Age Groups and the Measure of Population Aging*

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Abstract

This paper proposes the use of optimal grouping methods for determining the various age groups within a population. The cutoff ages for these groups, such as the age from which an individual is considered to be an older person, are then endogenous variables that depend on the entire population age distribution at any given moment. This method is first applied to the age distribution of the United States and subsequently to a group of 12 industrialized countries. The cutoff ages as well as the main indicators of aging are calculated.
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J.E.L Class: J0, J11.

Introduction

Population aging is often perceived as a very widespread phenomenon. According to the last United Nations ”Population Ageing Report” (2009), the proportion of the global population aged over 60 years was 8% in 1950, 10% in 2000, and is expected to reach 21% in 2050. In this report, the United Nations have used a very specific, albeit very common, type of measurement for assessing the population aging phenomenon. And yet, it is evident that today’s 60-year-olds are often very different from their parents at the same age and have absolutely nothing in common with their grandparents at the same age. The age at which one becomes an older person is a notion that changes over time; thus, calculating the proportion of older persons based on a fixed age only provides us with biased information. The use of such an indicator is often justified on the ground that these fixed ages (60, 65 or 80, depending on the study) correspond to the eligibility ages of certain social programs, most notably the pay–as–you–go pension system. However, recent events, for example in Europe, show that these ages also undergo changes. Indicators, though simple, are not neutral. While studying the history of social representation that defines old age as starting from 60 years, Bourdelais (1994, 1999) showed that indicators of aging based on fixed ages contributed to a dramatic portrayal of demographic evolutions, some of which were associated with the myth of decline. The aim of our paper is to propose a new means of determining the various age groups in a population and to recalculate new indicators of aging based on the cutoff ages of these groups.

The main difficulty in characterizing the size of older populations lies in the determination of the age at which an individual becomes an older person. We propose to use all the statistical information contained in the population age distribution to define this age. We proceed in the following manner: we predefine a certain number of age groups, then “optimally” divide individuals among these different groups. The optimal grouping rule, which was proposed by Aghevli and Mehran (1981), consists in selecting cutoff ages for groups such that age differences are a minimum within each group and a maximum between groups. The resulting age group–based representation is then optimal as it gives the best portrayal of the initial distribution. Information loss arising from the grouping of data is therefore minimal. Our concept of the stages of life is a relative one: the "age" of individuals within a given cohort depends on the size of the other cohorts. If there are still many older cohorts, it is unlikely for the cohort in question to be considered as belonging to the oldest group. Quite intuitively, an individual is considered to be an older person if his or her age is close to the mean age of the group of older persons. The ages that bound the groups then allow us to calculate various indicators of aging.

Our work is part of continuing efforts in the latest research on the demographics of aging. Two distinct bodies of work have led to the proposal of indicators of aging that are not based on the constancy of the age at which one becomes an older person. The first of these is founded on a simple idea, initially developed by Ryder (1975), that defines an individual's age not according to the number of years lived since birth, but according to the remaining number of years that he or she is expected to live. Thus, Ryder proposes considering an individual as an older person when his or her life expectancy is less than ten years. This type of characterization, which may be used to define the proportion of older persons in a population, constitutes a major advancement as it enables the distinction between individual and population aging. This idea has been pursued by Sanderson and Scherbov (2005), who establish the mean age of an age pyramid that is recalculated based on the life expectancy at each age. However, such approaches have two drawbacks. First, at a given date, an individual's life expectancy is unknown and its estimation using a period life table is imperfect (Goldstein and Wachter, 2006). To overcome this problem, Shoven (2010) proposes determining the beginning of old age by comparing the morbidity rate at each age at a given threshold. The second disadvantage of Ryder's indicator is that it is modified through simple proportional rescaling. This can be understood with the help of an example. Let us consider two stationary populations made up of individuals whose survival curve is rectangular; the age structure of these populations is therefore rectangular. Let us assume that the only difference between the two populations lies in the maximum age at death. Using the indicator based on over–60s, one would conclude that the youngest population is that whose life expectancy is the lowest. On the contrary, using Ryder's criterion would lead to the youngest population being that whose life expectancy is the greatest. Using our criterion, one would conclude that both populations have the same proportion of older persons. In summary, our criterion takes into account the phenomenon of individual aging and also has the advantage of being invariant with respect to simple proportional rescaling. Some other investigations have proposed other interesting indicators of aging, but these can only be applied to specific distributions. Coulson (1968) and Kii (1982) define an indicator based on the slope of a linear regression of the fraction of a population at each age with a constant term and age variables. An upward–sloping relationship then indicates an aging population. However, this indicator only provides information on the first-order effects of a change in the age distribution of a population, and is only accurate when the pyramid is monotonic. Chu (1997) develops a new aging index, but this requires that changes in the cumulative distribution of ages satisfy a first-order stochastic dominance property.

In this paper, we apply optimal grouping techniques to the age distributions of a population. These techniques were initially used by Aghevli and Mehran (1981) and Davies and Shorrocks (1989) for income distribution issues, and applied by Esteban et al. (2007) to polarization measurements. We demonstrate in a formalized manner how to apply these techniques to age distributions in order to calculate indicators of aging and prove that the latter are invariant with respect to proportional rescaling of distributions. These calculations are no more complicated than those proposed in the contributions mentioned earlier. Most notably, in the extreme case where only two age groups are considered, our indicator of aging becomes the proportion of individuals whose age is greater than the mean age. Applying this technique to total US population we find that the age at which one becomes an older person has dramatically increased over the last century. In our benchmark experiment involving 4 age groups, we find that the entry age into oldness was 48.7 years in 1930 and skyrocketed to 57.6 years in 2004. Most industrialized countries exhibit the same behavior of the entry age into oldness. We then find that the share of the so–defined elderly in total population remained stable over time and does not display a pronounced upward sloping trend. This remains even considering a long period of time. For instance, Swedish data are documented from 1751 to 2004 and exhibit the same pattern. In our benchmark experiment, the share of elderly persons in total population remained stable around 20.3%. We then compute the elder–child ratio and find that its time average increased over the last 50 years by less than 6.5% in the US, and by less than 8% on average in our full sample of countries. These findings then suggest that aging is less pronounced when a measure that takes evolutions in the age distribution into account is used.

