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Population Structure and Consumption Growth: Evidence from National Transfer Accounts

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Abstract

We assess the impact of population structure on economic growth. Following recent research, we focus on the generational turnover as a key driver of consumption growth. We characterize the impact of the average birth and death rates on the generational turnover, depending on the age-profile of consumption and on the extent of annuity market imperfection. Using recent data from the National Transfer Accounts on consumption profiles for a number of countries, we assess in a comparative way the sign and magnitude of generational turnover and its impact on consumption growth. We find considerable cross-country variation and trace it back to differences in demographic rates and in the consumption structure.

Keywords

Demography, Economic Growth, Generational Turnover, National Transfer Accounts.

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1 Introduction

In light of the substantial population aging that industrialized countries have been experiencing over the past decades, the question of whether this will hamper economic growth has received considerable attention from academics and the public alike.[1] Most recently, Mierau and Turnovsky (2014a) analyzed the long-run growth effects of population aging by relying on an AK-type model of endogenous growth with a realistic demographic structure. Heijdra and Mierau (2012) and Heijdra et al. (2013) also considered imperfect annuity markets and age-specific labor productivity within such a setting. One central insight from this strand of research is that the growth effect of aging crucially depends on the sign and size of the so called generational turnover effect: At each instant, a fraction of older individuals die and they are replaced by newborns. If older individuals are wealthier and can afford more consumption than young individuals, the ongoing replacement process reduces aggregate savings and therefore the growth of aggregate consumption expenditure. In this case the generational turnover effect is negative and increasing life expectancy — by reducing the turnover of generations — has the potential to lead to higher aggregate savings and faster economic growth.[2] In simulations for the US, Mierau and Turnovsky (2014a,b) find that the turnover effect is indeed negative along a balanced growth path and that increasing life expectancy fosters economic growth. Heijdra and Mierau (2012) obtain a similar result in simulations for the Netherlands.

In our contribution we seek to apply and broaden the framework of this analysis (i) by providing a representation of the generational turnover effect that allows for a straightforward and intuitive assessment of its sign, based on available demographic and consumption data, and (ii) by calculating and assessing the turnover quantitatively for a number of industrialized

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[1] See The Economist (2009) and Bloom et al. (2010) for discussions of the central channels that appear to matter. Furthermore, see Boucekkine et al. (2002) for more realistic demographic structures in growth models.

[2] A related mechanism is also at work within R&D-based endogenous growth models with an overlapping generations structure such as Kuhn and Prettner (2012), Prettner and Trimborn (2012), Prettner (2013), and Banz et al. (2014). Earlier contributions by d'Albis (2007), d'Albis and Augeraud-Véron (2009), and Lau (2009) focus on the impact of demographic structure on capital accumulation, where balanced growth implies, of course, that the (per capita) growth rate of capital equals that of consumption.

countries. Specifically, we find that a negative turnover is more likely the lower the ratio of births to deaths, the higher the ratio of the consumption of the deceased as opposed to the consumption of new cohorts, and the greater the imperfection of the annuity market.

Using detailed data from the National Transfer Accounts (Lee and Mason, 2011, 2014a,b) containing age-specific consumption and earnings profiles of important industrialized countries, we find considerable cross-country variation of the turnover, which we can trace back to the underlying demography and the consumption structure. In particular, economies with young populations and a comparatively flat age profile of consumption such as Chile and Taiwan feature a large positive generational turnover effect, whereas most of the aging European economies with an older population and a steeper age profile of consumption exhibit a strong negative turnover.

We also assess how the generational turnover as determinant of aggregate consumption growth interacts with population growth in determining the growth rate of *per capita* consumption. Overall, the drag on per capita consumption growth is weakest in Taiwan, which tends to benefit from its relatively flat age profile of consumption. On the other end of the spectrum, the growth drag is substantial in Germany due to its relatively old population, and, perhaps surprisingly, it is strongest in the US because of its steep age profile of consumption. Altogether, none of our findings relies on the assumption of balanced growth.

The remainder of the paper is organized as follows. Section 2 contains a theoretical derivation of the generational turnover effect. Section 3 is devoted to the assessment of the sign and the size of the turnover on the basis of data from the National Transfer Accounts, while in Section 4, we summarize and discuss our results.

