence to the hypothesised negative impact of age on support for government environmental protection expenditure.

Empirical research investigating the age variation in willingness to pay for environmental care suggests that individuals' support for environmental expenditure declines with age. A number of econometric analyses based on large cross-country surveys find that age and willingness to pay for environmental quality are consistently negatively related after controlling for key explanatory variables such as environmental knowledge and attitude, socioeconomic characteristics, and education. For example, Hersch and Viscusi (2005) utilise a 1999 Eurobarometer survey containing observations on more than 14 000 respondents from fifteen countries to examine the differential impact of age on support for environmental protection policies. The authors find that after controlling for socioeconomic characteristics and age-related differences in individuals' source and breadth of environmental information, perceived health implications stemming from climate change, and the extent of concern regarding climate change, the degree to which individuals are willing to incur higher petrol prices if such prices reflect a greater degree of environmental protection declines with age. Along a similar line of enquiry, Torgler, García Valiñas and Macintyre (2008) employ data from the 1999-2000 European Values Survey which includes 33 representative national samples of at least one thousand individuals per country to focus on the impact of age, gender and parenthood on preferences towards environmental protection and willingness to pay for environmental expenditure. Their results suggest a negative correlation between age and individuals' willingness to contribute a portion of their income for environmental protection or support higher tax rates to fund government environmental protection expenditure, after controlling for gender, parental status, education, marital and employment status, and religiosity. Israel and Levinson (2004) utilise household-level data containing observations on approximately 70 000 respondents in 48 countries from the third wave of the World Values Survey, which was conducted between 1995 and 1998. The authors' results provide evidence that age and willingness to pay for environmental care are negatively correlated after controlling for gender, income, education and city size. Specifically, each 10 year increase in age is associated with a 2 percent decline in the probability that an individual would be willing to pay higher prices to protect the environment. Israel (2004) examines the impact of per capita national income on public support for higher taxes to fund environmental protection. Employing data from a 1989 Harris poll surveying 6360 households in twelve developing and three developed countries, Israel (2004) finds that after controlling for household income, per capita GDP, rural or urban residence, education and pollution perception, the probability that an individual is willing to pay additional taxes to fund environmental protection is negatively correlated with age. Indeed the oldest age group, composed of individuals aged 65 years and older, exhibited the lowest willingness to pay relative to individuals aged 16-20 years.

In addition to the aforementioned analyses of age and willingness to pay for environmental protection based on large individual-level surveys, contingent valuation surveys have also found that age is consistently negatively correlated with willingness to pay for the preservation of environmental quality. Carlsson and Johansson-Stenman (2000) quantify willingness to pay for improved air quality in Sweden via contingent valuation methods. Data is drawn from the Household Market and Nonmarket Activities survey, conducted in 1996 and containing observations on 3240 individuals in 1922 households. The authors find that the mean willingness to pay for a 50 percent reduction in harmful substances in an individual's local environment is approximately 2000 Swedish Krona's per annum. Importantly, age had a statistically significant negative marginal effect on the probability that an individual exhibits a positive willingness to pay for environmental quality. Whitehead (1991) administered a contingent valuation survey designed to elicit willingness to pay values for the preservation of the Clear Creed wetland area in Kentucky in the United States, and found that age negatively impacted willingness to pay for wetland preservation.

Additional supporting evidence of the inverse relationship between age and support for government environmental expenditure is provided by Kahn (2002), who utilises the General Social Survey, conducted since 1972 in the United States and containing approximately 1500 independent yearly observations. The author finds that after controlling for demographic characteristics, the probability that an individual believes that sufficient government expenditure is currently devoted to environmental protection declines with age. In addition to the General Social Survey, Kahn (2002) analyses data from voting patterns on environmental ballots in California, local government expenditure across the United States, and congressional voting on environmental issues over a period of 25 years. Econometric analysis of voting patterns on environmental ballots in California did not yield a statistically significant estimate of the impact of age on support for environmental expenditure after controlling for various sociodemographic characteristics. Interestingly, age was found to positively affect local government environmental expenditure across the United States. Finally, one extra standard deviation of elderly individuals at the state level was estimated to reduce a congress person's environmental support 'rating' by 4 percentage points after controlling for state level sociodemographic variables.

A salient criticism of the contention that elderly individuals may exhibit diminished support for environmental protection expenditure centres around conceivably dramatic increases in support for government environmental protection expenditure across all age groups stemming from sustained increases in public environmental knowledge and awareness (Tonn, Waidley and Petrich 2001). This trend is likely to intensify as the causes and consequences of anthropogenic climate change continue to gain widespread public attention. Indeed, the environmental psychology literature suggests that pro-environmental behaviour is spurred by a combination of self interest and pro-social motives. Therefore an individuals' awareness and knowledge surrounding environmental issues is likely an important indirect determinant of environmental behaviour. Bamberg and Möser (2007) replicate and extend the meta-analysis of Hines, Hungerford and Tomera (1986) to find that over the period 1986-2006, despite rapid and significant political, social and economic changes the association between psychosocial variables and environmental behaviour is stable over time. Further, numerous studies have found that individuals' behaviour is often inconsistent with their professed environmental awareness and concern, suggesting that increased public environmental awareness and knowledge may not translate into pro-environmental behaviour (Ajzen and Fishbein 1977; Axelrod and Lehman 1993; Diekmann and Preisendorfer 1998; Newhouse 1990; Poortinga, Steg and Vlek 2004; Schultz and Oskamp 1996). These studies are supported by econometric analyses such as Hersch and Viscusi (2005) and Israel (2004) which find that age and willingness to pay for environmental care are negatively correlated *after* controlling for environmental awareness and perceptions. Consequently, heightened public pro-environmental attitudes may not translate into increased support for government environmental expenditure.

The empirical analyses of micro-level data detailed above suggest that willingness to pay for environmental care and support for government environmental expenditure declines with age. Important public policy implications arise when these results are considered together with the demographic trend of population ageing. In particular, if older individuals exhibit declining willingness to pay for environmental care and diminishing support for government environmental protection expenditure relative to alternate avenues of public expenditure such as health care, population ageing may cause public funds to be diverted away from environmental expenditure and towards elderly care.