The remainder of the paper is organized as follows. Section 1 describes our approach to defining endogenous age groups and defines our aging indicators. Section 2 revisits aging in the US in light of our new indicators. Section 3 extends the analysis to an international setting. A last section offers some concluding remarks.

1 Endogenous ages groups and the measurement of population aging

This section is devoted to the methodology to define endogenous age groups, from which we will derive population aging indicators.

The problem of defining age groups amounts to approximating the age distribution of population by a histogram that comprises a restricted number of age groups, that all gather individuals of different ages within a uniform group. There are two issues with such a process. The first one is to choose a number of groups. We will adopt a pragmatic approach to tackle this problem (see Section 2). A second issue regards setting the boundaries of each group. There is general agreement that there does not exist a unique definition of an age group. In particular, the boundaries of each group ought to be subjective. Several criteria can be used to gauge alternative definitions of age groups. Our approach is to define a grouping of individuals that preserves the characteristics of the age pyramid.In other words age groups will be defined in such a way that we minimize the loss of information that occurs when building a histogram of the age pyramid using a given number of age groups. Aghevli and Mehran (1981) have developed a grouping technique that precisely addresses this issue in the context of income distribution. We now describe the method in the context of our age grouping problem. The optimal grouping then amount to defining age groups that minimize the average difference of age pairs within each group. As shown by below, the measure of the dispersion will be the Gini coefficient.

Let us denote by f the density of an age distribution on support $[0,\omega]$, such that $\int_0^\omega f(x)\,\mathrm{d}x = 1$. Also let α denote the mean age of the population $\left(\alpha = \int_0^\omega x f(x)\,\mathrm{d}x\right)$. The Gini's absolute pairwise differences of f, $G(f)$ then writes:

$$G(f) = \frac{1}{\alpha}\int_0^\omega \int_0^\omega |x-z|\, f(x)\, f(z)\,\mathrm{d}x\mathrm{d}z.$$

Following Aghevli and Mehran (1981), for any integer $n \geq 2$, it is possible to obtain an $n-$cutoff representation of f. This amounts to defining a finite collection of real numbers $\mathbf{x} = \{x_0, x_1, ..., x_n\}$ such that $0 = x_0 < ... < x_n = \omega$, which induces a partition of the support of f into n non–overlapping intervals. For all $i = 1, ...n$, we set

$$y_i = \int_{x_{i-1}}^{x_i} f(x)\,\mathrm{d}x, \text{ and } \alpha_i = \int_{x_{i-1}}^{x_i} x f(x)\,\mathrm{d}x.$$

For any $n-$cutoff representation of f, the associated Gini coefficient, denoted $G(f,\mathbf{x})$, is written:

$$G(f,\mathbf{x}) = \frac{1}{2\alpha}\sum_i \sum_j \left|\frac{\alpha_i}{y_i} - \frac{\alpha_j}{y_j}\right| y_i y_j.$$

Aghevli and Mehran then suggest to choose $\mathbf{x}$ that minimizes the approximation error $\varepsilon(f,\mathbf{x})$ as defined by the difference between the two Gini coefficients:

$$\varepsilon(f,\mathbf{x}) \equiv G(f) - G(f,\mathbf{x})$$

Hence, $G(f,x)$ represents a "between group" Gini, while $G(f)-G(f,x)$ is the corresponding within–group component. The latter can be rewritten as

$$\varepsilon\left(f,\mathbf{x}\right)=\frac{1}{2\alpha}\sum_{i=1}^{n}\int_{x_{i-1}}^{x_i}\int_{x_{i-1}}^{x_i}\left|s-z\right|f\left(s\right)f\left(z\right)\mathrm{d}s\mathrm{d}z.$$

Aghevli and Mehran show that the optimal collection, $\mathbf{x}^{\star}$, satisfies

$$x_i^{\star}=\frac{\int_{x_{i-1}^{\star}}^{x_{i+1}^{\star}}xf\left(x\right)\mathrm{d}x}{\int_{x_{i-1}^{\star}}^{x_{i+1}^{\star}}f\left(x\right)\mathrm{d}x}$$

When $n=2$, the optimal cutoff age is simply given by the mean age of the population, α. As $n\to\infty$, the the cutoff is given by the level of the variable itself, $x^{\star}=x$.

This procedure leads to a clear endogenous definition of an elderly individual: One classifies as elderly any individual whose age is closer to the average age of the elderly group than to the average of any other group. A direct implication of this grouping is that the definition of old age fundamentally relies on the relative position of each cohort in total population and thus depends on the entire shape of the age distribution.

Once we obtain the optimal partition of the distribution, it is possible to define simple aging indicators. In particular, we will consider two standard indicators. The first reports the share of the oldest group in the total population:

$$\int_{x_{n-1}^{\star}}^{\omega}f\left(x\right)\mathrm{d}x.$$

The second is the so–called "elder-child ratio", which is computed as the ratio of the share of oldest group over the share of the youngest group:

$$\frac{\int_{x_{n-1}^{\star}}^{\omega}f\left(x\right)\mathrm{d}x}{\int_{0}^{x_1^{\star}}f\left(x\right)\mathrm{d}x}.$$

Our indicators have the nice property of being invariant to any proportional rescaling of the age distribution accompanying an increase in life expectancy. As defined by Lee and Goldstein (2003), proportional rescaling would appear indistinguishable from the effect of a simple change in the units of measurement of age/time. A population whose age distribution has been proportionally rescaled should of course not be considered as older. Consider the density of age distribution f on support $[0, \omega]$ with cumulative distribution function $F(a) = \int_0^a f(x)\, dx$. A distribution h on support $[0, \omega']$ where $\omega' > \omega$ is a proportional rescaling of f if:

$$H\left(a\frac{\omega'}{\omega}\right) = F(a) \text{ for all } a \in [0, \omega], \tag{1}$$

where H is the cumulative distribution function of h. Using an aging index with a fixed cutoff a_0 would misleadingly indicate a aging of the population as $H(a_0) < F(a_0)$ for all $a_0 \in [0, \omega]$. Using Ryder's (1975) index would also yield an unpleasant result. Let a_f and a_h be respectively the age at which an individual has a given life expectancy, e. g. 10 years, in distribution f and h respectively. a_f and a_h define the cutoff ages of entry in old age and since generically $a_f\omega \neq a_h\omega'$, the Ryder index would assimilate the proportional rescaling as either a population aging or a rejuvenation. Let us now turn to our indicators built using the optimal cutoffs defined as follows:

