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Population aging and carbon emissions in OECD countries: Accounting for life-cycle and cohort effects

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ABSTRACT

This paper investigates the relationship between emissions of carbon dioxide and the ongoing process of demographic transition in OECD countries. Our research is motivated by suggestions in the literature that emission-relevant consumption patterns may depend on the position in the life cycle and on the birth cohort to which people belong. We augment standard macroeconomic emission regressions by including the age and cohort composition of the population. Our estimation results on a panel of data for 26 countries, spanning the period 1960–2005, suggest that both life-cycle and cohort effects belong in a macroeconomic emission function for carbon dioxide. We find that shifts in both the age and the cohort composition have contributed to rising carbon emissions in OECD countries.

1. Introduction

Societies worldwide are currently subject to two fundamental changes in their living conditions. One is environmental change, especially with respect to the global climate. The other is demographic transition. Climate change due to atmospheric emissions of carbon dioxide and other so-called greenhouse gasses involves future increases in mean temperatures and changes in the patterns of temperature and precipitation across continents and countries (IPCC, 2007). Demographic transition entails changes not only in the size, but also in the age composition and the longevity of the population (Chesnais, 1992). Current and future stages of demographic transition are characterized by an aging of the population, both in developed and developing countries.

While population aging seems to be largely driven by secular trends in fertility and mortality, climate change is related to the level and structure of economic activity. Changes in economic activity are generally included in analyses of greenhouse gas emissions, as is the size of the population (most prominently IPCC, 2001; see Bongaarts, 1992 for an early study of the role of population size). What received less attention so far is the age composition and the longevity of the population. It is, however, intuitive that older age and longer lifetimes may affect emissions via several channels.

One important channel is the dependence of per capita economic activity on the age structure.[1] Another consists of the influence that the age composition may have on the industrial composition of production via altered demand patterns, especially the demand for energy. Finally, there is the possibility that increases in life expectancy may imply longer planning horizons and, hence, a higher weight attached to issues of sustainability.

The environmental effects of aging that have been examined in the literature mostly refer to aging in a static years-since-birth sense, thus focusing on the life cycle aspect and disregarding possible cohort effects. It is, however, likely that environmentally relevant attitudes and lifestyles depend on the time period in which a person was born and raised. Against this background, emissions may be influenced not just by changes in the age structure (life cycle effect) but also through shifts in the year-of-birth composition of the population (cohort effect).

The present paper studies the relationship between the ongoing process of population aging and the most important greenhouse gas, carbon dioxide. We take per capita income as given and investigate

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[1] A larger share of people that are out of the labor force reduces income per capita. Dalton et al. (2008) and O'Neill et al. (2010) analyze the effect of population aging on carbon emissions via induced changes in per capita income.

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how the level of carbon emissions is connected not just to the size of the population, but also to its composition in terms of age groups and year-of-birth groups. We estimate the linkage of carbon emissions to purchasing power parity adjusted real GDP per capita, the population size, and the age and cohort composition in a panel of data for 26 OECD countries, containing 242 observations that span the period 1960–2005.[2] We control for urbanization, endowment-related fossil energy intensity as well as country and year fixed effects. Including country and year effects allows us to capture country specific geographical and climatic conditions as well as period specific energy prices and technological innovations.

Consistent with earlier literature, we find that the relationship between per capita income and carbon emissions does not follow the hump-shaped pattern suggested by the environmental Kuznets curve (EKC).[3] Instead, growing per capita income raises carbon emissions at every income level. With respect to population aging we find that both the age and the cohort composition belong in a macroeconomic emission function for carbon dioxide. We find that a higher share of older persons and shifts in the year-of-birth composition both imply increasing carbon emissions.

There are few empirical macro-level studies which consider aging as a driver of carbon emissions, and they come to mixed results. York et al. (2003), Shi (2003), Cole and Neumayer (2004) and Farzin and Bond (2006) combined data from developed and developing countries. York et al. (2003) and Shi (2003) found that societies with a high share of working-age individuals are characterized by higher carbon emissions. By contrast, Farzin and Bond (2006) found that societies with a high share of individuals under 15 years of age emit more carbon dioxide. Finally, carbon emissions are not significantly related to the age composition according to Cole and Neumayer (2004).

The pooling of data from developed and developing countries has been criticized because it presumes homogeneous relationships between emissions and their determinants in spite of different socio-economic conditions. With respect to demographic factors, the homogeneity assumption seems to be questionable given that a certain chronological age in high income countries may reflect rather different positions in the life cycle than the same chronological age in low income countries. An individual with 50 years of age, living in the developing world (with an expected remaining life expectancy of about ten years), may behave differently from his or her fifty year old counterpart in the developed world (with an expected remaining life expectancy of approximately 30 years).

