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Abstract

The quality of age reporting in Ireland worsened in the years after the Great Irish Famine (1845–1852), even as other measures of educational attainment improved. We show how demography partly accounts for this seemingly conflicting pattern. Specifically, we argue that a greater propensity to emigrate typified the youngest segment (23–32- year-olds) used in conventional indices of digit preference. Quantification of age heaping must therefore be interpreted in light of an older underlying population which is more likely to heap. We propose how age heaping indices can adjust for such demographic change by introducing age standardisation.

JEL Codes: N33, J10

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I. Introduction

Economic historians continue to be intrigued by patterns of digit preference in the distribution of ages. The phenomenon, now widely referred to as age heaping, first came to prominence among economic historians when Joel Mokyr drew a link between digit preference and numeracy skills in his analysis of Irish emigrants to the US.[1] Viewed as a novel solution to the lack of historical data on human capital attainment, age heaping indices have since been energetically applied to a wide range of datasets to provide new illumination on education levels across time and space.[2]

However, a recent debate in the *Economic History Review* questions the efficacy of age heaping as a numeracy and human capital indicator.[3] Brian A'Hearn, Alexia Delfino and Alessandro Nuvolari argue that age heaping cannot represent numerical skills alone and posit two other explanations based on an analysis of historical Italian censuses: (1) state capacity, where the accuracy of census recording reflects available state resources; and (2) culture, where digit preference mirror changes to the social admiration of youth and the elderly.[4] They conclude that changing age heaping patterns are a combined outcome of the forces of modernisation rather than a narrow consequence of human capital accumulation. Joerg Baten, Giacomo Benati and Sarah Ferber reply that A'Hearn et al.'s concerns are exaggerated and reiterate the age-heaping-as-numeracy interpretation.[5] Then, a rejoinder by A'Hearn et al. argues that they are not dismissing age-heaping-as-numeracy, but rather adding nuance to the interpretation.[6]

We augment this exchange by identifying, and then subsequently solving, the "Irish heaping puzzle": a strange increase in age heaping, inversely a fall in the quality of age

[1] Mokyr, *Why Ireland starved*, which builds on Mokyr and Ó Gráda, 'Emigration and poverty'. De Bromhead, Fernihough and Ó Gráda, '175 years', now argue that Mokyr and Ó Gráda were 'almost certainly wrong'.
[2] Examples: A'Hearn, Baten and Crayen, 'Quantifying quantitative literacy'; Földvári, van Leeuwen and van Leeuwen-Li, 'How did women count?'; Blum, Colvin, McAtackney and McLaughlin, 'Women of an uncertain age'; Blum and Kraus, 'Age heaping'; Cappelli and Baten, 'Numeracy development'; and, most recently, Gómez-i-Aznar, '*Ad maiorem*'.
[3] Demographers identified problems with measuring individual ages long before economic historians discovered age heaping: Shryock, Siegel, and associates, *The methods and materials*; Siegel and Swanson, *The methods and materials*. For more examples of age heaping in demography, see: Mukherjee and Mukhopadhyay, 'A study of digit preference'; Bailey and Makannah, 'Patterns of digit preference'; Noumbissi, 'L'indice de Whipple modifié'; Spoorenberg and Dutreuilh, 'Quality of age reporting'; Fayehun, Ajayi, Onuegbu and Egerson, 'Age heaping among adults'; and Singh, Kashyap and Bango, 'Age heaping among individuals'.
[4] A'Hearn, Delfino and Nuvolari, 'Rethinking age heaping'.
[5] Baten, Benati and Ferber, 'Rethinking age heaping again'. They present technical issues with A'Hearn et al.'s methodology and cite evidence from cross-country regressions that age heaping is not correlated with measures of state capacity – although the cultural component of age heaping is left unaddressed.
[6] A'Hearn, Delfino and Nuvolari, 'Age heaping and its discontents'. Another sceptical look at the heaping-numeracy link is Beltran Tapia, Diez-Minguela, Martinez-Galarraga and Tirado-Fabregat, 'Two stories'.

reporting, between the 1841 and 1871 censuses (see Figures 1 and 2),[7] despite increasing literacy, school enrolment and educational attainment. Our analysis suggests a fourth explanation for patterns of age heaping: it is a mechanical phenomenon, driven by demographic forces. When we adjust for the underlying demographic characteristics of the population, our heaping puzzle is partly solved.

We illustrate how the underlying demography of a geographic unit influences its measure of heaping by showing that younger populations are less inclined to report rounded ages. We argue that Ireland's population was automatically more likely to heap in 1871 because it was significantly older.[8] Without taking this demographic change into consideration, scholars could incorrectly assume that Ireland had experienced a decline in numeracy, a reduction in state capacity, or a change in culture.[9] Instead, the reality is a famine-induced "premature ageing" effect, precipitated by Ireland's Great Famine-era mortality and migration experiences. Ireland's post-Famine emigrants were in large measure young female and male domestic servants and young male agricultural labourers. Only 25 per cent of the cohort aged 10–19 in 1841 remains in the 1871 census, whereas 32 per cent of the cohort aged 20–29 in 1841 remains in 1871.[10]

Documenting a reversal of age heaping in famine-affected areas is not by itself a novel contribution. Manzel observes a famine-related reversal for Spain; Baten, Ma, Morgan and Wang for China; and Baten, Crayen and Voth for England.[11] And for Ireland, Baten et al. first notice the pattern, while Blum, Colvin, McAtackney and McLaughlin speculated on its causes.[12] However, to our knowledge, we are the first to systematically test the hypothesis that famine-induced *demographic* change is a chief driver of such heaping reversals, and the first to design a modified index to incorporate age standardisation.[13]

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[7] These are presented as conventional population pyramids in Appendix Figure A1.

[8] Crayen and Baten, 'Global trends', acknowledge a higher propensity to age heap among older populations. Their simple solution is to focus only on 23–72-year-olds. However, by constructing unweighted mean Whipple indices 'in the frequent case of several age groups per birth decade', Crayen and Baten introduce selection bias into these measurements due to selective migration and mortality. The appendix to their paper provides a useful discussion and statistical analysis of the issue of age grouping and heaping propensity.

[9] Ireland's unusual age structure is discussed by Walsh, 'Empirical study', and its demographic change is described in Kennedy and Clarkson, 'Birth, death, and exile'. See also Gilleard, 'The other Victorians', where the ageing population is discussed.

[10] Relatedly, Gomellini and Ó Gráda, 'Migrations', explore whether Italy's experience of selective emigration explain longitudinal age heaping patterns there.