$$x_{i,f} = \frac{\int_{x_{i-1,f}}^{x_{i+1,f}} xf(x)\, dx}{\int_{x_{i-1,f}}^{x_{i+1,f}} f(x)\, dx} \text{ and } x_{i,h} = \frac{\int_{x_{i-1,h}}^{x_{i+1,h}} xh(x)\, dx}{\int_{x_{i-1,h}}^{x_{i+1,h}} h(x)\, dx}, \tag{2}$$

where the $\star$'s are eliminated to simplify notation. Simple computations yield

$$\frac{\omega}{\omega'}x_{i,h} = \frac{\int_{\frac{\omega}{\omega'}x_{i-1,h}}^{\frac{\omega}{\omega'}x_{i+1,h}} xf(x)\, dx}{\int_{\frac{\omega}{\omega'}x_{i-1,h}}^{\frac{\omega}{\omega'}x_{i+1,h}} f(x)\, dx}, \tag{3}$$

which implies that $x_{i,h} = x_{i,f}\omega'/\omega$. Consequently, the share of the oldest group in the total population is left unaffected by a proportional rescaling:

$$\int_{x_{n-1,f}}^{\omega} f(x)\, dx = \int_{x_{n-1,h}}^{\omega'} h(x)\, dx.$$

2 Aging in the US: A Reappraisal

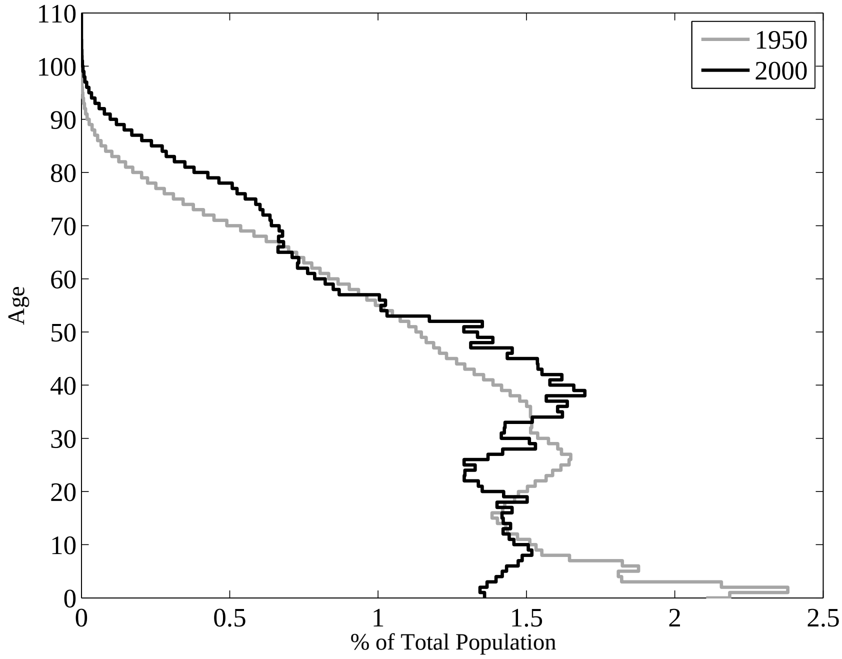
In this section, we revisit aging in the US using data for the age structure of population. The data are obtained from the Human Mortality Database (HMD hereafter)[1] and document the size of the US population at each age between birth and age 110 for the year 1933 through 2005 .

A first and straightforward way of assessing aging within a population is to have a look at the age pyramid. In Figure 1, we depict the share of population of each age group in total US population in 1950 and 2000. The graph suggests that major changes took place in the last 50 years of the twentieth century. First and foremost, the upper tail of the distribution —that associated with the oldest individuals — has widened quite substantially. This is witnessed in the increase in the share of population above 60. For instance, this share rose from 12.13% in 1950 to 16.31% in 2000 — a nearly 35% increase. Over the same period, a second important phenomenon took place in the lower tail — that associated with the youngest individuals. The base of the pyramid narrowed drastically. The share of individuals below 15 decreased by 19% over this period (28.14% in 1950, 22.22% in 2000). Otherwise stated, the two indicators traditionally used to assess aging —elder–child ratio and the share of people above 60— increased.

The main information that Figure 1 provides is that the age distribution of US population changed dramatically over the period. However, the relative position of an individual of a given age within the distribution of ages may have also changed. Otherwise stated, being 60 in 2000 may be totally different from being 60 in 1950. An extra normalization is needed. This is provided by the examination of the Lorenz curve, as shown in Figure 2. The figure shows the graph of the cumulative distribution of the total years lived by US population against the cumulative distribution of total US population for 1950 and 2000. Strikingly, there is not much discrepancy between two Lorenz curves, although the 2000 distribution is closer to the uniform distribution, which would be characteristic of

[1] Data are available from `http://www.mortality.org/`.

Figure 1: Age Pyramids



a stationary population composed of individuals with rectangular survival curve. This reshaping of the age pyramid clearly appeared in Figure 1 and can be quantified by the computation of the Gini coefficient. It was 0.42 in 1950, it went down to 0.36 in 2000.

As discussed in section 1, these Lorenz curves can be used to compute age groups that minimize loss of information arising in grouping. We choose to divide the population age distribution into 4 groups. This choice is made for pragmatic reasons and comparative purposes. It indeed leads to cutoff ages for the youngest and oldest groups of about 15 and 60 in the end of the 1990s in the international comparison we will carry out in the next section. We will however assess the robustness of our results to the number of groups. Figure 3 shows the optimal grouping of age distributions in 1950 and 2000. The shaded areas correspond to the histograms that approximate age pyramid minimizing the loss of information.