2 Generational Turnover: Theory

Consider an economy at time t that is populated by cohorts that are distinguishable by their date of birth (t_0) with each cohort consisting of a measure $n(t_0, t)$ of individuals. Following Heijdra and Mierau (2012), these individuals face an age-specific death rate denoted by $\mu(t - t_0)$. Consequently, the population grows at rate $\pi = \beta - \bar{\mu}$, where β is the crude birth rate, and $\bar{\mu} := \int_{t-D}^{t} n\left(t_0, t\right) \mu\left(t_0 - t\right) dt_0$ is average mortality. Assuming that instantaneous utility is logarithmic (see Chetty, 2006, for a justification), an individual's discounted stream of lifetime utility can be written as

$$u = \int_{t_0}^{t_0+D} e^{-\rho(\tau - t_0) - M(\tau - t_0)} \log[c\left(t_0, \tau\right)] d\tau, \tag{1}$$

where D is the maximum age of survival, $\rho > 0$ is the subjective time discount rate, $M(\tau - t_0) = \int_0^{\tau - t_0} \mu(s)\, ds$ is cumulative mortality up to age $\tau - t_0$, and c refers to individual consumption. Following Heijdra and Mierau (2012), individuals save by buying actuarial notes on an imperfect life-insurance market. Consequently, the evolution of individual wealth is given by

$$\dot{k} = [r + \theta\mu(t - t_0)]k + w(t - t_0) - c + s(\theta, t_0, t), \tag{2}$$

where k denotes the individual capital stock, where r refers to the interest rate, where $w(t - t_0)$ is an age-dependent (net) income, where $\theta \in [0, 1]$ measures the degree of annuity market imperfections, and where $s(\theta, t_0, t)$ denotes the redistribution of the profits of insurance companies to individuals aged $t - t_0$ at time t. For the purpose of this paper we can understand $w(t - t_0)$ quite generally as non-capital income, including earnings during the individual's working life and financial transfers (e.g. public pension payments) net of taxes and social security contributions. Note that a perfect annuity market is characterized by $\theta = 1$ such that $s(1, t_0, t) = 0$ for all (t_0, t). By contrast, for an imperfect annuity market $(\theta < 1)$ we have $s(\theta, t_0, t) \neq 0$ for at least some (t_0, t). Utility maximization implies that the optimal consumption path of an individual is characterized by

$$\frac{\dot{c}(t_0, t)}{c(t_0, t)} = r - \rho - (1 - \theta)\mu(t - t_0), \tag{3}$$

which corresponds to the standard Euler equation for the case of complete annuity markets $(\theta = 1)$. By contrast, uninsured mortality within an incomplete annuity market $(\theta < 1)$ implies a downward drag on consumption growth. This is the more realistic case on which we focus our attention from now on: as $\mu(t - t_0)$ becomes large for age $a = t - t_0$ approaching D, it follows that consumption declines towards the end of life.[3]

We can write aggregate consumption as

$$C(t) = N(t) \int_{t-D}^{t} n(t_0, t)\, c(t_0, t)\, dt_0,$$

where $n(t_0, t) = \beta e^{-\pi(t - t_0) - M(t - t_0)}$ is the population share at time t of the cohort born at

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[3] Given that the interest rate exceeds the rate of time preference, this will generate the hump-shaped age-profiles of consumption that are typically observed in the data. See e.g. Hansen and Imrohoroglu (2008) or Heijdra and Mierau (2012).

time t_0, given the survival function $e^{-M(t-t_0)}$. Differentiating with respect to time, we obtain

$$\begin{aligned}\dot{C}(t) &= \pi C(t) + N(t)\left\{\beta c(t,t) + \int_{t-D}^{t}\left[-\left(\pi + \mu(t-t_0)\right) + \frac{\dot{c}(t_0,t)}{c(t_0,t)}\right] n(t_0,t)\, c(t_0,t)\, dt_0\right\} \\ &= (r-\rho)C(t) + N(t)\left[\beta c(t,t) - (2-\theta)\int_{t-D}^{t}\mu(t-t_0)n(t_0,t)c(t_0,t)dt_0\right],\end{aligned}$$