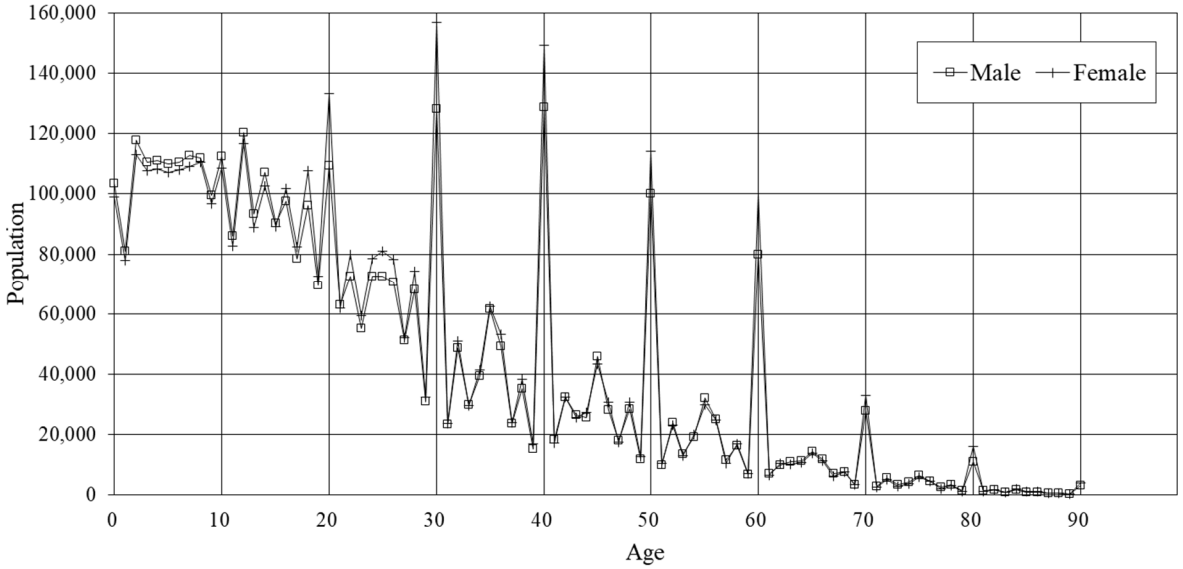
[11] Manzel, 'Essays on human capital'; Baten, Ma, Morgan and Wang, 'Evolution of living standards'; Baten, Crayen and Voth, 'Numeracy'.

[12] Baten et al., 'Evolution of living standards', p. 356; Blum et al., 'Women of an uncertain age'.

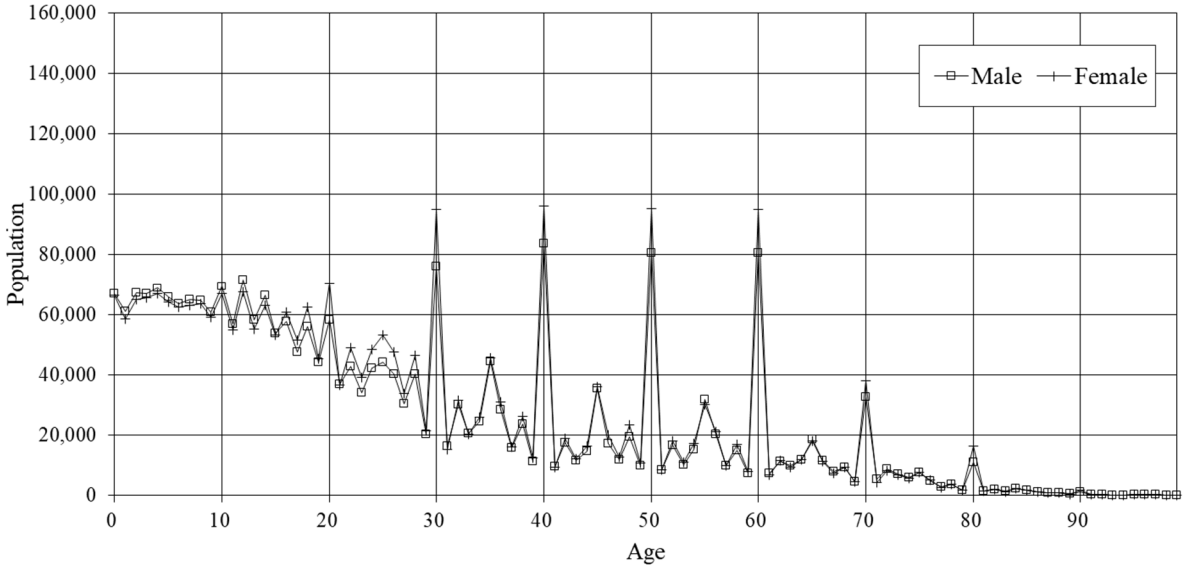
[13] Ó Gráda, 'Dublin Jewish demography', was also aware of the problem of demography in his study of Jewish migrants from Tsarist Russia included in the 1911 Irish census. Rather than constructing a single age heaping index, he simply reports separate age heaping indices for each age band.