Figure 4 reports the evolution of the entry age into the oldest group (left panel) and the share of that group (right panel) within total US population. A first result that

Figure 2: Lorenz Curve

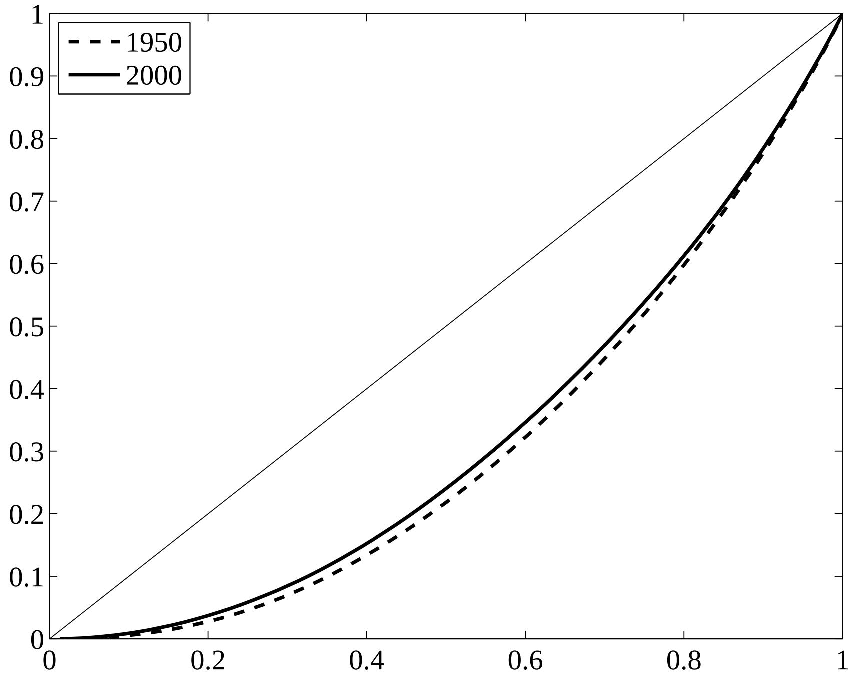
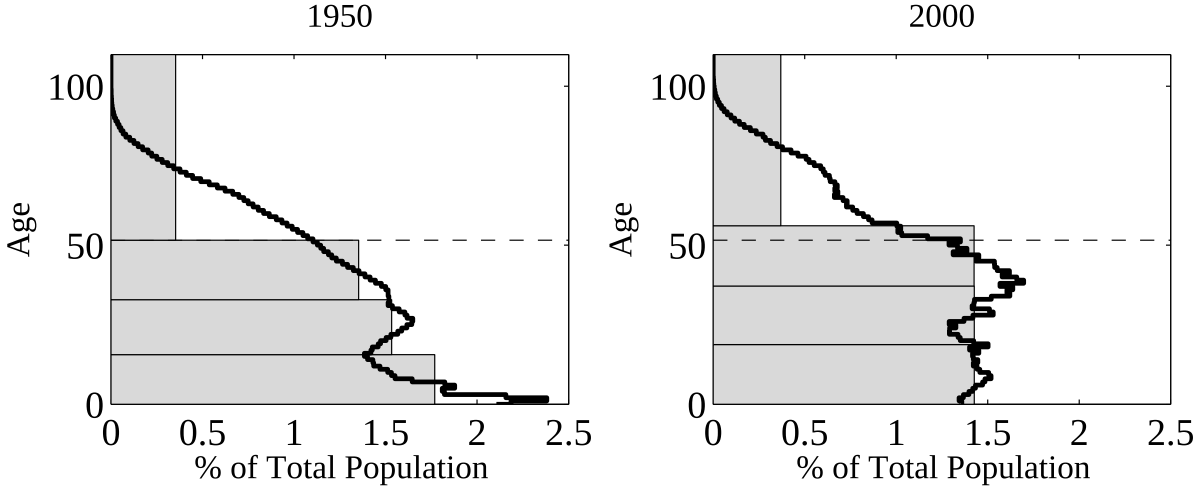
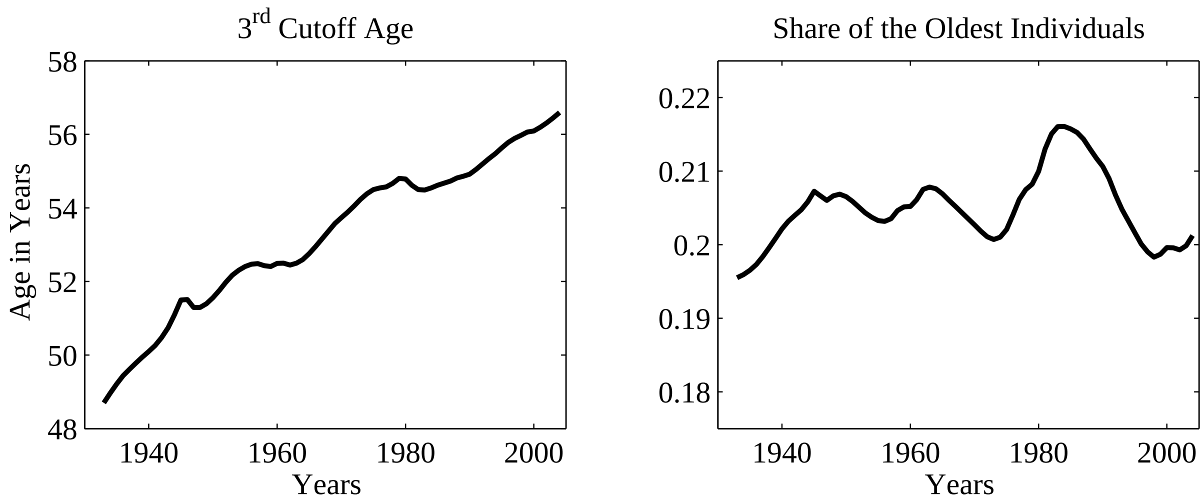