where we used $\dot{N}(t) = \pi N(t)$ and $n(t-D,t) = c(t-D,t) = 0$ by definition of D and the fact that individual consumption approaches zero at the maximum age of survival (see Heijdra and Mierau, 2012). Thus, aggregate consumption increases with population growth and consumption of the newborn cohort, decreases to the extent that the population shares of living cohorts decline both with population growth and due to mortality, and changes in line with individual consumption growth within each cohort. Defining average consumption across the deceased by

$$c^{\dagger}(t) := \frac{1}{\overline{\mu}}\int_{t-D}^{t}\mu(t-t_0)\, c(t_0,t)\, n(t_0,t)\, dt_0$$

and denoting per capita consumption by $c(t) = C(t)/N(t)$, allows us to write the aggregate Euler equation as $\dot{C}(t)/C(t) = r - \rho + \Omega(t)$, where

$$\Omega(t) := -\overline{\mu}\left[(2-\theta)\frac{c^{\dagger}(t)}{c(t)} - \frac{\beta}{\overline{\mu}}\frac{c(t,t)}{c(t)}\right] \tag{4}$$

represents the impact of generational turnover on consumption growth. By inspecting Equation (4), we can state the following.

Proposition 1 *The impact of generational turnover on consumption growth is negative if and only if the ratio between consumption of the deceased and the newborns exceeds the ratio between births and deaths by a sufficient amount, i.e., if and only if* $c^{\dagger}(t)/c(t,t) > (2-\theta)^{-1}\beta/\overline{\mu}$.

This condition is more likely satisfied for economies featuring a relatively steep age profile of consumption up to those ages in which the majority of deaths occur and for populations which exhibit population aging due to low birth rates, β. Note that such populations are typically also characterized by higher average mortality $\overline{\mu}$ because the population is concentrated within older age classes subject to high mortality rates. Finally, note that annuity market imperfections are conducive toward a negative impact of generational turnover.

While the sign of the generational turnover helps us to understand the impact of demography on aggregate consumption growth, typically the interest lies with the development of per capita consumption as expressed by

$$\begin{aligned}\frac{\dot{c}(t)}{c(t)} &= \frac{\dot{C}(t)}{C(t)} - \pi = r - \rho + \Omega(t) - (\beta - \overline{\mu}) \\ &= r - \rho - \overline{\mu}\left[(2-\theta)\frac{c^{\dagger}(t)}{c(t)} - 1\right] - \beta\left[1 - \frac{c(t,t)}{c(t)}\right].\end{aligned}$$

Here, it is straightforward to establish the following result.

Proposition 2 *Both, the average mortality rate and the average birth rate depress the rate of per capita consumption growth if* $c^{\dagger}(t) \geq c(t) \geq c(t,t)$.

Typically, we would expect this condition to be satisfied in economies that exhibit increasing consumption levels up to ages which are subject to relatively high mortality. Here, the negative impact of the birth rate β on growth of per capita consumption mirrors the capital dilution effect of high population growth. Note that this is true even though a high birth rate is conducive to aggregate consumption growth. Conversely, while a high death rate $\overline{\mu}$ dampens population growth, this is not enough to overturn its negative impact on aggregate consumption growth. Overall, this suggests that populations with a high turnover, i.e., with high mortality and high fertility alike, tend to perform worse in terms of per capita consumption growth than populations with a low turnover.[4]

We conclude with the following caveat. For the purpose of this analysis, we keep distinct the role of the aggregate demographic rates β and $\overline{\mu}$, on the one hand, and the consumption structure, as measured by $c(t,t)$, $c(t)$, and $c^{\dagger}(t)$ on the other. This allows us to predict the impact on economic growth based on empirical observations of the demographic rates and the consumption structure, as we will pursue in the following subsection. However, this analysis stops short of taking account of the fact that the demographic rates and the consumption structure are typically co-determined: For instance, the age-profile of mortality rates $\mu(t-t_0)$ determines both the average death rate $\overline{\mu}$ and the consumption structure.