It is instructive at this point to briefly outline the political economy dimension of the hypothesis that in altering the identity of the median voter, the demographic shift may heighten political pressure to tilt the composition of social spending in favour of the elderly at the expense of environmental care. The political economy approach to environmental policy emphasises that political processes play a crucial role in determining the extent and form of environmental protection policy. Theoretical and empirical evidence clearly suggest that governments seek not simply to maximise net social benefits, but also to accommodate the preferences of competing interest groups and the median voter. Hence the literature on the political economy approach to environmental policy makes clear that the ageing of the median voter may have a significant impact on environmental protection policy (for an overview see Oates and Portney 2003; Preston 1983).

Though the macro-level impact of the demographic shift on government environmental protection expenditure has been virtually completely overlooked in the literature, numerous micro-based analyses suggest that age and an individual's support for environmental protection expenditure are inversely related. The next section summarises theoretical contributions on the link between population ageing and environmental quality.

3.2 A review of the theoretical literature

Numerous studies theoretically analyse the link between economic growth and the environment. For example, John and Pecchenino (1994) and Jouvet, Michel, and Vidal (1997) consider capital allocation and the environment. John et al. (1995) develop a model of environmental externalities and population growth. Howarth and Norgaard (1990), Howarth (1991) and Mourmouras (1993) analyse intergenerational equity. Environmental valuation and intergenerational environmental equity is the focus of Howarth and Norgaard (1992) and Howarth (1998). Mourmouras (1991), Babu, Kumar, and Nurthy (1997), and Krautkraemer and Batina (1999) concentrate on intergenerational allocation of environmental resources. Timber bequest issues are analysed by Ollikainen (1998) and Amacher et al. (1999). Briefly detailed below are a limited number of studies which specifically focus on the link between environmental sustainability and population ageing.

Ono and Maeda (2001) and Ono (2005) analyse the effect of population ageing on the environment via a two-period OLG model of environmental externalities incorporating uncertain longevity. The authors focus on two facets of population ageing which may have opposing effects on environmental quality. First, greater longevity may increase an individuals' care about future environmental maintenance. Second, population ageing due to a lower rate of population growth implies that lower aggregate pollution emissions may result from a reduction in population size. Ono and Maeda's (2001) results suggest that the impact of population ageing on the environment is dependent on the shape of the utility function. If the degree of relative risk aversion with respect to consumption is less than one, the positive effect of population ageing outweighs the negative effect and vice versa. Consequently if an agent is more risk averse with respect to consumption, ageing is harmful to the environment, whereas a less risk averse agent implies that ageing is beneficial to the environment. Ono (2005) focuses on how greater longevity and lower population growth affect a politically determined environmental tax on firms and environmental quality. Since increased longevity simultaneously induces the government to assign a greater weight to agents' consumption, thereby decreasing the tax rate; and a higher weight to utility derived from environmental quality, therefore increasing the tax rate, at equilibrium the net effect of ageing on the environmental tax rate is zero. The effect of increased longevity on environmental quality is non-positive and operates via the impact of the annuity market on capital accumulation which in turn affects pollution emissions and environmental investment. Ono (2005) additionally finds that since older individuals in an ageing society hold increased political power and by assumption do not have a preference for environmental quality, population growth negatively affects the environmental tax rate on firms.

Mariani, Pérez-Barahona and Raffin (2009) present an OLG model in which longevity and environmental quality dynamics are jointly determined. Their model relies on two key motivations. First, the authors hypothesise that an individuals' longevity is directly related to their valuation of the future. Increased life expectancy may therefore increase individuals' willingness to invest in environmental quality. Second, the causation between life expectancy and environmental quality may operate in the opposite direction, since environmental quality is an important determinant of health and morbidity. Taken together with the observed cross-country correlation between environmental quality and longevity, these two motivations lead Mariani, Pérez-Barahona and Raffin (2008) to explicitly model the two-way causality between environmental quality and life expectancy. Key among their results is that increases in agents' probability of survival in the third and final period of life boosts investment in environmental quality and reduces consumption activities which deplete the environment. Further, since longevity is endogenous, if it is affected by environmental quality via a convex-concave function, the model accommodates multiple equilibria which may explain the presence of environmental poverty traps characterised by low environmental quality and high morbidity.

4 Theoretical Model

Though numerous theoretical contributions analyse the relationship between environmental quality and growth, relatively unexplored in the literature is the link between environmental sustainability and population ageing. This model incorporates a number of salient features of the relationship between population ageing and environmental quality. The population consists of two groups, workers and retirees, who value environmental quality and consumption both in youth and old age. Working adults are taxed at a constant rate and this taxation revenue has two alternative avenues for expenditure - environmental investment and a transfer to the elderly. Environmental maintenance expenditure improves environmental quality in the next time period, and there exists a negative consumption externality. Agents therefore clearly experience tension between their preferences for consumption and environmental quality. In this model ageing has two contradictory effects. Ageing increases the proportion of elderly individuals in the population and thereby increases political pressure for the public planner to tilt the composition of public spending in favour of a transfer payment made to the elderly and away from environmental investment. Ageing may simultaneously increase the young generation's demand for environmental expenditure since greater longevity implies an increased return from such investment. If the public planner seeks to maximise the lifetime expected utility of the electorate, the latter effect - that is, the increased demand for environmental investment prompted by an increase in longevity - overwhelms the preferences of the older generation for higher transfers and lower environmental expenditure.

A number of elements differentiate this model from existing models which incorporate features of the relationship between population ageing and environmental sustainability (see Ono and Maeda 2001; Ono 2005; Mariani, Pérez-Barahona and Raffin 2009). Key among these aspects is the way in which this model incorporates intra-generational tension regarding government expenditure. Existing models typically conceptualise that agents choose to allocate their income either to consumption or environmental maintenance investment. More realistically, I model decision making at two distinct levels. First, agents maximise their lifetime utility and decide upon an equilibrium level of consumption in period t and period $t+1$, plus saving in period t. Second, the public planner maximises the aggregate welfare of the electorate taking into account these individual-level choices. Furthermore, incorporating the allocation of government expenditure among two competing uses is unique to this model. This feature allows an analysis of how the tension between the opposing policy preferences of two distinct generations potentially alters the composition of public expenditure as the population ages.