Figure 1. *Population distribution by age*

Panel A. *1841 census*



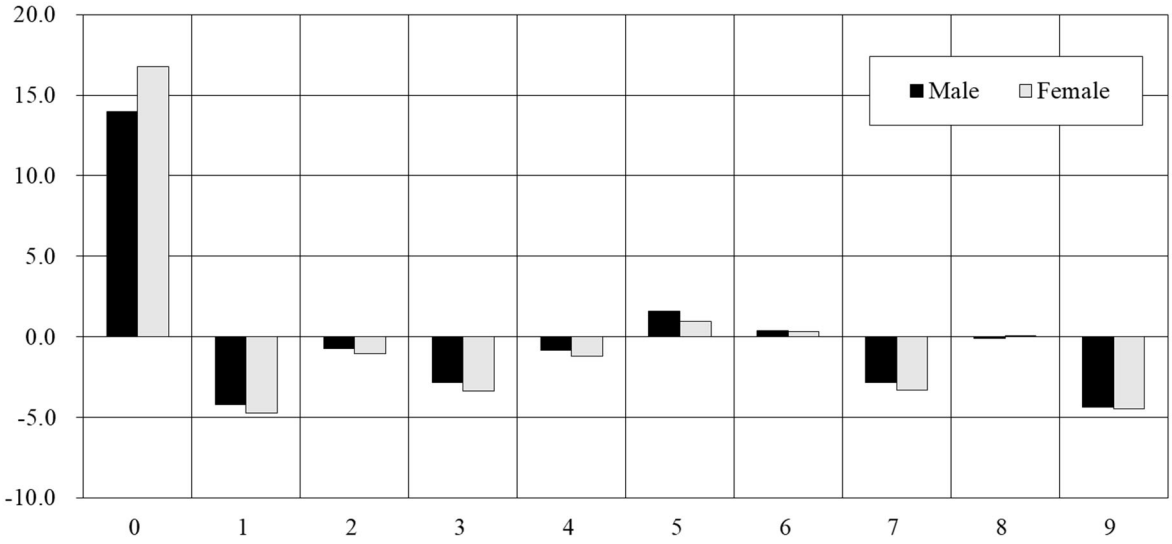
Panel B. *1871 census*



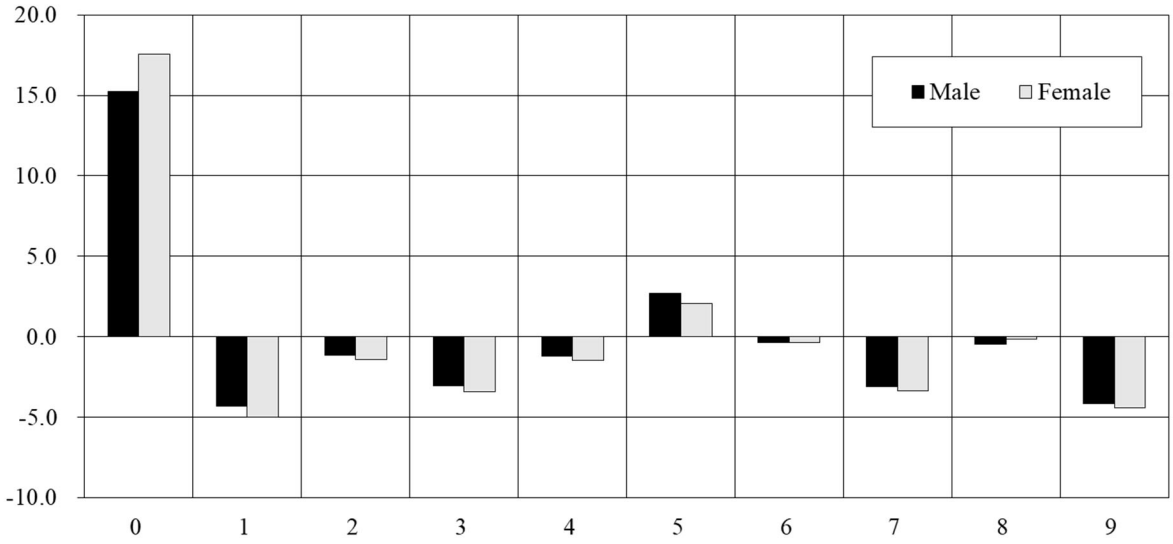
Note: The last point for 1841 is 90-years-and-over.
Source: *Census of Ireland* (P.P. 1843, XXIV); *Census of Ireland* (P.P. 1876, LXXXI); using US Census Bureau Population Analysis System (https://www.census.gov/data/software/pas.html).

Figure 2. *Digit preference, Myers method*

Panel A. *1841 census*



Panel B. *1871 census*



Note: Robert J. Myers's blended population is a weighted sum of the number of persons reporting ages ending in each of the ten terminal digits (Myers, 'Errors and bias'; Myers, 'Accuracy of age reporting'). For 1841, only ages up to 90 are used.
Source: See Figure 1.

The implication of our findings is that demographic correction should be carried out by other researchers too; yes, demographic change may be particularly pronounced in the Irish case, but all populations experience year-on-year changes due to fluctuations in birth and death rates, ageing and changes to life expectancy, and patterns of immigration and emigration. In particular, the type of rural-urban migration typical of nineteenth-century industrialisation distorts population distributions and makes direct rural-urban comparisons fraught with difficulty in the absence of some sort of demographic standardisation correction. More locally to Ireland, our findings also suggest a more explicit role for demographic ageing in debates about the island's post-Famine economic performance.[18]

We proceed as follows: Section II sets out the Irish puzzle; Section III demonstrates the salience of population age structure in explaining the Irish puzzle; Section IV develops a standardisation correction approach to account for age structure in heaping indices; and Section V discusses the applicability of our approach to other times and places.

II. Ireland's digit preference

There are several alternative indices available with which to evaluate the extent of age heaping in a single metric. The *ABCC* index has become the most popular among economic historians. It is a modification of the Whipple index.[19] The original Whipple index is a ratio of the share of people reporting an age ending in 0 or 5 to all age statements, where the population is restricted to those aged between 23 and 62:

$$WI = \left(\frac{n_{25}+n_{30}+\cdots+n_{55}+n_{60}}{1/5\times(n_{23}+n_{24}+n_{25}+\cdots+n_{62})}\right)\times 100 \; if \; WI \geq 100; \; else \; WI = 100 \qquad (1)$$

where *n* is the sum of individuals with that specific age. As calculated, the *WI* would give greater weight to the bottom of the age distribution for a traditional "pyramid" shaped population distribution; because there are more younger people this means that younger age groups affect *WI* more than older people. A *WI* value of 500 indicates that all age statements end in 0 or 5; a value of 100 indicates no heaping.

A'Hearn, Baten and Crayen – on the suggestion of Gregory Clark – modify *WI* to range between 0 and 100, where 0 indicates that everyone reports an age terminating in 0 or 5, and

[18] For recent perspectives on post-Famine economic performance, see: Begley, Geary and Stark, 'Convergence'; Henderson, 'Religion and development'; and Kenny, Lennard and O'Rourke, 'An annual index'.
[19] Or as Whipple referred to it, 'method of adjusting data troubled with these concentrations on the round numbers' (Whipple, *Vital statistics*, p. 180).

100 that there is no heaping on ages terminating in 0 and 5.[20] This modified index is argued to be interpretable as the percentage of the population that is numerate, and is given as follows:

$$ABCC = \left(1 - \frac{(WI - 100)}{400}\right) \times 100, if\ WI \geq 100;\ else\ ABCC = 100 \quad (2)$$

What is less well documented in the economic history literature is that, contemporaneous to the A'Hearn et al. contribution, an active debate among demographers has also led to a modified Whipple index. This modification, due to Spoorenberg and Dutreuilh, generalises the Whipple index to all digits in a similar fashion to the Myers index (as highlighted in Figure 2).[21] For demographers the purpose of modified indices is to assess what changes in digit preference drive the improvement in age reporting quality, also for digits besides 0 and 5. Spoorenberg and Dutreuilh apply their method to historical census data for India (poor age reporting quality), Morocco (intermediate age reporting quality) and Switzerland (good age reporting quality).[22]

In Table 1, we report age heaping indices for Ireland across four decennial census points: 1841, 1851, 1861 and 1871. The table suggests greater heaping in 1871 (as compared to 1841) was not an exception; heaping was more pronounced in all three census years after 1841. By contrast, reported literacy in Ireland increased from roughly 1-in-2 in 1841 to 7-in-10 in 1871. This runs counter to the correlation we would expect to see if heaping is an indicator of human capital.[23]

[20] A'Hearn et al., 'Quantifying quantitative literacy'.
[21] Spoorenberg and Dutreuilh, 'Quality of age reporting', was published two years prior to A'Hearn et al., 'Quantifying quantitative literacy'.
[22] Spoorenberg and Dutreulih build on an earlier modified Whipple index by Noumbissi, 'L'indice de Whipple modifié', who applies it to historical data for Cameroon, Belgium, and Switzerland.
[23] We acknowledge that historical census estimates of literacy are themselves imperfect, e.g., based on self-reported information and limited in scope.

Table 1. *Estimates of heaping (Whipple and ABCC), illiteracy and industrial production, 1841–1871 censuses*

Year	*Whipple (23–62)*			*ABCC (23–62)*			*Illit. % (5 years & over)*			*Production (1841=100)*		
	Male	*Female*	*Both*	*Male*	*Female*	*Both*	*Male*	*Female*	*Both*	*Output*	*Output per cap.*	*Produc-tivity*
1841	203	213	209	74	72	73	46	59	53	100	100	100
1851	221	231	226	70	67	68	42	51	47	150	189	207
1861	217	225	221	71	69	70	35	42	39	144	204	240
1871	219	225	222	70	69	69	31	36	33	186	282	353

Note: A higher Whipple or lower *ABCC* implies more heaping. Illiteracy is the percentage of persons who can neither read nor write of persons 5 years and upwards. Output is measured as industrial output. Productivity is labour productivity, measured as industrial output per worker.
Source: *Census of Ireland* (P.P. 1843, XXIV); *Census of Ireland* (P.P. 1851, XXXI)*; Census of Ireland* (P.P. 1863, LVII)*; Census of Ireland* (P.P. 1863, LXI)*; Census of Ireland* (P.P. 1876, LXXXI). Output data from Kenny et al. 'An annual index'.