Figure 3: Optimal Grouping



emerges from the left panel is that the entry age in the oldest group has increased over the whole sample. For instance in 1933 the cutoff age was 48.7 while it raised to 56.6 at the end of the sample — a 16.22% increase. In order to make sense of this result, let us consider an individual of age 55. In 1933, this individual would have been classified as belonging to the group of the oldest. This is no longer the case in the current US society. Otherwise stated, at age 55, a US individual is younger in 2005 than in 1933. At first glance, this phenomenon can be attributed to individual aging, as captured, for example, by life expectancy. For instance, life expectancy at age 55 was 19.2 years in 1933. It was 26.7 years in 2005. This idea of a time varying old age is already present in Ryder (1975) and subsequent literature. However, as mentioned above, the optimal grouping approach makes use of the entire distribution, which implies that this increase in the cutoff age does not solely reflect changes at the individual level but any change in the shape of the distribution. Once we allow for the time varying cutoff age, the share of the oldest group in total US population can be computed. This share can be seen as an alternative measure of aging that corrects for a time varying entry age into the oldest group. Its evolution is reported in the right panel of Figure 4. It appears that the share

Figure 4: Share of Elderly

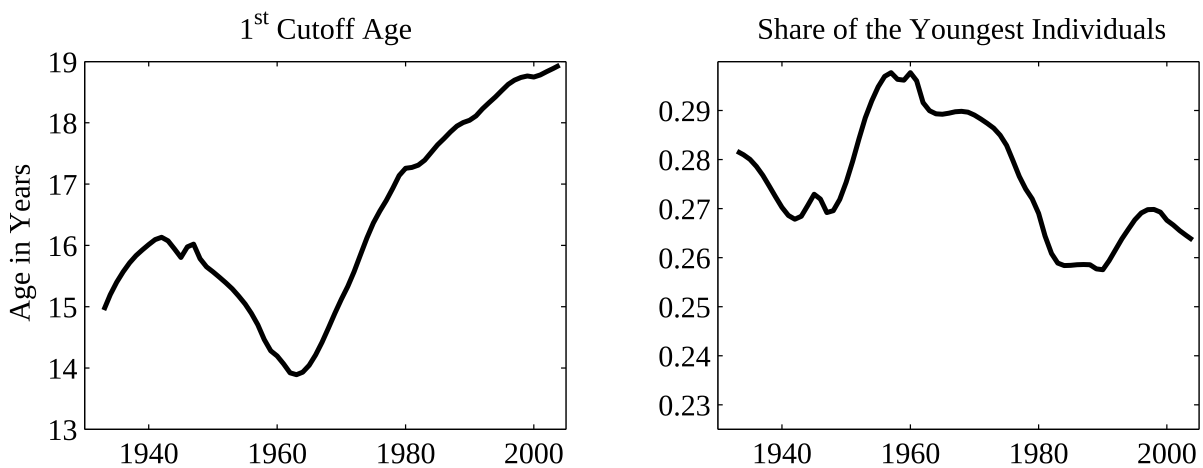


of the oldest group has exhibited variations over time around an average value of 20.48%.

These movements are quite significant as reflected by a standard deviation of about 0.5 points. More importantly, there is no trend in the evolution of this ratio over the last 50 years.[2] According to this indicator, the US has not aged. In other words, the US simply experienced an upward translation in the age pyramid for the oldest ages over the last 50 years (see Figure 1) that has been compensated by an increase in the age when an individual becomes old. This is also reflected in the upper part of the Lorenz curves that remained unchanged.

It is however important to note that most of the changes in the US age pyramid took place in the young ages (See Figure 1). The significant narrowing in the bottom of the pyramid suggests that the ratio of old to young individuals ought to have increased markedly over the last 50 years. This fact is usually interpreted as aging. We now investigate this issue. Figure 5 reports the evolution of the age at which an individual exits the group of the youngest (left panel), and the share of that group in total US population (right panel). Over the entire sample, the cutoff age has increased by 27%

Figure 5: Share of the Young



(15 in 1933, 19 in 2004). This increase can also be attributed to the evolution of life

[2] A Student test on the rate of growth yields to reject significance at the 95% confidence level.

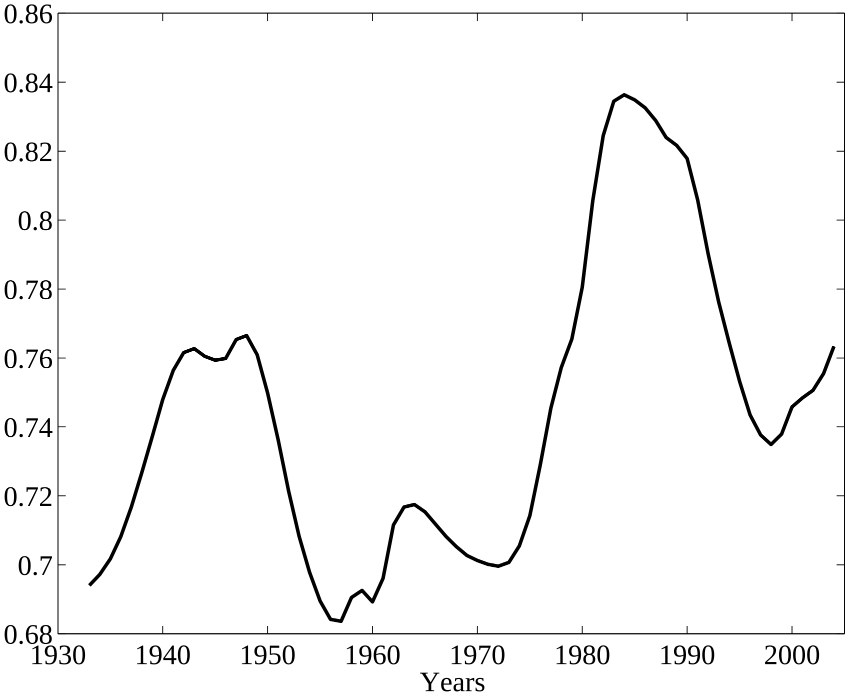
expectancy: in a society where life is longer on average, so is youth. It however displays swings in its evolution, which can be related to the post WWII baby–boom. With our measure, the first and direct effect of a baby–boom is to reduce the average age of the youngest group. Consequently, the oldest former members of this group will be excluded and reassigned to the next group. Hence, the cutoff age will decrease. This is exactly what we observe until the early sixties. As baby boomers grow older, there is an upward pressure on the average age of the youngest group and the direct effect of the increase in the life expectancy comes into play. When baby boomers start to have children, there is an echo effect that dampens the increase in the cutoff age. This can be seen in the deceleration in the evolution of that age which took place in the late seventies. This evolution translated to that of the share of the youngest group in total US population. Just like the evolution of the share of the oldest group, the share of young individuals does not display any significant trend. It however exhibits large fluctuations around its mean (27.6%) with a standard deviation of 1.22 points. The share of the young population increased during the baby–boom, despite the diminishing cutoff age.