To formalise this model, consider an OLG economy with two contemporary generations. Each agent lives for a maximum of two periods - youth and old age - however agents may die at the end of youth. Let $p \in (0,1)$ be the probability that an agent lives for two periods. This probability is the same for all agents. Since the young population is constant, it can be normalised to one. Therefore at any time t there is a unit measure of young individuals and a measure p of old individuals. Consequently, p has two interpretations - it captures the longevity of a given individual, and it is also directly proportional to the fraction of old individuals alive in a particular period. The lifetime utility of an agent born in period t is

$$U = (\ln c_t^1 + E_t) + p\beta(\ln c_{t+1}^2 + E_{t+1})$$

where c_t^1 is consumption by an agent of generation t during youth, c_{t+1}^2 is consumption by an agent of generation t during old age[1], E_t is an index for the quality of the environment in period t, E_{t+1} is an index for the quality of the environment in period $t+1$, and $0 < \beta < 1$ is the discount factor.[2]

In the first period of their lives, agents work and supply one unit of labour inelastically. In the second period of their lives, agents retire. Working adults of generation t allocate their income between current consumption, c_t^1 and current saving, s_t, according to the budget constraint

$$c_t^1 + s_t = (1-\tau)w_t + B_t$$

where w_t represents agents' wage which is taxed at a constant rate, τ. Agents may also receive an unintentional bequest, denoted B_t.

Agents fund their consumption in period $t+1$ via their savings in period t. Let R denote the gross rate of return on private savings.[3] The retirement period budget constraint for a generation t individual is therefore

$$c_{t+1}^2 = p(R.s_t).$$

If agent's die at the end of the first period of their lives, their savings are distributed to their heirs in the form of an unintentional bequest, hence $B_{t+1} = (1-p)(R.s_t)$.[4]

Environmental quality at time t, denoted E_t, is a public good that is reduced by aggregate

[1] The superscript '1' denotes youth and the superscript '2' represents old age.
[2] The utility function is specified as quasi-linear primarily for analytical tractability.
[3] Assuming that this is a small open economy, the gross rate of return on savings is constant over time and taken as given from the point of view of the agent's optimisation problem.
[4] Following from this, $B_t = (1-p)(R_t s_{t-1})$. Note also that $B_{t+1} + c_{t+1}^2 = (R_{t+1} s_t)$.

consumption and can be improved by maintenance investment. Environmental quality evolves according to

$$E_{t+1} = E_t + b(E^n - E_t) - \alpha(c_t^1 + c_t^2) + \gamma m_t$$

where $E^n > 0$ is natural environmental quality in the absence of human intervention. The parameter $b \in [0, 1]$ measures the speed at which environmental quality reverts to this autonomous level.[5] A parameter of consumption externalities is denoted by $\alpha > 0$, $c_t^1 + c_t^2$ is aggregate consumption in period t, $\gamma > 0$ is a parameter that represents environmental maintenance technology, and m_t is total maintenance investment in period t. This formulation of environmental quality is from Ono and Maeda (2002) and John and Pecchenino (1994).[6]

Environmental maintenance investment in period t, m_t, is financed via tax revenue. Tax revenue in period t is $\tau.w_t$. The proportion of tax revenue devoted to environmental expenditure is denoted ϕ_t. Consequently, $m_t = \phi_t.\tau.w_t$.

Elderly care is funded via a lump sum transfer equal to the portion of taxation revenue not used for environmental investment, hence $T_t = (1 - \phi_t)\tau(w_t)$. The retirement period budget constraint for a generation t individual therefore becomes

$$c_{t+1}^2 = p(R.s_t + T_{t+1}).^7$$

To simplify the analysis, assume that the economy's production function is linear with respect to the aggregate input of human capital, as such $Y_t = L_t$ and $w_t = 1$.

An agent in generation t takes as given the wage rate, w_t, bequests, B_t, the gross return on savings, R, environmental quality, E_t, the tax rate, τ, and the aggregate consumption of old agents

[5] Examples of possible interpretations of E_t include: an index of biodiversity, the cleanliness of rivers and oceans, and the inverse of atmospheric concentration of greenhouse gases or other pollutants.

[6] John and Pecchenino represent environmental quality as an index which may take positive and negative values. A value of zero represents environmental quality in the absence of human intervention. Ono and Maeda reformulate this expression to assume that the index of environmental quality is strictly positive and $E^n > 0$ represents environmental quality in the absence of human intervention.

[7] Note that $TR_{t+1} = (1 - \phi_{t+1})\tau_{t+1}(w_{t+1})$. This is exogenous from the point of view of agents born at time t.

in period t, pc_t^2. The maximisation problem faced by a generation t agent is

$$\max_{(c_t^1, c_{t+1}^2, s_t)} \quad (\ln c_t^1 + E_t) + p\beta(\ln c_{t+1}^2 + E_{t+1}), \tag{1}$$

subject to

$$c_t^1 + s_t = (1-\tau)w_t + B_t, \tag{2}$$

$$c_{t+1}^2 = p(R.s_t + T_{t+1}), \tag{3}$$

Maximising the objective function (1), subject to (2) - (3) the equilibrium values of c_t^1, c_{t+1}^2, and s_t are therefore:

$$s_t = \frac{Rw_t p\beta(1-\tau_t) + RB_t p\beta - T_{t+1}}{(p\beta+1)R} \tag{4}$$

$$c_t^1 = \frac{Rw_t(1-\tau_t) + RB_t T_{t+1}}{(p\beta+1)R} \tag{5}$$

$$c_{t+1}^2 = \frac{p^2\beta(Rw_t(1-\tau_t) + RB_t + T_{t+1})}{p\beta+1} \tag{6}$$

Following from this,

$$c_t^2 = \frac{p^2\beta(Rw_{t-1}(1-\tau) + RB_{t-1} + T_t)}{p\beta+1} \tag{7}$$

Substituting (5), (7), $m_t = \phi_t.\tau.w_t$, and the transfer payment received by the elderly at time t, $T_t = (1-\phi_t)\tau(w_t)$ into the expression for environmental quality in period $t+1$, E_{t+1}, we have:[8]

$$
\begin{aligned}
E_{t+1} &= E_t + b(E^n - E_t) \\
&\quad -\alpha\left(\frac{R(1-\tau)+RB_tT_{t+1}}{(p\beta+1)R} + \frac{p^2\beta(R(1-\tau)+RB_{t-1}+(1-\phi_t)\tau)}{p\beta+1}\right) \\
&\quad +\gamma\,(\phi_t.\tau)
\end{aligned}
\tag{8}
$$