3 What do the Data Say?

In order to assess the impact of demography on aggregate and per capita growth of private consumption, we employ data from the National Transfer Accounts (NTA) on cohort-specific

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[4] This is most clearly seen for the case where $\beta = \overline{\mu}$ and, therefore, $\pi = 0$. We then have $\dot{c}(t)/c(t) = r - \rho - [\overline{\mu}c(t,t)/c(t)]\left[(2-\theta)c^{\dagger}(t)/c(t,t) - 1\right]$, which is unambiguously falling in the rate of turnover, $\overline{\mu}$.

consumption from Lee and Mason (2011, 2014a), which allows us to directly infer the relative cohort sizes $n(t_0, t)$. This in turn enables us to calculate $\bar{\mu}$ as the cohort-weighted average of the age-specific mortality rates as taken from the Human Mortality Database (2014). We then calculate the relative cohort size of the "newborns", $n(t, t)$, by averaging population shares over the age-groups 0-20.[5] Next, we use the relative cohort sizes, data on age-specific consumption, and the age-specific death rates to calculate the average consumption of the deceased, $c^{\dagger}$.[6] Finally, we calculate the factor $\beta/\bar{\mu} \approx n(t, t)/\bar{\mu}$. Based on this we calculate the turnover $\Omega(t)$ for different values of θ, as presented in Table 1. Note that $\theta = 1$ refers to perfect annuity markets, while $\theta = 0$ refers to the case of a missing market. The empirically most relevant case is $\theta = 0.75$ (see Friedman and Warshawsky, 1990; Mitchell et al., 1999).

Table 1: Results from NTA data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8a)	(8b)	(8c)	(9)
									$\Omega(t)$		growth drag
Country	$n(t,t)$	$\bar{\mu}$	$\frac{n(t,t)}{\bar{\mu}}$	$c(t)$	$\frac{c(t,t)}{c(t)}$	$\frac{c^{\dagger}}{c(t)}$	$\frac{c^{\dagger}}{c(t,t)}$	$\theta = 0$	$\theta = 0.75$	$\theta = 1$	$\theta = 0.75$
Austria	0.0122	0.0099	1.2275	0.3911	0.6163	0.9654	1.5663	-0.0117	-0.0045	-0.0021	-0.0067
Chile	0.0192	0.0064	3.0208	0.6668	0.7915	1.1320	1.4302	0.0008	0.0062	0.0080	-0.0066
Finland	0.0124	0.0096	1.2952	0.3946	0.5969	1.0489	1.7572	-0.0127	-0.0052	-0.0026	-0.0080
Germany	0.0108	0.0111	0.9725	0.4481	0.5833	1.0701	1.8347	-0.0175	-0.0086	-0.0056	-0.0083
Japan	0.0102	0.0086	1.1835	0.5036	0.6467	1.0771	1.6655	-0.0119	-0.0050	-0.0027	-0.0066
Slovenia	0.0111	0.0095	1.1665	0.3498	0.7133	0.9619	1.3485	-0.0104	-0.0035	-0.0012	-0.0051
Spain	0.0114	0.0091	1.2540	0.4304	0.6974	0.9436	1.3530	-0.0092	-0.0028	-0.0006	-0.0051
Sweden	0.0126	0.0110	1.1435	0.3236	0.5953	0.9649	1.6208	-0.0137	-0.0058	-0.0031	-0.0073
Taiwan	0.0164	0.0059	2.7746	0.4844	0.8842	0.9718	1.0991	0.0030	0.0073	0.0088	-0.0032
US	0.0147	0.0090	1.6271	0.4974	0.5743	1.2423	2.1633	-0.0140	-0.0056	-0.0028	-0.0112

We immediately see that for most countries, the turnover effect is negative regardless of the perfection of the annuity market [see columns (8a)-(8c)]. The notable exceptions are Chile and Taiwan both of which feature a positive turnover for all configurations of the annuity market. For these two economies, the positive turnover is driven by a high birth/mortality ratio, $n(t, t)/\bar{\mu}$ [see column (3)], implying that these populations, and with them the aggregate economy, are growing at considerable rates. For Taiwan this effect goes almost unchecked because the consumption level of entering cohorts is almost as high as that