Ireland was the first constituent polity of the UK to receive state-funded primary education, from 1831.[24] National schools taught the "three R's" – reading, writing, and arithmetic – with book-keeping being an especially sought-after subject.[25] It is unsurprising to see this education policy bearing fruit in terms of the reduction in illiteracy 40 years after the policy was implemented. But it is quite surprising that there was an increase in heaping over the same period, if heaping is to be interpreted narrowly as numeracy skills. It is this puzzle that we now attempt to solve.[26]

III. Explaining the Irish puzzle

To explore Ireland's curious heaping reversal, we use tabulated age data from the 1841 and 1871 censuses of Ireland. Unlike other Irish censuses, these have the advantage of reporting ages by county (32 counties, equivalent to NUTS-3) and therefore permit spatial comparisons across the island.[27] Figure 3 maps *ABCC* values by county for 1841 and 1871 and shows a striking decline in *ABCC* across most of the polity.

Our focus is the changing demographic composition of the population: the Irish population became older after the Famine. Among the population used in calculating the *ABCC* index, the main difference was a 4.35 percentage-point *decrease* in the share of the population aged 23–32 and a 5.05 percentage-point *increase* in the share of the population aged 53–62. This was primarily a consequence of increased emigration flows to Great Britain and North America. Irish migrants were overwhelmingly young single individuals (male and female); they tended not to migrate in family groups.[28]

We model the change in *ABCC* at the county level between 1841 to 1871 using a simple OLS regression. This allows us to distinguish the salient factors correlated with digit preference patterns within a multi-variable setup. Following our hypothesis that age structure can account for the heaping reversal, our main variables of interest are the shares of the population in

[24] Blum et al., 'Women of an uncertain age'.
[25] Coolahan, *Irish education*; Clarke, 'The teaching of bookkeeping'.
[26] Likewise, state capacity also increased over this period, with the full implementation and operation of poor laws creating local government infrastructure that complemented central government. One indicator of state capacity is the increased ratio of police per capita (McLaughlin, Colvin and Blum, 'Anthropometric history').
[27] Ages are only reported at the national (NUTS-1) and provincial (four provinces, NUTS-2) level in the censuses of 1851 and 1861.
[28] Ó Gráda and O'Rourke, 'Migration as disaster relief'.

Table 2. *Descriptive statistics*

Variable	*Mean*	*St. dev.*	*Min*	*Max*
ABCC 1841	73.42	4.02	65.75	81.76
ABCC 1871	68.55	5.40	57.28	81.19
Δ *ABCC* 1841–71	–4.87	2.81	–10.23	4.32
Illiteracy 1841	51.24	13.96	22.99	79.01
Illiteracy 1871	33.44	9.98	15.63	57.37
Δ Illiteracy 1841–71	–17.80	5.51	–26.09	–7.01
Δ 23–32 share in *ABCC* 1841–71	–4.36	2.64	–10.57	0.17
Δ 33–42 share in *ABCC* 1841–71	–1.91	1.35	–4.15	0.56
Δ 43–52 share in *ABCC* 1841–71	0.88	1.39	–1.69	3.72
Δ Female:male (23–62) 1841–71	0.94	4.99	–13.33	9.07
Famine-era excess mortality	21.73	15.74	–2.10	58.40
Famine-era migration	144.09	76.90	–177.21	259.44

Note: Illiteracy is the percentage of persons who can neither read nor write of persons 5 years and upwards.
Source: Age, illiteracy and sex: *Census of Ireland* (P.P. 1843, XXIV); *Census of Ireland* (P.P. 1876, LXXXI). Famine-era excess mortality: Mokyr, *Why Ireland starved*, Table 9.2, lower bound. Famine-era migration: based on Ó Gráda and O'Rourke, 'Migration as disaster relief'.

The different age bands used in the Whipple calculation. We also add Famine-era excess mortality and migration as control variables. Famine-era excess mortality is Mokyr's average annual excess death rate between 1846 and 1851.[29] Famine-era migration is Ó Gráda and O'Rourke's estimation between the 1841 and 1851 censuses.[30] We include the initial *ABCC* level in 1841 to control for level effects. We repeat the regressions with illiteracy as the focus, to see whether this differs from our findings for heaping. Table 2 reports the descriptive statistics and Table 3 the regression results.

The results show the importance of the changing composition of the population in explaining the change in *ABCC* over time. In specification 1, changing age structure and *ABCC* in 1841 explain 34 per cent of the variation in the dependent variable. With the inclusion of Famine-era migration and excess mortality in specification 3, the magnitude of the age structure effects is smaller but still statistically significant. Notably, Famine-era migration is more statistically important than Famine-era mortality. This is to be expected; it was the oldest

[29] Mokyr, *Why Ireland starved*, Table 9.2. Mokyr provides both lower and upper bound estimates. We use the lower bound, but the upper bound yields similar results.
[30] Ó Gráda and O'Rourke, 'Migration as disaster relief'.

Table 3. *OLS regressions of the change in ABCC and illiteracy between 1841 and 1871*

Variable	*Δ ABCC 1841–71*			*Δ Illiteracy 1841–71*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Δ 23–32 share in *ABCC* 1841–71	1.390***	1.431***	0.597**	0.791	0.679	0.327
	(0.479)	(0.484)	(0.253)	(0.670)	(0.599)	(0.478)
Δ 33–42 share in *ABCC* 1841–71	1.040*	1.144**	0.644**	1.274**	0.942	0.819
	(0.521)	(0.534)	(0.287)	(0.573)	(0.568)	(0.505)
Δ 43–52 share in *ABCC* 1841–71	2.527**	2.815**	1.252**	1.401	0.558	–0.211
	(1.029)	(1.092)	(0.477)	(1.299)	(1.201)	(1.033)
Δ Female:male (23–62) 1841–71		–0.101	–0.138*		0.303***	0.286***
		(0.093)	(0.072)		(0.104)	(0.089)
Famine-era excess mortality			–0.045			–0.085*
			(0.034)			(0.049)
Famine-era migration			–0.021***			–0.012
			(0.004)			(0.008)
ABCC 1841	0.023	0.034	–0.100			
	(0.134)	(0.138)	(0.136)			
Illiteracy 1841				–0.263***	–0.256***	–0.162**
				(0.062)	(0.055)	(0.065)
Constant	–0.751	–1.331	9.281	0.323	–0.713	–2.949
	(10.770)	(10.904)	(10.647)	(1.935)	(2.153)	(2.374)
Observations	32	32	32	32	32	32
R-squared	0.338	0.362	0.715	0.710	0.766	0.834

Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Illiteracy is the percentage of persons who can neither read nor write of persons 5 years and upwards.
Source: See Table 2.

and the youngest that were most prone to perish during the Famine.[31] However, Famine-era migration was the main driver of the compositional change of the population – specifically, those age groups included in the most widely-used age heaping indices.

Demography also matters when looking at illiteracy in specifications 4 to 6. Younger generations increasingly benefitted from the rise of the publicly funded education, and this invariably fuelled declining illiteracy over time. But of crucial importance was the increased literacy of the female population; the educational attainment of women in particular was emphasised by both Fitzpatrick and Blum et al.[32] Here also Famine-era migration and excess mortality account for decreased illiteracy.