According to expressions (4)-(8), the lifetime expected welfare of a working adult is

$$
\begin{aligned}
V_t^1 &= (\ln c_t^1 + E_t) + p\beta(\ln c_{t+1}^2 + E_{t+1}) \\
&= \ln\left[\frac{R(1-\tau)+RB_tT_{t+1}}{((p\beta+1)R)}\right] + E_t \\
&\quad +p\beta[\ln\left(\frac{p^2\beta(R(1-\tau)+RB_t+T_{t+1})}{p\beta+1}\right) \\
&\quad +(E_t + b(E^n - E_t) - \alpha(\frac{R(1-\tau)+RB_tT_{t+1}}{(p\beta+1)R} \\
&\quad +\frac{p^2\beta(R(1-\tau)+RB_{t-1}+(1-\phi_t)\tau}{p\beta+1}) + \gamma\,(\phi_t.\tau)]
\end{aligned}
$$

while the welfare level of a contemporary retiree in period t is given by

$$
\begin{aligned}
V_t^2 &= \ln c_t^2 + E_t \\
&= \ln\left[\frac{p^2\beta(R(1-\tau)+RB_{t-1}+(1-\phi_t)\tau)}{p\beta+1}\right] + E_t.
\end{aligned}
$$

[8] Note that for clarity, the substitution $w_t = 1$ has been made from this point onwards.

Inspection of V_t^1 and V_t^2 clearly demonstrates the divergent policy preferences of the two population groups. The lifetime expected welfare of a retired individual in period t is strictly decreasing in ϕ_t. This result is highly intuitive. Since environmental maintenance expenditure at time t increases environmental quality only at time $t+1$, retirees will not reap the benefit of such investment in the current period. Older individuals therefore strictly prefer that the minimum proportion of taxation revenue be spent on environmental care in order to maximise the transfer payment that they receive. In contrast, the relationship between ϕ_t and the lifetime expected welfare of a young individual is positive. The last term in the expression for V_t^1 reflects that environmental investment at time t will increase a young agent's lifetime welfare via its positive effect on environmental quality in period $t+1$. The second-last term in the expression for V_t^1 also indicates that an increase in environmental investment will be welfare enhancing for young individuals. Since an increase in ϕ_t necessarily implies a decrease in T_t - the transfer payment to the elderly - the decreased consumption of the elderly consequently enhances environmental quality in period $t+1$ via a reduction in the negative consumption externality.

Since the policy preferences of the two politically active population groups - the workers and the retirees - diverge, policy choices are determined through a political process. Political parties converge to platforms that maximise the aggregate lifetime utility of the electorate. An important, and arguably realistic feature of this model of the political process is that the influence of a particular group of voters is determined by the change in the marginal utility of that group following a change in government policy. Indeed, this is a prominent feature of probabilistic voting models such as those of Lindbeck and Weibull (1987). This treatment of the political process is appropriate considering that application of a majority voting mechanism is problematic in an OLG framework. Since the old are always the minority, the policy preferences of the older generation will, therefore, have no impact on political outcomes if age is the only determinant of policy choices (Gradstein and Kaganovich 2004).

Given the constituent age groups in this model, aggregate welfare at time t is defined by

$$V_t = V_t^1 + pV_t^2 \tag{9}$$

Hence the political decision in period t amounts to choosing the proportion of taxation revenue devoted to environmental expenditure, ϕ_t, which maximises the aggregate utility of the electorate:

$$\max_{(\phi_t)} \quad V_t = V_t^1 + pV_t^2,$$

Importantly, I treat the tax rate as exogenous. This assumption is not particularly restrictive considering that the tax rate may be determined by considerations relating to, for example, taxable capacity or tax rate conventions (Creedy and Moslehi 2010). Indeed, as articulated by Tridimas (2001), this common assumption is defensible given that in practice policy makers are often restricted in the policy instruments which they may vary at a particular point in time. Given that ϕ_t is chosen endogenously by the public planner, we search for the value of ϕ_t which maximises V_t. Taking the partial derivative of V_t with respect to ϕ_t we have

$$\frac{\delta V_t}{\delta \phi_t} = \frac{p\beta(\alpha p^2 \beta\tau)}{(p\beta + 1)} + \gamma\tau + \frac{p\tau}{-(1-\phi_t)\tau + R\left(-1 + \tau - B_{t-1}\right)} \tag{10}$$

Defining the $B = B_{t-1}$ and $\phi = \phi_t$ in the steady state, and solving for ϕ^* :

$$\phi^* = \frac{Rp\beta\left(p^2\alpha\beta + p\beta\gamma + \gamma\right)(1+B) - p\beta - 1}{p\beta\tau\left(\alpha\beta p^2 + \beta\gamma p + \gamma\right)} + 1 - R \tag{11}$$

We can now perform comparative statics to evaluate the impact on ϕ^* when p changes. Ex-ante, there exist two opposing effects governing the impact of an increase in the longevity parameter on the proportion of taxation revenue devoted to environmental care. Recall that the elderly generation strictly prefers a lower level of environmental expenditure such that their transfer payment is maximised. Since a higher p increases the size of the older generation, in maximising the aggregate utility of the electorate the public planner will therefore place more weight on the preferences of the elderly and consequently may tilt the composition of spending in favour of the retirees.

Conversely, the young generation supports public spending on environmental care. The benefit which the young generation receives at time $t+1$ from investment in environmental quality at time t increases with the longevity parameter p, owing to a longer remaining lifespan in which to enjoy enhanced environmental quality. Consequently the public planner places more weight on the increased preference of the young generation for environmental expenditure. The overall impact of an increase in p on ϕ^* will therefore depend on the relative strength of these two effects.