We are now in a position to compute the elder–child ratio, which, in our case, is computed as the ratio of the size of the group of the oldest to that of the youngest individuals. This ratio is shown in Figure 6. Interestingly, this ratio varies a lot over the sample. In particular, between the late fifties and the mid seventies, the ratio decreased significantly, reflecting a nontrivial rejuvenation of the US population which is in line with some common wisdom. However, over the last 50 years, the ratio exhibits a significant upward sloping trend. But, the average growth rate remains small and reaches 0.13% per year. In other words aging is less pronounced than usually claimed.

We now assess the robustness of our results to the choice of the number of groups. We consider 4 alternative values for the number of groups, n, ranging from 3 to 6.[3] Figure

[3]We will not consider the case $n = 2$, as the elder–child ratio does not correspond to a dependency ratio.

Figure 6: Elder–Child Ratio



7 reports the evolution of the share of the oldest group (top–right panel), the share of the youngest group (top–left panel) and the elder–child ratio (lower panel). As should be expected, the level of the shares crucially depends on the number of groups: the larger the number of groups, the lower the share. However, the overall evolution of the shares is very similar. In particular, the evolution of the share of the oldest group indicates that, no matter the number of groups, aging is very limited. The elder–child ratio must allow us to assess the robustness of our approach, as it should be level invariant. As seen from the lower panel of Figure 7, the elder–child ratio lies within the same range of values for all values of n. It is also striking that, as reported in Table 1, the ratios, as computed with different numbers of groups, are highly positively correlated. This indicates that the properties of the aging indicator, as derived from optimal grouping, is rather robust to the choice of the number of groups.