[31] Mokyr and Ó Gráda, 'What do people die of'.
[32] Fitzpatrick, ''A share of the honeycomb''; Blum et al., 'Women of an uncertain age'.

IV. Introducing the age-standardised age heaping index

Baten et al. argue that age heaping is best analysed by birth cohort rather than from a population average. However, comparing different birth cohorts derived from one census source introduces selection bias.[33] For example, using the 1871 census and comparing those born in the 1820s with those born in the 1810s introduces bias from selective mortality and selective migration. Equally, isolating a single birth cohort reported across different decadal censuses means the underlying data will be selected.

The resultant demographic change can be significant: as noted already in the introduction, only 25 per cent of the cohort aged 10–19 in 1841 remains in the 1871 census, whereas 32 per cent of the cohort aged 20–29 in 1841 remains in the 1871 census. This is further highlighted in Figure 4, which plots the *ABCC* values of the cohorts born in the 1810s from both the 1841 and 1871 censuses. The decline in male and female *ABCC* values for the cohort born in the 1810s is at least partially driven by selective mortality and migration. This finding is further illustrated in Appendix Figure A2, which documents regional trends in cohorts born in the 1810s, 1820s, and 1830s from successive censuses between 1841 and 1871; each cohort sees a decline in *ABCC* scores in the census years after 1841.[34]

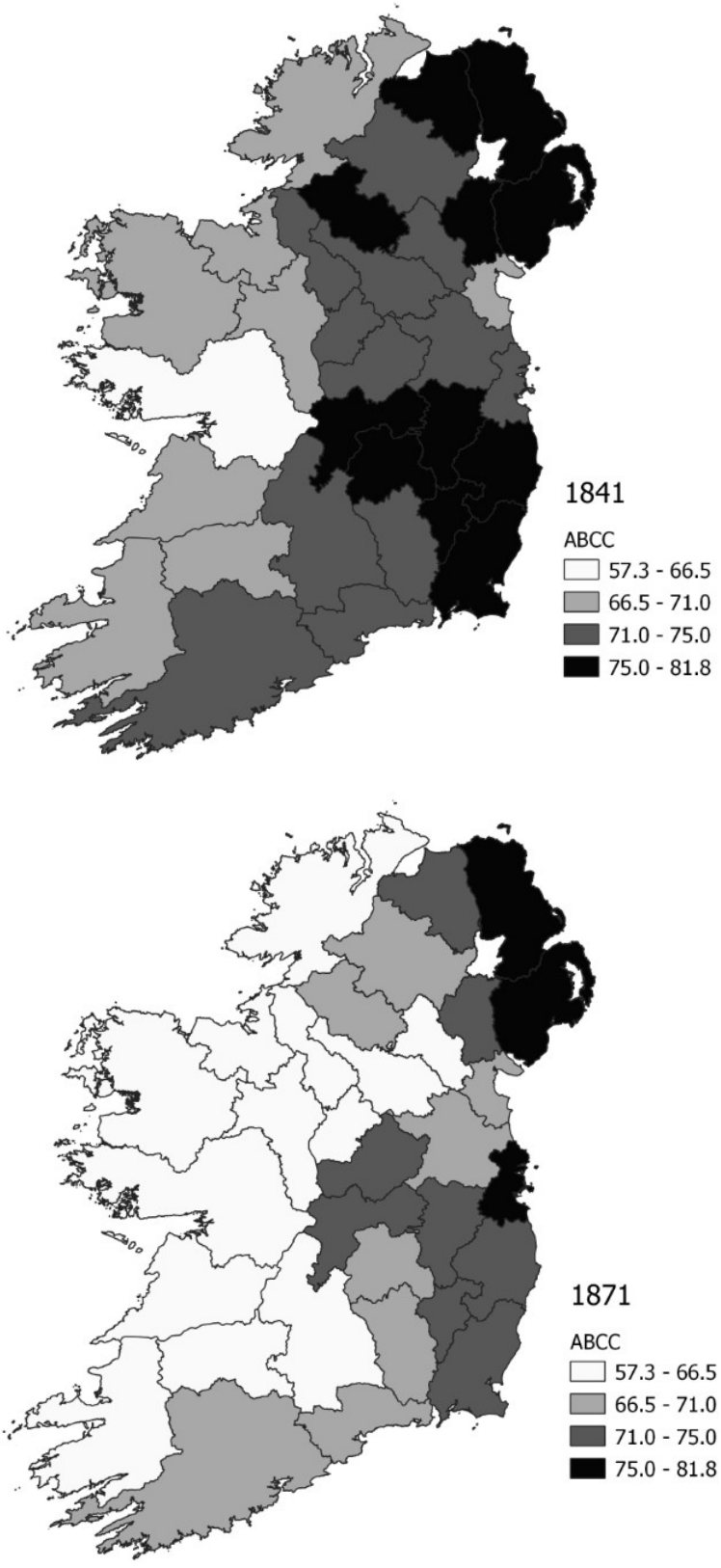
An alternative approach is to compare the same age group, not cohort, across census years. This allows us to compare like with like: youth with youth, middle-aged with middle-aged, and elderly with elderly. Figure 5 illustrates the change in *ABCC* values between the two census points by sex and age bin. There is very little change in the 23–32 age group for men and women, while the largest change is in the 43–52 age group. Women see negligible decline in the 53–62 age group, whereas for men there is still a substantial decline. The principal change is the relative weight of each group in the wider population.

Our technical solution to the demographic problem inherent in extant age heaping indices is to adjust the conventional Whipple index by standardising it by age. Our modified Whipple index functions as a demographic diagnostic tool. Adjusting for demographic composition is commonly carried out when comparing mortality rates. A classic example is the

[33] Bodenhorn, Guinnane and Mroz, 'Sample-selection biases', have a similar argument in relation to anthropometrics.

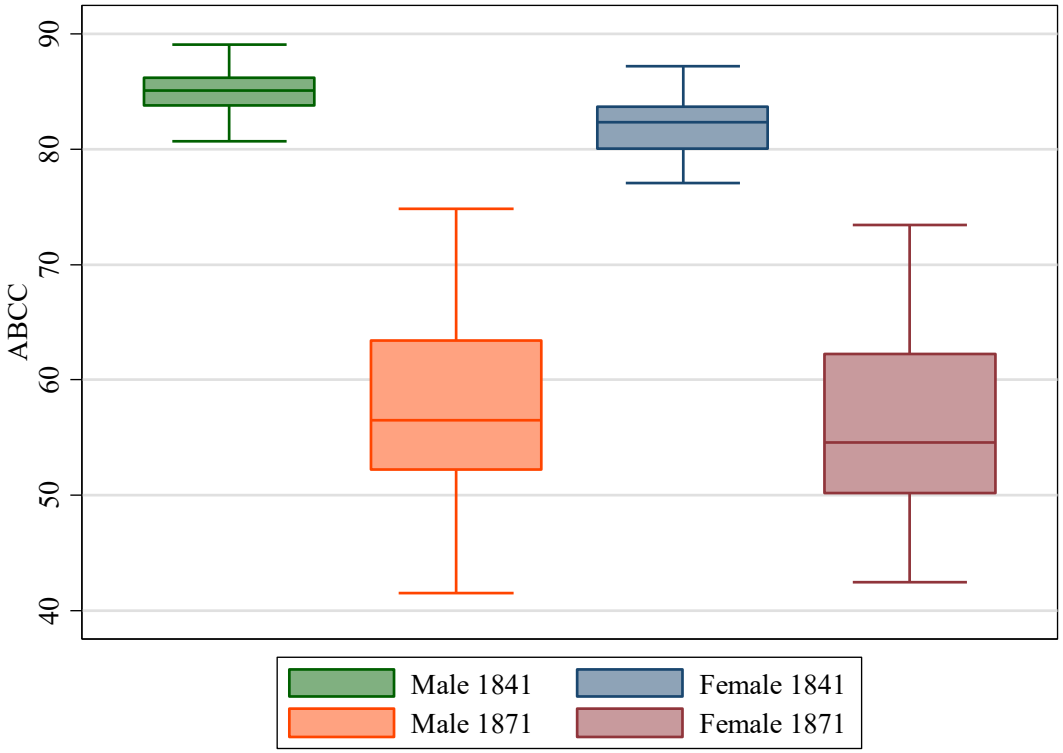
[34] Baten, 'How to perform numeracy analysis', also explores these heaping trends in post-Famine Ireland. But in contrast to our analysis, he argues 'numeracy by birth decade did not change much during this period, and the deviations between the two census years were also not large'. It is hard to reconcile this view with the evidence presented in Figure A2. The discrepancy is explained by the fact that Baten uses the post-Famine censuses and does not compare 1851 and 1861 with the pre-Famine 1841 census.