Proposition 1 *An increase in the longevity parameter p will cause the equilibrium value of the proportion of taxation revenue devoted to environmental expenditure in period t, ϕ^* to increase.*

Proof. Taking the partial derivative of (11) with respect to p, we have

$$\frac{\delta\phi^*}{\delta p} = \frac{p\beta\left(2\alpha p^2\beta + \gamma p\beta + 3\alpha p + 2\gamma\right) + \gamma}{p^2\beta\tau\left(\alpha\beta p^2 + \beta\gamma p + \gamma\right)^2}$$

which is strictly positive. Hence, in this model as p - the proportion of older individuals in the population - increases, ϕ^* - the equilibrium value of the proportion of government expenditure devoted to environmental quality - unambiguously increases. ■

In summary, this theoretical model aims to shed light on the relatively unexplored link between population ageing and environmental sustainability. Incorporating two contemporary generations who derive utility both from consumption and environmental quality in youth and old age, this model incorporates a number of key features of the relationship between population ageing and environmental quality. In particular, there exists a clear tension between the young and the older generation regarding their preferences for government expenditure. Crucially, the young generation supports environmental care expenditure while the retirees prefer that this expenditure is minimised such that the transfer payment they receive is maximised. In this model ageing has two opposing effects. Ageing increases the proportion of elderly individuals in the population and consequently heightens political pressure for the public planner to tilt the composition of spending away from environmental maintenance and towards elderly care. Ageing simultaneously increases the young generation's demand for environmental expenditure since increased longevity implies a higher return from such investment. If the public planner seeks to maximise the lifetime expected welfare of both generations, the latter effect - the increased preference for environmental care expenditure, dominates the preferences of the older generation for higher transfers and lower environmental expenditure. The next section empirically tests this theoretical result.

5 Public Environmental Expenditure and Population Ageing: An empirical investigation

5.1 Data and methodology

To empirically investigate the impact of population ageing on environmental protection expenditure, I utilise a panel data set specifically constructed for this research project. Government environmental expenditure data is sourced from the United Nations Statistics Division's National Accounts Official Country Data. This data is available for 47 countries and covers the years 1970 to 2007, though as illustrated by Table 2, the number of years for which data is available varies significantly between countries. A key strength of this data set is the diversity of countries it contains - low, middle and high income countries are represented and the sample contains significant social, political and institutional country-level variation. General government final consumption expenditure, general government gross disposable income and GDP data were also sourced from the United Nations Statistics Division's National Accounts Official Country Data. Data on population density, demography, GDP, economic growth, and government cash surplus/deficit was sourced from the World Bank's World Development Indicators. Table 3 describes in detail each variable used in this empirical analysis and its source. Table 4 contains summary statistics.

I estimate the following reduced-form regression equation:

Country	Years	Country	Years	Country	Years
Azerbaijan	1990-2000	Iceland	1998	Norway	1990-2004
Argentina	1993-1998	India	1999-2005	Pakistan	2000-2007
Australia	1998-2002	Iran	1994-2005	Panama	1996-2006
Austria	1995-2007	Israel	1995-2006	Poland	2002-2006
Belgium	1990-2006	Italy	1995-2006	Portugal	1990-2006
Chad	1994-2001	Japan	1990-2006	Russia	2005
Cyprus	1998-2006	Republic of Korea	1993-2006	San Marino	2003-2004
Czech Republic	1995-2006	Kyrgyzstan	1995-2006	Slovakia	2003-2006
Denmark	1990-2007	Lithuania	2002-2006	Slovenia	2000-2005
Estonia	2003-2004	Luxembourg	1990-2007	Spain	1995-2006
Finland	1990-2006	Macao (China)	1996-2006	Sweden	1995-2006
France	1995-2005	Malta	1996-2006	Ukraine	2001-2007
Germany	1991-2006	Netherlands	1995-2006	United Kingdom	1990-2005
Greece	1995-2006	Antilles	1996-2004	United States	1970-2006
Hong Kong	2000-2006	New Zealand	2003-2005	Venezuela	1997-2005
Hungary	2001-2005	Nicaragua	1994-2004		

Table 2: Government Environmenal Expenditure and Population Ageing: Data availability

$$e_{it} = \alpha + \beta_0 L_{it} + \beta_1 O_{it} + \beta_2 Y_{it} + \beta_3 (L_{it} * Y_{it}) + \beta_k X_{it} + u_{it} \tag{12}$$

where the error term is specified as $u_{it} = \varepsilon_{it} + \mu_i$ and is decomposed into a white-noise component ε_{it}, and a country effect, μ_i, which captures unobservable country-specific factors. In Eq. (12), the dependent variable e_{it} is government environmental expenditure as a proportion of government gross domestic income in country i at time t, L_{it} is life expectancy, O_{it} is the proportion of individuals aged 65 years and older, and Y_{it} represents the proportion of individuals aged between 15 and 64 years. According to the theoretical model in Section 4, the estimated coefficients on L_{it} and Y_{it} are expected to be positive. To elaborate, since the younger generation supports public environmental expenditure, an increase in longevity implies a longer remaining lifespan and therefore a higher return from such investment. Similarly, an increase in the proportion of individuals aged between 15 and 64 years is hypothesised to positively impact environmental expenditure since a larger proportion of young people in the population will cause the welfare maximising public planner to divert more resources towards environmental care. The interaction $(L_{it} * Y_{it})$ is included to capture potential non-linear effects between life expectancy and the proportion of the population

Variable	Description	Units	Source
General government final consumption expenditure	Government final consumption expenditure consists of expenditure, including imputed expenditure, incurred by general government on both individual consumption goods and services and collective consumption services.	National currency current prices	Government final consumption expenditure by function: General government final consumption expenditure. National Accounts Official Country Data. United Nations Statistics Division.
Environment protection	General government final consumption expenditure is disaggregated according to the classification of the functions of government (COFOG). There are ten components of government final consumption expenditure, one of which is environment protection expenditure.	National currency current prices	Government final consumption expenditure by function: Environment protection. National Accounts Official Country Data. United Nations Statistics Division.
General government gross disposable income	General government gross disposable income is derived by adding all current transfers, except social transfers in kind, receivable by the general government sector, and subtracting all current transfers, except social transfers in kind, payable by the general government sector.	National currency current prices	General government gross disposable income. National Accounts Official Country Data. United Nations Statistics Division.
Population density	Population per square kilometer of land.	Percentage	World development indicators (2009), World Bank.
Population 65+	Proportion of the population aged 65 years and over.	Percentage	World development indicators (2009), World Bank.
Population 15-64	Proportion of the population aged aged between 15 and 64 years.	Percentage	World development indicators (2009), World Bank.
Population	Country population	-	World development indicators (2009), World Bank.
Life expectancy	Life expectancy at birth	Years	World development indicators (2009), World Bank.
GDP	Annual gross domestic product	National currency current prices	Gross domestic product by expenditures at current prices. National Accounts Official Country Data. United Nations Statistics Division.
Real GDP	Real annual gross domestic product	US dollars 1990 prices	World development indicators (2009), World Bank.
Growth	Annual GDP growth	Percentage	World development indicators (2009), World Bank.
Inflation	Annual inflation	Percentage	World development indicators (2009), World Bank.
Cash surplus/deficit	Government revenue (including grants) minus expenses, minus net acquisition of nonfinancial assets.	Percentage of GDP	World development indicators (2009), World Bank.