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[5] By explicitly considering the cohorts 0-20 we deviate from the numerical calibrations of most OLG models, which typically ignore these cohorts (see e.g. Heijdra and Mierau, 2012; Heijdra et al., 2013). This is because in these models individuals are (reasonably) assumed not to actively take life-cycle decisions before entering adolescence. For the purpose of assessing the generational turnover, however, we deem it important to include all cohorts from birth onwards, as consumption of the age groups 0-20 clearly has a non-negligible impact on the level and dynamics of aggregate consumption. For the sake of the argument, we may assume here that altruistic parents are allocating consumption to their children in a way that is reflecting the optimal life-cycle allocation. In order to mitigate possible errors in the estimation of the consumption level of children, we consider the weighted average over the age-groups 0-20.

[6] Note that in the NTA data private consumption is normalized by the average labor income across the ages 30-49.

of the deceased. This is in contrast to most other countries, where the consumption ratio $c^{\dagger}(t)/c(t,t)$ is typically well in excess of one [see column (7)].

Some pair-wise comparisons across countries provide further insights as to the determinants: Chile and Spain, for instance, exhibit similar consumption ratios $c^{\dagger}(t)/c(t,t)$. Nevertheless, Chile experiences a positive turnover, whereas Spain experiences a negative one, this being due to the much higher birth/mortality ratio, $n(t,t)/\bar{\mu}$, in Chile. When comparing the US and Slovenia, the former feature a substantially larger birth/mortality ratio. While this would suggest that the US exhibit a negative turnover that is smaller in absolute terms, in fact, the converse is true. The underlying reason is that the US feature a rather steep consumption profile that leads to a high ratio, $c^{\dagger}(t)/c(t,t)$, and, therefore, to a negative turnover that is more pronounced.

As we do not have country-specific data on the performance of the annuity market, it is difficult to gauge the "true" level of turnover. What our calculations illustrate is that the nature of the annuity market has a strong influence [see across columns (8a)-(8c)]. For the US, for instance, the generational turnover increases by a factor of five (from -0.28 percentage points to -1.14 percentage points) when moving from a perfect to a missing annuity market.

We conclude by observing that for most countries the generational turnover exerts a non-negligible impact on consumption growth: For the empirically plausible specification $\theta = 0.75$, we obtain that aggregate consumption growth is reduced by more than half of a percentage point for Finland, Germany, Sweden, and the US and increased by more than half of a percentage point for Chile and Taiwan [see column (8b)]. Indeed, the generational turnover has the strongest negative value in Germany (-0.86 percentage points), reflecting both a strongly aging economy and a relatively steep consumption profile, and the strongest positive value in Taiwan (0.73 percentage points), reflecting a young economy with a relatively flat consumption profile.[7]

The consumption structure in all countries is such that the private consumption level of the entering cohorts falls short of the average [see the ratios in column (5)], implying that per capita consumption growth is unambiguously depressed by high birth rates. A more ambivalent picture emerges with regard to the consumption of the deceased in relation to the average [see the ratios in column (6)]. Here, the ratio is in excess of one for Chile, Finland, Germany, Japan, and the US, implying that in these countries, the growth of per capita consumption is unambiguously depressed by high death rates. For Austria, Slovenia, Spain, Sweden, and Taiwan, the ratio $c^{\dagger}(t)/c(t)$ is below one, implying that an increase in

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[7] The prominence of population aging in Germany is captured fact that the ratio $n(t,t)/\bar{\mu}$ lies below one, implying an excess of deaths over births.

death rates would foster per capita consumption growth provided that the annuity market is sufficiently perfect. Indeed, it would always do so for $\theta = 1$.

Overall, the drag on per capita consumption growth for our benchmark case $\theta = 0.75$ [see column (9)] is weakest in Taiwan (-0.32 percentage points), which tends to benefit from its relatively flat consumption profile. As expected, the growth drag in relation to the old population in Germany is substantial (-0.83 percentage points); but surprisingly perhaps, it is strongest in the US with -1.12 percentage points. The reason is, once again, the steep consumption profile which amplifies the growth penalty on both, births and deaths alike. Finally, it is instructive to compare Chile and Japan. The two countries experience the same growth drag of -0.66 percentage points, although for very different reasons: For Chile the growth drag is due to a strong growth penalty from population growth, $n\left(t,t\right)-\bar{\mu}$, overturning with -1.28 percentage points the growth stimulus from a positive generational turnover. For Japan, in contrast, population growth has little additional impact with -0.16 percentage points. Here, the growth drag is, indeed, predominantly driven by the negative generational turnover.