Figure 3. *ABCC index by county in the 1841 and 1871 censuses*



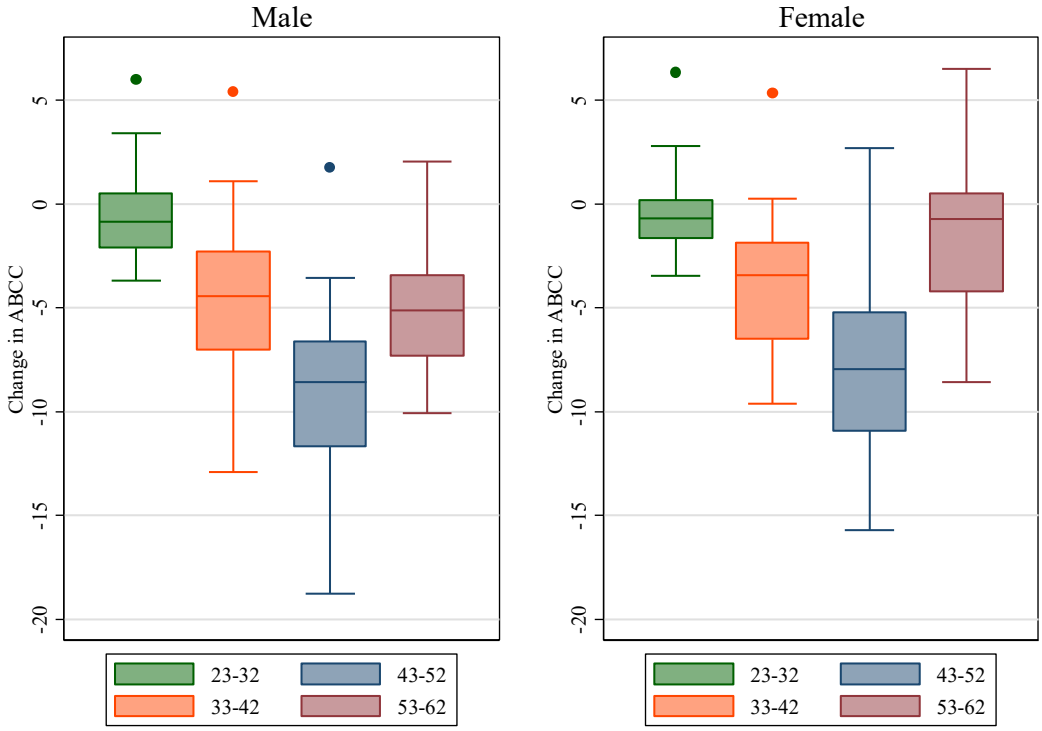
Note: Bins are nested means derived from the mean of all for both years, the mean between the minimum and the mean, and the mean between the mean and the maximum for both years.
Source: See Table 2.

Figure 4. *ABCC values of cohorts born in the 1810s reported in the 1841 and 1871 censuses*



Note: Boxplot demonstrating the locality, spread and skewness of cohorts through their quartiles. We use the 23–32 cohort from 1841 and the 53–62 cohort from 1871.
Source: See Table 2.

Figure 5. *Change in ABCC values by age-category between the 1841 and 1871 censuses*



Note: Outliers plotted as individual points.
Source: See Table 2.

comparison of mortality rates in Florida, which is famously a destination for retirees, and Alaska, which has a younger population. Without adjusting for age composition, the Florida-Alaska comparison gives a misleading impression of mortality.[35] The same principle applies to age heaping.

Whipple made a distinction between 'secessive' and 'accessive' populations, the former being a population which has excess emigration and the latter one with excess immigration.[36] Yet the Whipple index itself compares the relative frequency of age statements terminating in 0 and 5 for the population aged between 23 and 62 without allowance for the age composition of the population. This is because Whipple's original purpose was to adjust for 'errors in age' rather than for making comparisons of populations across time and space. Simply put, this index is not being applied in the way that it was originally intended.

We can account for age composition differences by constructing a weighted average Whipple index, using standardised population weights to make our adjustment.[37] As the magnitude of error is in individual ages, the weights are derived from the underlying data source by grouping the ages:

$$AgeWI = \sum \left(\frac{n_{25}+n_{30}}{1/5\times(n_{23}\ldots+n_{32})}\right)(m_{23-32})+\ldots+\left(\frac{n_{55}+n_{60}}{1/5\times(n_{53}\ldots+n_{62})}\right)(m_{53-62}) \quad (3)$$

where *m* are age-standardised weights for each age group.[38] Standardised estimates then adjust for the differences in population structure and enable us to see whether the changing composition of the population explains the differences in heaping observed.[39] Essentially, our age-standardised Whipple index allows us to compare like-with-like.[40] Our index can be incorporated into an *ABCC* computation to provide an age-standardised *ABCC* (*AgeABCC*) by replacing *WI* with *AgeWI* in Equation 2.

[35] See Colvin and McLaughlin, 'Death, demography and the denominator', for an application of this in measuring the demographic impact of the 1918 influenza pandemic.
[36] Whipple focuses on the population distribution of those between 15 and 50. Classification of secessive and accessive is based on whether this population is below or above 50%. The examples given are Sweden (50%) versus Massachusetts in 1910 (57%) (Whipple, *Vital statistics,* p. 190).
[37] As Whipple noted: 'for purposes of computation and comparison it is often convenient to have some standard of age distribution which can be used as a basis of reference' (Whipple, *Vital statistics*, p. 191).
[38] These constitute the following age bins: 23–32, 33–42, 43–52, and 53–62.
[39] Demographers refer to adjustments for age and digit preference as ways to reduce it in the underlying data source (e.g., discussion in Siegel and Swanson, *The methods and materials*).
[40] Our standardised Whipple index differs from the above cited modified Whipple indices of Noumbissi and Spoorenberg and Dutreulih as it does not focus on specific digits but instead weights all digits.