Table 3: Government Environmenal Expenditure and Population Ageing: Data description and sources

Variable	Number of Obs.	Mean	Standard Deviation	Minimum	Maximum
General government final consumption expenditure/GDP	450	18.47	4.80	4.46	30.12
Environment protection/general government gross disposable income	352	1.61	1.63	0	10.57
Population density	425	702.36	2643.23	2	17727
Population 65+	424	12.23	4.71	3	20
Population 15-64	424	65.87	4.21	51	78
Population	425	4500000	135000000	29457	1090000000
Life expectancy	357	76.03	4.55	52	82
Real GDP per capita	425	16064.98	12114.26	122.68	57826.56
Growth	440	3.39	3.85	-23.1	27.32
Inflation	439	13.57	106.75	-8.52	1664.53
Cash surplus/deficit	304	-1.23	3.84	-11	16

Table 4: Government Environmenal Expenditure and Population Ageing: Summary statistics

aged between 15 and 64 years. If the hypothesis that older individuals do not support public environmental expenditure is empirically supported, an increase in the proportion of individuals aged over 65 years in a population will negatively impact environmental expenditure. Hence the sign of the estimated coefficient on O_{it} is expected to be negative.

A vector of control variables, X_{it}, includes: the logarithm of real per capita GDP, economic growth, population density, inflation and government cash surplus or deficit. The functional form for real per capita GDP is quadratic. The environmental Kuznets curve literature[9] suggests that an 'inverted-U' shaped relationship exists between per capita pollution emissions and per capita GDP. One of the hypothesised factors driving this relationship is that past a certain threshold level of GDP per capita, the income elasticity of demand for environmental quality may exceed unity, thereby contributing to improvements in environmental quality. Consequently per capita real GDP enters the regression equation as a quadratic to account for potential non-linear effects of income on environmental expenditure. The growth rate of GDP accounts for the business cycle. The expected sign of the estimated coefficient corresponding to the rate of economic growth is positive, since during periods of economic prosperity government environmental expenditure is likely to rise (Aubin

[9] See, for example, Grossman and Krueger (1991), Selden and Song (1994), Shafik and Bandyopadhyay (1992).

et al. 1988; Dreher 2006). Empirical studies suggest that more densely populated countries exhibit higher demand for environmental quality at every income level relative to more sparely populated countries (Selden and Song 1994). Therefore population density enters the regression with an expected positive coefficient. The inflation rate enters the regression equation as a quadratic. Since countries with persistently high inflation may develop mechanisms to mitigate its real effects, the effect of inflation may be non-linear (Brender and Drazen 2009; Lin 1992). Finally, the inclusion of the government's cash surplus or deficit as a proportion of GDP controls for the budgetary position of the government. Since a tighter government budget constraint is likely to lead to increased spending on items such as social services and unemployment relief to the detriment of lower priority budgetary items such as environmental care, the estimated coefficient on government cash surplus/deficit is expected to be positive.

5.2 Empirical results

Table 5 illustrates fixed effect estimation results. Fixed effect estimation controls for various country-specific time-invariant factors which conceivably affect government environment protection expenditure, for example whether the country is a democracy. The use of fixed effect regression is supported in all specifications by the failure to reject the hypothesis of no systematic difference between random effect and fixed effect results in the Hausman test. Further, the fixed effect estimation results are corrected for autocorrelation, justified on the basis of the Wooldridge (2002) test for autocorrelation in panel data rejecting the null hypothesis of no serial correlation in all specifications.

Table 5 illustrates a series of three nested econometric specifications for estimating the impact of population ageing on government environmental protection expenditure. Table 5 illustrates that the estimated coefficients, their sign and statistical significance are robust across all specifications. Hence the following discussion focusses on Specification III, which is the most complete specification.

The estimated coefficient on $life\_expectancy$ is positive and statistically significant. However, given that the interaction term $(population\_15-64)*(life\_expectancy)$ has a negative estimated coefficient and is statistically significant, the computation of the overall impact of $life\_expectancy$ on government environmental expenditure necessitates taking both coefficients into account:

$$\frac{\partial \; Environmental\_protection\_expenditure}{\partial \; life\_expectancy} = 0.430 - 0.006 * population\_15 - 64.$$

The impact of $life\_expectancy$ is thus positive when $population\_15 - 64 < 71.6$, which is the case for more than 95 percent of the sample. Hence for approximately 95 percent of the countries in this sample, increases in longevity positively impact on environmental protection expenditure, in accordance with the theoretical predictions of Section 4.

The estimated coefficient on $population\_65+$ is negative as expected, though statistically insignificant. Notably though, $population\_65+$ is jointly significant with $life\_expectancy$ $\{F(2, 131 = 4.90)\}$, and is also jointly significant with $population\_15 - 64$ $\{F(2, 131 = 5.71)\}$. This strongly suggests that demographic factors play an important role in determining the proportion of government disposable income which is devoted to environmental expenditure. The negative coefficient on $population\_65+$ implies that, in accordance with the theoretical predictions in Section 4, older individuals do not support public environmental expenditure and that an increase in the proportion of individuals over the age of 65 may increase pressure for the public planner to shift the composition of public expenditure away from environmental care and towards goods and services more highly valued by the elderly. Importantly however, the absence of individual significance of the estimated coefficient on $population\_65+$ lends support to the theoretical prediction that if the public planner seeks to maximise the aggregate welfare of the electorate, the positive impact of increasing longevity on government environmental expenditure may overwhelm the negative impact of an increase in the proportion of older individuals in the population.