Against this background, Fan et al. (2006) permitted the relationship between aging and emissions to be heterogeneous across countries with different income levels. They found that in 1975–2005 the share of the working-age population was positively correlated to carbon emissions in a subset of countries with low income, whereas it was negatively related to emissions in high income countries. Liddle and Lung (2010) focused on 17 developed countries, 1960–2005, and, similar to Fan et al. (2006), found a negative correlation between the population share of the age group between 35 and 64 years and carbon emissions. That is, both studies provide indirect evidence for a positive correlation between the share of senior citizens and carbon emissions.

Similar to these studies, we acknowledge that the correlation between aging and emissions may depend on a country's position in the development process. Given that population aging in developed countries precedes that in developing countries, our analysis focuses on OECD countries. Within this scope, our main contribution to the literature is that we consider not only life-cycle effects but also year-of-birth effects of demographic change and that we find the latter to be important drivers of carbon emissions.[4] In addition, by analyzing data from 26 countries we extend previous work that addressed developed countries with respect to the cross-sectional dimension.

The paper is structured as follows. In Section 2 we review the theory and evidence pertaining to population aging and its relationship to environmental pressure. Section 3 presents the model, the data and the empirical strategy, and Section 4 contains the estimation results. Section 5 concludes.

Table 1
Demographic variables by region.

		1950–1975	1975–2000	2000–2025	2025–2050
OECD North-America	PG	1.70%	1.26%	0.89%	0.44%
	MA	27.00	29.29	34.94	39.88
OECD Europe	PG	0.85%	0.50%	0.27%	−0.03%
	MA	31.29	33.65	40.09	45.06
OECD Asia	PG	1.50%	0.74%	0.13%	−0.28%
	MA	25.14	33.43	42.97	49.99
Non-OECD Europe and Eurasia	PG	1.32%	0.46%	−0.25%	−0.45%
	MA	27.70	31.34	36.50	42.71
Non-OECD Asia	PG	2.38%	2.15%	1.36%	0.69%
	MA	19.15	20.29	26.30	33.73
China	PG	2.08%	1.27%	0.50%	−0.14%
	MA	21.37	24.82	35.29	42.98
India	PG	2.02%	2.16%	1.26%	0.53%
	MA	20.08	21.00	26.58	34.65
Middle East	PG	2.98%	3.16%	1.78%	0.99%
	MA	18.35	18.23	24.83	32.80
Africa	PG	2.50%	2.73%	2.04%	1.47%
	MA	18.20	17.71	19.92	24.44
Central- and South-America	PG	2.58%	1.91%	1.18%	0.51%
	MA	19.65	22.15	28.30	35.68

Note: PG = population growth (percent per year), MA = median age (years). Source: Own Calculations based on United Nations (2007).

2. Background: demographic transition and environmental pressure

2.1. Demographic transition

The concept of demographic transition refers to a progress from a regime of high fertility and high mortality to a regime in which both are low. In the early stages of the transition process, mortality decline is more pronounced than fertility decline, whereas the reverse applies to the later stages (before a hypothesized new equilibrium is attained). This basic pattern implies an increasing rate of population growth in the early stages and a decreasing (possibly negative) one later on. In addition, the changes in mortality and fertility rates imply changes in the age composition. While the population share of young persons rises initially and declines later on, the reverse applies to the share of old persons (see Chesnais, 1992 on stages and patterns of demographic transition). The transition process is typically characterized by an aging of the population, especially in later stages of transition.[5]

[2] Population data are available in steps of five years. That is, our data set includes observations from ten time periods (1960, 1965, …, 2005).

[3] The EKC entails that pollution per capita first increases, then decreases with per capita income, see Stern (2004) and Levinson (2008) for reviews.

[4] Menz and Kühling (forthcoming) addressed year-of birth effects with respect to sulfur dioxide.

[5] The demographic transition model has been referred to as "one of the best-documented generalizations in the social sciences" (Kirk, 1996), but it is subject to controversy whether the model qualifies as a *theory*. As to its two components – mortality decline and fertility decline – the former has been found much easier to explain than the latter: Mortality decline is obviously related to better hygiene, the spread of vaccination, and improved diagnosis and treatment of disease, which together may be viewed as a secular trend. With respect to fertility decline, economic, social, and ideational explanations have been offered. In addition, it has been argued that mortality decline not only precedes fertility decline, but causes it, in the sense that reduced mortality and morbidity and a healthier population are major contributors to a rise in living standards, which are often regarded as a major factor in fertility decline (Kirk, 1996).