Table 4. *Population weights and sex ratios by age bin*

	Age bin			
	23–32	*33–42*	*43–52*	*53–62*
1841 census weights	0.39	0.27	0.20	0.14
1871 census weights	0.35	0.25	0.21	0.19
US 1900 weights	0.38	0.29	0.20	0.13
Composite weights	0.37	0.28	0.20	0.15
Equal weights	0.25	0.25	0.25	0.25
1841 female population share	0.53	0.52	0.51	0.52
1871 female population share	0.54	0.52	0.53	0.52

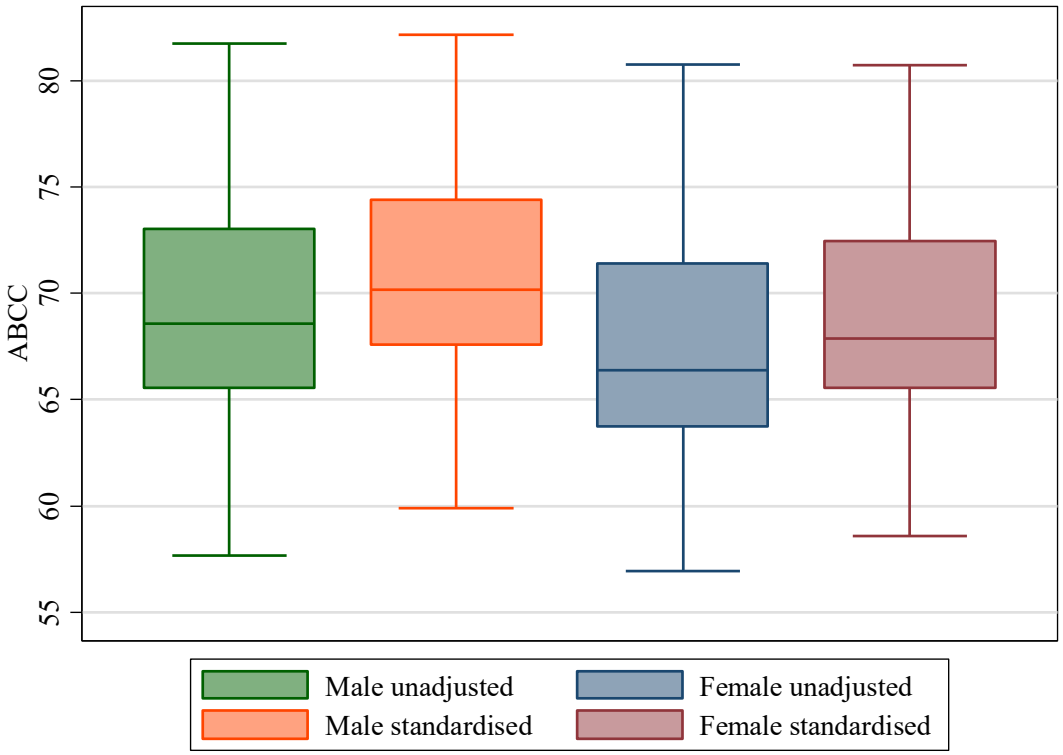
Source: 1841 census weights derived from *Census of Ireland* (P.P. 1843, XXIV); 1871 from *Census of Ireland* (P.P. 1876, LXXXI); US 1900 weights from the *Twelfth census of the United States*; composite weights based on England and Wales 1901 census (P.P. 1904, CVIII) and Belgian 1900 census (*Recensement général*) weighted by population size.

We use weights derived from the 1841 census (reported in Table 4) to directly compare 1841's younger population with 1871's older population.[41] Reweighting censuses to synthesise a stable population across time is akin to using a base year in the calculation of real GDP. The effect of this adjustment is best illustrated by comparing the unadjusted and adjusted *ABCC* values for 1871, shown in Figure 6. The adjustment (i.e., standardisation) using the 1841 weights increases the mean *ABCC* values for both men and women. As a robustness exercise we include weights based on Whipple's observation that neither Belgium nor England reported as populations with an 'abnormal use of rounding'.[42] We also use the US population from 1900. Finally, we report equal weights as implied by A'Hearn et al.'s footnote 38.[43] Corresponding age pyramids are reported in Appendix Figure A1.

Our adjustment leads to a significant alteration of the 'change in *ABCC* between 1841 and 1871' variable used as the dependent variable in our regression analysis. Figure 7 depicts the percentage difference of the change (1841–1871) between unadjusted and standardised figures in a boxplot. After standardisation, the change in *ABCC* values was 30 per cent lower for males and 33 per cent lower for females. In extreme cases, such as in County

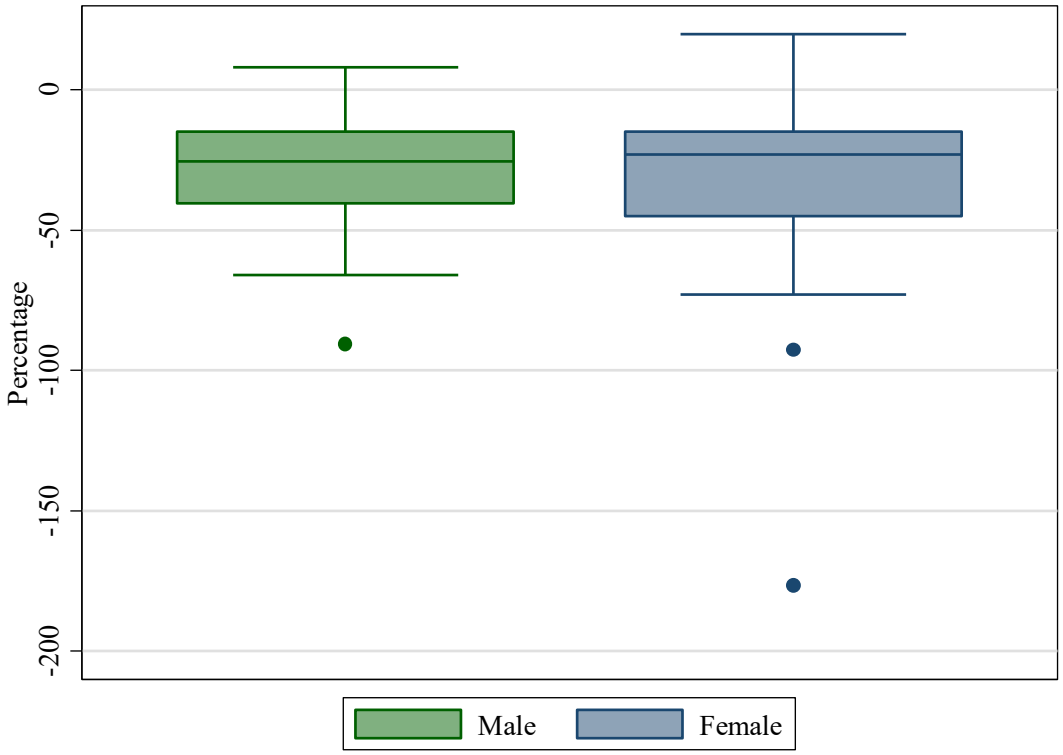
[41] We use 1841 as the reference year because it is the earlier observation year and occurred before the catastrophic demographic change caused by the Great Famine.
[42] Whipple, *Vital statistics,* Table 32. Whipple referred to the England and Wales population as the 'England and Wales Standard Million of 1901' (Table 39).
[43] A'Hearn et al., 'Rethinking age heaping'. However, as indicated in Table 4 this creates a distorted and unrealistic reference group as it significantly under-weights 23–32-year-olds and over-weights 53–62-year-olds.