The estimated coefficient on $population\_15-64$ is positive and statistically significant. Similarly to the case with $life\_expectancy,$ to determine the overall impact of $population\_15 - 64$ the interaction term $(population\_15 - 64)*(life\_expectancy)$ must additionally be taken into account:

$$\frac{\partial \; Environmental\_protection\_expenditure}{\partial \; population\_15-64} = 0.500 - 0.006 * life\_expectancy.$$

Therefore the impact of $population\_15 - 64$ is positive when $life\_expectancy < 83.3$, which is the case for the entire sample. The proportion of a country's population aged between 15 and 64 years unambiguously increases the proportion of government disposable income which is devoted to environmental expenditure. This result parallels the theoretical prediction that younger individuals unequivocally support environmental expenditure. An increase in the proportion of younger individuals in a population will therefore tilt the composition of government expenditure in favour of the preferences of the young.

The estimated coefficients of the vector of control variables, X_{it} in equation (12) are all in accordance with expectations. The estimated coefficient on $GDP/capita$ is negative and the estimated coefficient on $(GDP/capita)^2$ is positive. Both $GDP/capita$ and $(GDP/capita)^2$ are statistically significant. The turning point occurs at approximately \$20,300 (1990 US dollars). This result supports the notion that per capita income is indeed an important component of the demand for public environmental expenditure, and the demand for public environmental expenditure is positively related to per capita income past a particular threshold level. The estimated coefficients on $growth$, $inflation$, $(inflation)^2$, and $cash\_surplus/deficit$ all have the predicted sign and point to the important role that macroeconomic conditions - in particular the business cycle and the degree of tightness of the government budget constraint - play in determining the composition of government expenditure. Though the estimated coefficient on $growth$ is non-statistically significant, $cash\_surplus/deficit$ is individually significant and $inflation$ and $(inflation)^2$ are jointly significant $\{F(2, 131 = 3.95)\}$. Finally, $central\_government\_final\_consumption\_expenditure/GDP$ is positive, though statistically insignificant, and the estimated coefficient on $population\_density$ is positive and statistically significant as expected.

In summary, the results of this empirical investigation into the role of population ageing in determining government environmental protection expenditure support the theoretical model presented in Section 4. Though the proportion of individuals in the population aged 65 years and over negatively affects public spending on the environment, this effect is counteracted by the statistically significant positive impact of increases in longevity and the proportion of the population aged between 15 and 64 years.

Explanatory Variable	I	II	III
Life expectancy	1.482***	1.574***	0.430***
	(0.162)	(0.164)	(0.143)
Population 65+	-0.018	-0.022	-0.028
	(0.062)	(0.062)	(0.045)
Population 15-64	1.708***	1.819***	0.500***
	(0.185)	(0.191)	(0.154)
Population 15-64*Life expectancy	-0.022***	-0.024***	-0.006***
	(0.002)	(0.003)	(0.002)
Log of real GDP per capita	-23.580***	-25.285***	-7.536***
	(2.909)	(3.085)	(2.616)
Log of (real GDP per capita)^2	1.166***	1.259***	0.380**
	(0.187)	(0.197)	(0.163)
Growth	-	0.009	0.003
		(0.008)	(0.005)
General governmnet final consumption expenditure/GDP	-	0.035 (0.034)	0.016 (0.025)
Population density	-	-	0.0005***
			(0.0002)
Inflation	-	-	-0.017*
			(0.010)
(Inflation)^2	-	-	0.0001
			(0.0002)
Cash surplus/deficit	-	-	-0.019**
			(0.009)
Constant	5.561***	5.451***	7.521***
	(0.189)	(0.190)	(0.158)
F-test for the joint significance of Life expectancy and Population 65+	F(2, 216) =42.14***	F(2,212) =46.02***	F(2,131) =4.90***
F-test for the joing significance of Population 65+ and Population 15-64	F(2,216) =42.93***	F(2,212) =45.19***	F(2,131) =5.71***
R-squared	0.01	0.01	0.03
Number of observations	N=255	N=252	N=174

Notes:
The dependent variable is government environmental protection expenditure as a proportion of government gross disposable income.
Estimation proceedure: fixed effect estimation corrected for autocorrelation.
***, **, * indicates statistical significance at the 1, 5, and 10% levels, respectively.
Standard errors are in parentheses.

Table 5: Government Environmenal Expenditure and Population Ageing: Empirical Results

6 Conclusion

In conclusion, this paper provides theoretical and empirical justification for the hypothesis that population ageing may have two opposing effects on government environmental protection expenditure. Firstly, ageing increases the proportion of elderly individuals in the population and may consequently heighten political pressure for the public planner to tilt the composition of spending away from environmental maintenance and towards elderly care. Secondly, ageing may simultaneously increase the young generation's demand for environmental expenditure since increased longevity implies a higher return from such investment. If the public planner seeks to maximise the lifetime expected welfare of both generations, the latter effect - the increased preference for environmental care expenditure among the younger generation, may dominate the preferences of the elderly generation for reduced public environmental expenditure.

7 References

Aubin, C, Berdot, JP, Goyeau, D and Lafay, JD 1988, 'The growth of public expenditure in France'. In JA Lybeck & M. Henrekson (Eds.), *Explaining the growth of government*, Amsterdam, The Netherlands.

Ajzen, I and Fishbein, M 1977, 'Attitude-Behavior Relations: A Theoretical Analysis and Review of Empirical Research, *Psychological Bulletin*, vol. 84, no. 5, pp. 888-918

Axelrod, LJ and Lehman, DR 1993, 'Responding to environmental concerns: What factors guide individual action? *Journal of Environmental Psychology*, vol. 13, iss. 2, pp. 661-669.

Shafik, N and Bandyopadhyay, S 1992, 'Economic growth and environmental quality: time series and cross-country evidence', *The World Bank*, Background Paper for the World Development Report 1992.

Bamberg, S and Möser, G 2007, 'Twenty years after Hines, Hungerford and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour', *Journal of Environmental Psychology*, vol. 27, pp. 14-25.

Brender, A and Drazen, A 2009, 'Do Leaders Affect Government Spending Priorities?', *NBER Working Paper Series*, Working Paper no. 15368, National Bureau of Economic Research, Cambridge, United States.

Carlsson, F and Johansson-Stenman, O 2000, 'Willingness to pay for improved air quality in Sweden', *Applied Economics*, vol. 32, pp. 661-669.

Creedy, J and Moslehi, S 2010, 'The Optimal Division of Government Expenditure Between Public Goods and Transfer Payments', *Australian Economic Papers*, vol. 49, iss. 2, pp. 87-100.