4 Conclusions

We derived a simple representation of the generational turnover as key influencing source of aggregate consumption growth. Relying on data from Lee and Mason (2011, 2014a) and the Human Mortality Database (2014), we showed that countries vary largely in respect to the magnitude and in some cases the sign of the turnover: Economies with young populations such as Chile and Taiwan feature large positive generational turnover, whereas most of the aging European economies exhibit a strong negative turnover. Notably even the US feature a negative turnover despite their more favorable demography. This is because of a comparatively steep age profile of consumption. While countries differ in regard to the sign of the generational turnover and, thus, in the impact of demographic rates on aggregate consumption growth, all of them are subject to a demographic penalty in terms of per capita consumption growth. This notwithstanding, there is considerable variation in this growth penalty, which increases by a factor of 3.5 when turning from Taiwan, the country with the flattest age-profile of consumption, to the US, the country with the strongest.

We conclude with a number of observations. First, our findings in regard to the sign and magnitude of the generational turnover are not relying in any way on a balanced growth assumption. This makes them general in as far as they have been derived for real-world economies which may or may not follow a balanced growth path. Against this backdrop, the positive turnover we identified for Chile and Taiwan does not stand in contradiction to the theoretical finding by Mierau and Turnovsky (2014a,b) that in equilibrium the generational turnover should be negative. At the same time, their finding is supported for all of the countries with relatively weak population growth, where the turnover is, indeed, negative.

Second, while our findings accurately represent the impact on consumption growth of fertility and mortality, which are the processes typically depicted in the literature on generational turnover, additional impacts arise in the presence of migration. Here, the forces are similar in the sense that the average consumption level of immigrants is offset by the average consumption level of emigrants. Lack of detailed data on the consumption profiles of migrants, however, forces us to defer a more detailed analysis of this aspect to future research.

Third, by focusing on private consumption we are entirely in line with both the theoretical (e.g. Hansen and Imrohoroglu, 2008; Heijdra and Mierau, 2012; Mierau and Turnovsky, 2014a,b) and empirical (as surveyed e.g. in Fernandez-Villaverde and Krueger, 2007; Attanasio and Weber, 2010) literature on life-cycle consumption. However, as evidenced in Tung (2011) on the basis of NTA data, a substantial share of overall consumption can be attributed to "public consumption" on behalf of the individuals. This is true, in particular for the youngest (education) and oldest (health) age-groups. It is not clear a priori what forms of public consumption should count toward the aggregate Euler equation; neither is it clear what mechanics are driving the public components of consumption. To gauge the extent to which the inclusion of public consumption would change our findings, we have provided analogous calculations to those presented in Table 1 based on NTA data on total private and public consumption (Lee and Mason, 2014a). These calculations, which are available on request, reveal that, despite some quantitative differences, the overall level and sign of the generational turnover and growth drag are of similar magnitude and sign across the countries under consideration.[8] Thus, we are reasonably confident that our findings are robust to the precise specification of consumption.

Finally, our cross-country comparison is helpful in identifying macroeconomic relationships between demographic rates, consumption structure, and consumption growth. These relationships are the outcome of life-cycle choices and should ultimately be traced back to preferences and the various constraints. Nonetheless, given the scarce knowledge and data on the generational turnover and its relationship to consumption growth to date, a first un-

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[8] Considering the benchmark case, $\theta = 0.75$, we find, e.g. for Germany a generational turnover of -0.73 percentage points and a growth drag of -0.8 percentage points; for Taiwan a generational turnover of 0.9 percentage points and a growth drag of -0.17 percentage points; and for the US a generational turnover of -0.45 percentage points and a growth drag of -0.98 percentage points.

derstanding of the accounting mechanics behind the generational turnover provides crucial information on the macroeconomic consequences of life-cycle decision-making and should prove a useful guide to future research.

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