Figure 7: Robustness to the number of groups

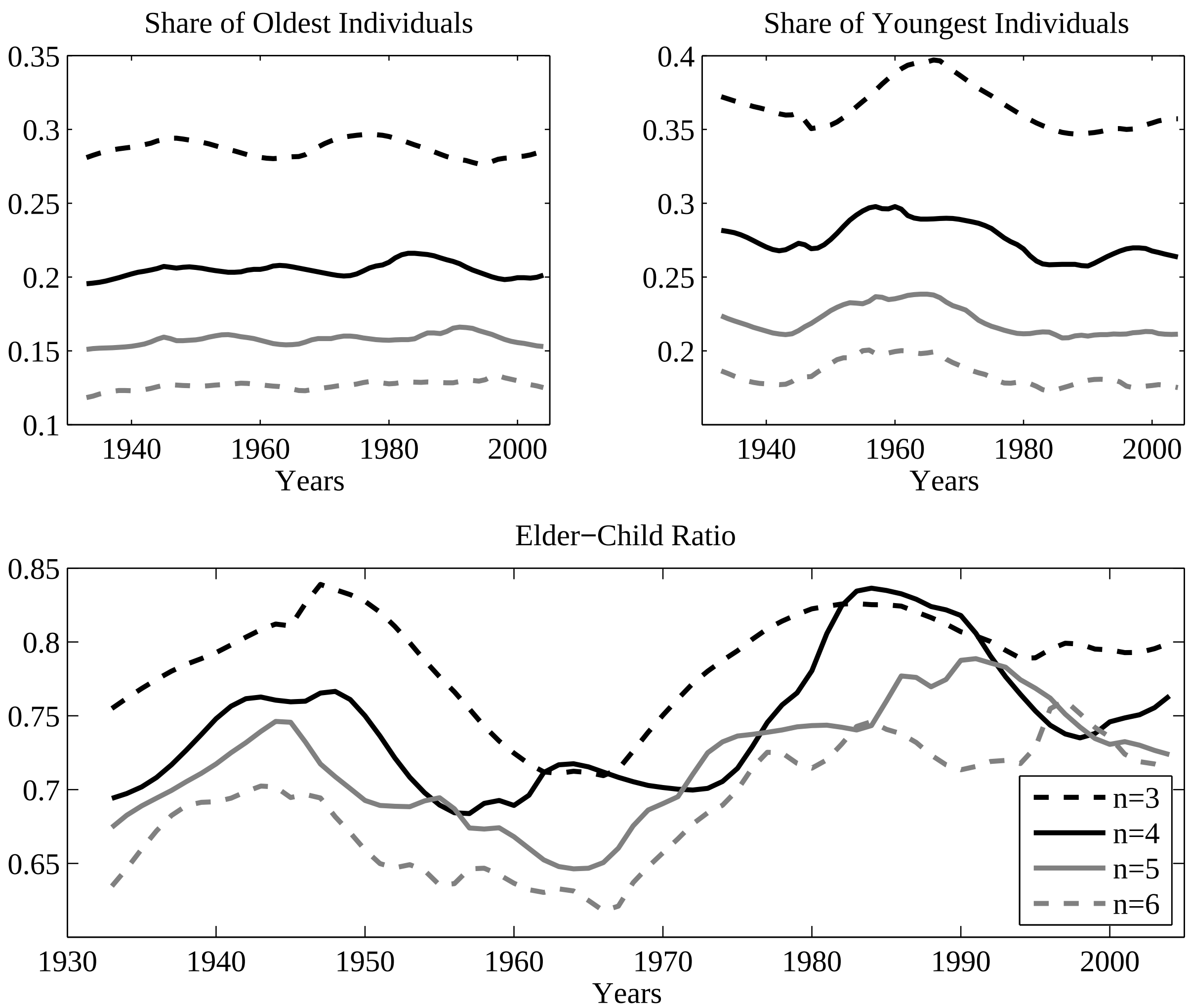


Table 1: Correlation of Elder–Child Ratios

n	3	4	5	6
3	1.00	0.71	0.75	0.73
4	–	1.00	0.77	0.74
5	–	–	1.00	0.89
6	–	–	–	1.00

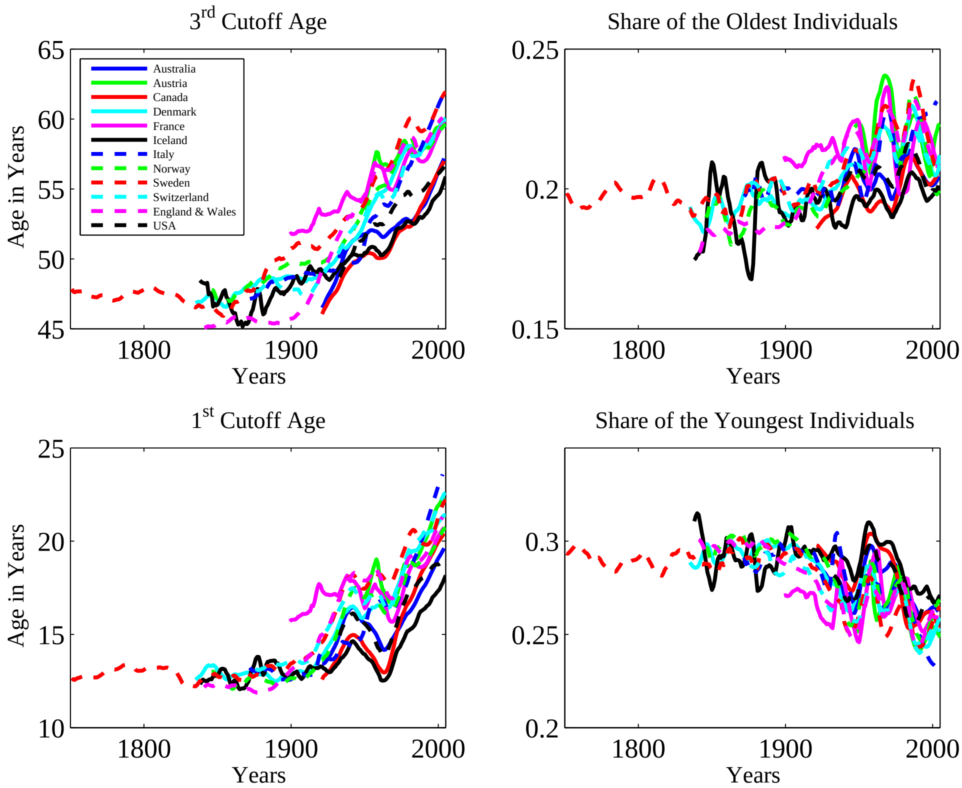
3 An International Perspective

Aging is usually perceived as a phenomenon affecting all industrialized economies. The previous section has shown for the US economy that aging may not be as pronounced as commonly thought as soon as we take into account that the age of entry into old age varies over time. In this section we will investigate whether this result extends to other industrialized economies. We use annual data from the HMD for Australia, Austria, Canada, Denmark, France, Iceland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, England & Wales. The time period runs from 1751 (for Sweden only) to 2005. As in the case of the US, we choose to split the population into 4 groups for practical reasons.

Figure 8 reports for each country, on the right panel, the cutoff ages for old (top) and young (bottom) and, on the left panel, the shares of the old and young groups in total population of the country. The results show a lot of similarities to the US case. First of all, the age at which an individual is classified as being old increases in all countries. As witnessed by the Swedish case, for which we have a very long run of data, this increase accompanied economic development. In Sweden this age was 47.74 in 1751 and reached 61.95 in 2005 —a 30% increase. But it really accelerated in the post 1950 period in most countries under study. Again, in order to make more sense of this result, it will be useful to consider the case of a 55-year-old individual. In 1900, no matter the country we consider, this individual would have been classified as belonging to the group of the oldest people. In 2005, he/she would no longer belong to that group in any country of the sample. At age 55, an individual is younger in 2005 than in 1900. Again, this phenomenon mainly accounts for individual aging, as captured by life expectancy (in Sweden, life expectancy at birth was 46.74 in 1751 and reached 79.94 in 2005) but can also be attributed to any change in the distribution.

Once we correct for this effect, aging —as measured by the share of old people in total population— is mitigated. The share exhibits fluctuations in all the countries, with standard deviations ranging from a low 0.49 points in the US to a high 1.63 points in

Figure 8: International Comparison



the UK. However, the share appears to be remarkably stable over time and remains close to 20% in most countries of our sample. It therefore indicates that aging of the society as a whole may not be as strong as usually claimed. For instance, consider the case of Sweden. The share of old people in total population, as computed by optimal grouping, was 19.78% in 1751 and reached 20.56% in 2005, a less than 4% increase over the whole time period. In order to investigate this issue more precisely, we compute the average annual rate of growth of the share by fitting a linear trend to the logarithm of the share. This is done both for the whole available time period in each country (γ in Table 2) and for the last 50 years of the sample (γ_{50} in Table 2). The results mitigate population aging, as the average annual rate of growth γ is always less than 0.16% whatever country we consider. As a matter of fact, Denmark, France, Norway, Sweden, England & Wales and USA have not experienced any statistically significant growth in the share of old individuals over the last 50 years, therefore ruling out population aging during that period. Only Australia, Canada, Iceland and Italy significantly aged in the period. Interestingly, Austria and Switzerland even experienced negative growth in this share over the last 50 years, suggesting a rejuvenation of their populations.

Patterns for the age below which an individual is classified as young are very similar to those obtained in the US case. The cutoff age increased in all countries. At low frequencies, this can be related to the increase in life expectancy at birth. In particular, we observe the same acceleration in the cutoff age as the one we observed in the threshold determining old age. This acceleration was delayed up until the beginning of the twentieth century. Interestingly, we recover the same effects of baby–booms in all countries that experienced them. In all these countries, the cutoff age decreased in the mid–sixties. The share of young people as obtained on international data displays many similarities to the US. Unlike the share of the oldest group, the share of young individuals exhibits a significant although small negative trend. For instance over the last 50 years of the sample, the rate of decline in the share ranges from a low -0.02% in France to a high -0.17% in