Diekmann, A and Preisendorfer, P 1998, 'Environmental behavior - Discrepancies between aspirations and reality', *Rationality and Society*, vol. 10, no. 1, pp. 302-339.

Dreher, 2006, 'The influence of globalization on taxes and social policy – An empirical analysis for OECD countries', *European Journal of Political Economy*, vol. 22, no. 1, pp. 179-201.

Gavrilov, LA and Heuveline, P 2003, 'Aging of Population', in *The Encyclopedia of Population,* in DJ Ekerdt (ed), Macmillan Reference, New York, United States.

Gradstein, M and Kaganovich, M 2004, 'Aging population and education finance', *Journal of Public Economics*, vol. 88, pp. 2469-2485.

Grossman, GM and Krueger, AB 1995, 'Economic Growth and the Environment', *Quarterly Journal of Economics*, May, pp. 353-377.

IPCC 2007, *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment*, Report of the Intergovernmental Panel on Climate Change, RK Pachauri and Reisinger, A (eds.), IPCC, Geneva, Switzerland, pp. 1-22.

Hersch, J and Viscusi, WK 2005, 'The Generational Divide in Support for Environmental Policies: European Evidence', *NBER Working Paper Series*, Working Paper no. 11859, National Bureau of Economic Research, Cambridge, United States.

Hines, JM, Hungerford, HR and Tomera, AN (1986/87), 'Analysis and synthesis on responsible environmental behavior: A meta-analysis', *Journal of Environmental Education*, vol. 18, no. 2, pp. 1-8.

Israel, DK 2004, 'International support for environmental protection', Environment and Development Economics, vol. 9, pp. 757-780.

Israel, D and Levinson, A 2004, 'Willingness to Pay for Environmental Quality: Testable Implications of the Growth and Environmental Literature', *Contributions to Economic Analysis & Policy*, vol. 3, iss. 1, pp. 1-29.

John, A and Pecchenino, R 1994, 'An Overlapping Generations Model of Growth and the Environment', The Economic Journal, vol. 104, no. 427, pp. 1393-1410.

Jouvet, P-A, Pestieau, P and Ponthiere, G 2007, 'Longevity and Environmental Quality in an OLG Model', *Environmental Economics & Management Memorandum*, Center for Operations Research and Econometrics (CORE), September.

Kahn, ME 2002, 'Demographic Change and the Demand for Environmental Regulation', *Journal of Policy Analysis and Management*, vol. 21, no. 1, pp. 45-62.

Lahiri, R and Magnani, E 2008, 'On inequality and the allocation of public spending', *Economics Bulletin*, vol. 5, no. 8, pp. 1-8.

Lin, S 1992, 'The Effect of Inflation on Government Expenditure: New Evidence', *Atlantic Economic Journal*, vol. 20, no. 4, pp. 86.

Lindbeck, A and Weibull 1987, 'Balanced-budget redistribution as the outcome of political competition', *Public Choice*, vol. 52, no. 3, pp. 273-297.

Mariani, F, Pérez-Barahona, A and Raffin, N 2008, 'Life expectancy and the environment', *Documents de travail du Centre d'Economie de la Sorbonne v08048*, Université Panthéon-Sorbonne (Paris 1), Centre d'Economie de la Sorbonne.

Newhouse, N 1990, 'Implications of attitude and behavior research for environmental conservation', *Journal of Environmental Education*, vol. 22, no. 1, pp. 26-32.

Nyce, SA and Schieber, SJ 2005, *The Economic Implications of Aging Societies: The Costs of Living Happily Ever After*, Cambridge University Press, Cambridge, New York, United States.

Oates, WE and Portney, PR 2003, 'The Political Economy of Environmental Policy', in K-G Mäler and JR Vincent (eds), *Handbook of Environmental Economics*, Elsevier, Amsterdam, The Netherlands, pp. 325-354.

Ono, T 2005, 'The Political Economy of Environmental Taxes with an Aging Population', *Environmental and Resource Economcs*, vol. 30, pp. 165-194.

Ono, T and Maeda, Y 2001, 'Is Aging Harmful to the Environment?', *Environmental and Resource Economics*, vol. 20, pp. 113-127.

Ono, T and Maeda, Y 2002, 'Sustainable development in an aging economy', *Environment and Development Economics*, vol. 7, pp. 9-22.

Poortinga, W, Steg, L and Vlek, C 2004, 'Values, Environmental Concern, and Environmental Behavior: A study Into Household Energy Use', *Environment and Behavior*, vol. 36, no. 1, pp. 70-93.

Schultz, PW and Oskamp, S 1996, 'Effort as a moderator of the attitude-behavior relationship: General environmental concern and recycling', *Social Psychology Quarterly*, vol. 59, no. 4, pp. 375-383.

Selden, TM and Sond, D (1994), 'Environmental Quality and Development: Is there a Kuznets curve for air pollution emissions?', *Journal of Environmental Economics and Management*, vol. 27, pp. 142-162.

Tonn, BE, Waidley, G and Petrich, C 2001, 'The Ageing US Population and Environmental Policy', *Journal of Environmental Planning and Management*, vol. 44, no. 6, pp. 851-876.

Torgler, B, García Valiñas, MA and Macintyre, A 2008, 'Differences in Preferences Towards the Environment: The Impact of a Gender, Age and Parental Effect, *Fondazione Eni Enrico Mattei Working Papers*, Nota Di Lavoro 18.2008, Fondazione Eni Enrico Mattei, Milan, Italy.

Tridimas, G 2001, 'The economics and politics of the structure of public expenditure', *Public Choice*, vol. 106, iss. 3-4, pp. 299-316.

United Nations Population Division 2002, *World Population Ageing 1950-2050*, Population Division, Department of Economic and Social Affairs, United Nations.

Whitehead, JC 1991, 'Environmental Interest Group Behavior and Self-Selection Bias in Contingenet Valuation Mail Surveys', *Growth and Change*, vol. 22, pp. 10-21.

Whitehouse, E 2007, *Pensions Panorama: Retirement-Income Systems in 53 Countries*, The International Bank for Reconstruction and Development/The World Bank, Washington DC, United

States.

Wooldridge, JM 2002, *Econometric Analysis of Cross Section and Panel Data*, MIT Press, Cambridge, United States.