Table 2: Test for a trend in indicators

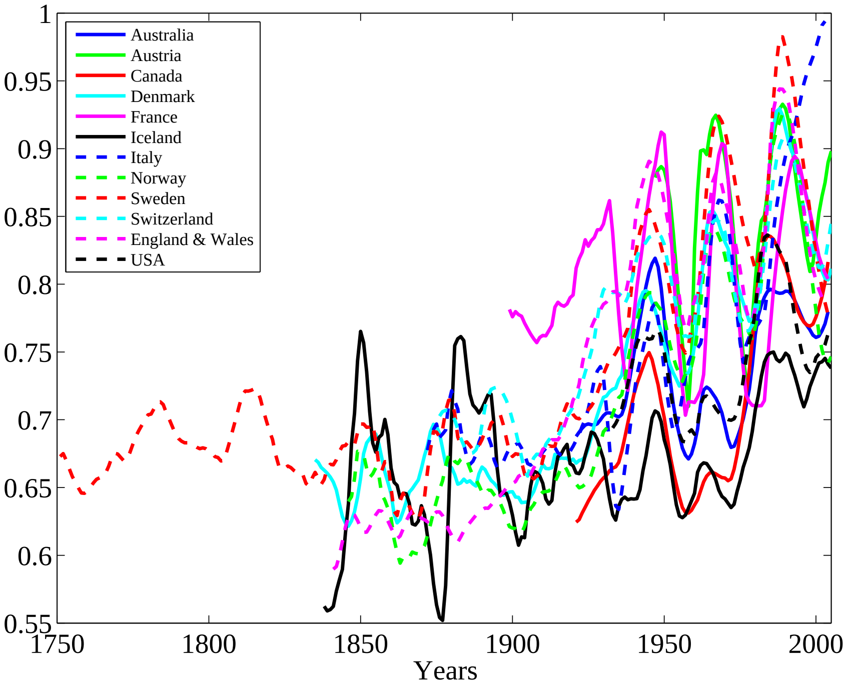
	Old		Young		Ratio	
Country	γ%	γ_{50}%	γ%	γ_{50}%	γ%	γ_{50}%
Australia	0.0412	0.0429	-0.0717	-0.2846	0.1129	0.3275
	[0.0004]	[0.0422]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Austria	-0.0639	-0.0963	-0.1304	-0.2393	0.0665	0.1430
	[0.0577]	[0.0311]	[0.0004]	[0.0000]	[0.2251]	[0.0452]
Canada	0.0975	0.1652	-0.1715	-0.4264	0.2690	0.5916
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Denmark	0.0946	-0.0414	-0.1005	-0.2835	0.1950	0.2421
	[0.0000]	[0.1676]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
France	0.0179	0.0383	-0.0236	-0.2212	0.0416	0.2595
	[0.1553]	[0.4493]	[0.0772]	[0.0000]	[0.0696]	[0.0010]
Iceland	0.0326	0.0547	-0.0293	-0.3203	0.0619	0.3750
	[0.0000]	[0.0057]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Italy	0.1076	0.2323	-0.1352	-0.3575	0.2428	0.5898
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Norway	0.1084	-0.0619	-0.1106	-0.2157	0.2190	0.1538
	[0.0000]	[0.1486]	[0.0000]	[0.0000]	[0.0000]	[0.0266]
Sweden	0.0539	-0.0210	-0.0570	-0.1464	0.1109	0.1254
	[0.0000]	[0.6051]	[0.0000]	[0.0002]	[0.0000]	[0.0867]
Switzerland	0.0773	-0.0440	-0.1208	-0.2335	0.1981	0.1895
	[0.0000]	[0.0404]	[0.0000]	[0.0000]	[0.0000]	[0.0001]
UK	0.1562	-0.0010	-0.1159	-0.1428	0.2721	0.1418
	[0.0000]	[0.9756]	[0.0000]	[0.0001]	[0.0000]	[0.0158]
USA	0.0251	-0.0173	-0.0974	-0.2937	0.1225	0.2764
	[0.0664]	[0.4646]	[0.0000]	[0.0000]	[0.0001]	[0.0000]

Note: γ corresponds to the growth rate of the share of the last group in the population as obtained from an OLS regression of the log of this share on a constant term and a linear trend. γ_{50} is the corresponding value over the last 50 years of the sample. Both γ and γ_{50} are expressed in percentage points. p–value of nullity test is in brackets.

Canada. Again, the share of the young population exhibits fluctuations, with standard deviation between 1.10 points in Iceland and 1.74 points in the UK. In particular, these fluctuations echo the evolution of the cutoff age during the baby–boom.

Figure 9 finally reports the second aging indicator, which is computed as the ratio of the share of old to that of young individuals. The ratio seems to exhibit an upward sloping trend as soon as longer datasets are used. In particular, looking at Swedish data it appears that while the ratio was about 0.67 (2 old individuals for 3 young people) in 1751, it reached about 1 in the 1990's. It is therefore not surprising that Table 2 indicates that most countries display a significant and positive trend (with Austria and France as exceptions). It is however worth noting that the growth rates are all below 0.3%. However, as in the US case, this ratio displays much variability. This is mainly true in the

Figure 9: Elder–Child Ratio



second part of the twentieth century. In particular, baby–booms all yield a rejuvenation of the population in their later phase. Likewise, in continental Europe, wars lead to a rejuvenation in their aftermaths as many middle–aged people are killed and the fertility rate drops. Therefore after wars, there are more people with high age, and consequently the age below which an individual is classified as young increases which leads to a decrease in the corresponding share. Henceforth the elder–child ratio increases.

4 Conclusion

This paper proposes an alternative measure of aging that resorts to optimal grouping techniques. This approach leads to an endogenous definition of old age that depends on the entire distribution of ages within the population. Therefore, the old age cutoff may depend on the type of population, the country and the date at which it is evaluated. For instance, in the US the age at which one is considered an older person has increased continuously over the last century. Despite the potential high sensitivity of this old age cutoff to the distribution, most industrialized countries exhibit a very similar pattern. Likewise, we find that, contrary to the common arguments of an aging population, the share of elderly individuals within the total population has not increased much and has remained stable in these countries. The main advantage of the measure we propose is to offer a method for calculating the cutoff ages of major age groups such as adulthood and old age. Our approach could thus be applied to the study of medical spendings as in Curtler and Sheiner (2001), dependency ratios as in Oliveira Martins et al. (2005) and the labor force as in Shoven (2007).

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