Figure 6. *Unadjusted and age standardised ABCCs in 1871*



Source: See Table 2.

Figure 7. *Percentage difference of ΔABCC (1841–1871) between unadjusted and standardised*



Source: See Table 2.

Westmeath, the difference between 1841 and 1871 was 66 per cent lower for males and 177 per cent lower for females; the latter reflecting a decrease in heaping when standardised figures are used. County Dublin, which is unusual due to the reduction in heaping it experienced from 1841 to 1871, has larger changes in *ABCC* when standardised figures are used. This underscores the sizeable implications of standardisation.[44]

V. Conclusion

Our analysis suggests Ireland's nineteenth-century digit preference puzzle can be solved by considering the island's changing demographic structure over time. Those appearing in the later 1871 census were the survivors and "remainers" in a post-Famine Ireland, where mortality and emigration had selectively yielded an older Irish population more inclined to report rounded ages, i.e., age heap.

The implications of our findings for other studies using age heaping as a development indicator are twofold. Firstly, for comparative purposes, stable populations are the most appropriate for the application of heaping metrics. The Irish case shows that demographic shocks can induce changes in heaping propensity which are inconsistent with changes in other human capital or state capacity indicators. This is especially important when heaping is used as the sole indicator of human capital development, because while there is generally a positive correlation with other human capital indicators, this is not always the case. Secondly, standardisation should be considered for use in other studies of age heaping as it adds credibility to comparisons across time and space and is grounded in the scientific methods of demography and epidemiology. Yes, in some cases standardisation will produce negligible differences, but this does not negate the value of enhancing the precision of our metrics.

Our study also provides impetus for future inquiry. At a local level, it raises questions about the impact of an older (and more heaping-inclined) population for post-Famine economic and social development. This is especially interesting given the social conservatism and lack of industrialisation that prevailed in the post-Famine decades. More generally, our introduction of standardisation into the heaping literature raises questions about the role of standardisation in the comparative methods of economic history. Of particular interest for future debate is the choice of an appropriate benchmark when comparing different times and places.[45]

[44] Appendix Tables A1 and A2 report the full set of unadjusted and age-standardised *ABCC* indices by sex and county. Tables A3 to A8 then adopt weights from other benchmarks in Table 4 to facilitate comparisons.
[45] The precise choice will depend on the research interest and question; a counterfactual scenario may suggest reference to a particular point in time as a baseline.

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Table A1. *Unadjusted and standardised (using 1841 Irish census weights) ABCC indices for men, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	78.85	72.36	5.50	4.29	78.78	74.00	5.21	4.32	–0.07	1.63
Dublin	76.95	81.06	2.95	16.82	76.80	81.24	2.57	14.52	–0.15	0.18
Kildare	79.14	76.46	5.89	10.19	79.14	76.59	5.69	7.98	0.00	0.14
Kilkenny	75.89	72.25	1.53	4.13	75.62	73.96	0.99	4.27	–0.27	1.71
King's*	76.82	73.02	2.78	5.23	76.96	74.38	2.79	4.85	0.14	1.36
Longford	74.34	67.05	–0.54	–3.37	74.95	68.53	0.10	–3.39	0.61	1.48
Louth	70.56	68.81	–5.60	–0.83	71.19	70.29	–4.92	–0.90	0.63	1.48
Meath	73.53	69.09	–1.62	–0.42	73.79	70.45	–1.45	–0.68	0.26	1.36
Queen's**	76.78	69.00	2.72	–0.56	76.71	70.83	2.45	–0.15	–0.07	1.83
Westmeath	74.59	73.02	–0.20	5.24	74.92	74.38	0.06	4.86	0.33	1.36
Wexford	82.58	74.70	10.48	7.65	82.79	76.10	10.57	7.28	0.21	1.40
Wicklow	80.73	73.28	8.01	5.61	80.72	74.59	7.81	5.15	–0.01	1.31
Munster										
Clare	72.94	64.83	–2.41	–6.57	72.40	67.20	–3.31	–5.26	–0.54	2.37
Cork	73.01	68.35	–2.32	–1.49	72.75	70.05	–2.85	–1.24	–0.27	1.70
Kerry	70.66	64.97	–5.47	–6.37	70.48	66.78	–5.87	–5.86	–0.17	1.81
Limerick	72.93	67.86	–2.43	–2.19	72.63	69.55	–3.00	–1.95	–0.30	1.69
Tipperary	73.16	68.21	–2.12	–1.70	72.65	69.88	–2.97	–1.49	–0.51	1.67
Waterford	72.73	67.35	–2.70	–2.93	72.13	69.52	–3.67	–1.99	–0.60	2.17
Ulster										
Antrim	82.11	81.73	9.86	17.79	82.19	82.16	9.77	15.82	0.08	0.43
Armagh	75.86	73.06	1.50	5.30	76.25	74.44	1.83	4.95	0.39	1.38
Cavan	73.05	64.68	–2.27	–6.78	73.45	66.14	–1.90	–6.76	0.40	1.46
Donegal	69.31	63.30	–7.27	–8.77	70.07	65.29	–6.42	–7.96	0.76	1.99
Down	80.24	76.99	7.35	10.96	80.55	78.35	7.58	10.46	0.31	1.37
Fermanagh	77.60	69.03	3.82	–0.51	77.99	70.45	4.16	–0.68	0.39	1.41
Londonderry	76.43	71.54	2.25	3.11	77.07	72.66	2.93	2.43	0.64	1.12
Monaghan	71.94	65.66	–3.75	–5.38	72.56	67.49	–3.10	–4.85	0.62	1.84
Tyrone	74.42	67.70	–0.43	–2.43	75.19	69.08	0.42	–2.61	0.77	1.38
Connacht										
Galway	67.19	62.00	–10.11	–10.64	67.21	64.57	–10.24	–8.97	0.02	2.57
Leitrim	76.64	66.08	2.54	–4.77	76.76	67.74	2.52	–4.50	0.12	1.67
Mayo	68.49	57.66	–8.37	–16.90	68.50	59.90	–8.52	–15.56	0.01	2.24
Roscommon	70.97	65.49	–5.05	–5.62	71.18	67.61	–4.93	–4.68	0.21	2.13
Sligo	71.37	63.76	–4.51	–8.11	71.65	65.66	–4.31	–7.43	0.28	1.90
National										
Mean	74.74	69.39			74.88	70.93			0.13	1.55
Weighted***	74.21	70.31			74.27	71.77				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

Table A2. *Unadjusted and standardised (using 1841 Irish census weights) ABCC indices for women, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	75.80	70.37	5.01	3.85	75.71	71.63	4.93	3.72	–0.09	1.26
Dublin	72.32	76.80	0.18	13.34	71.75	77.12	–0.57	11.67	–0.57	0.32
Kildare	75.59	72.82	4.71	7.47	75.64	73.62	4.83	6.61	0.06	0.80
Kilkenny	72.14	69.40	–0.06	2.41	72.04	71.30	–0.17	3.24	–0.11	1.90
King's*	73.33	70.59	1.59	4.18	73.36	72.06	1.67	4.35	0.03	1.47
Longford	71.91	65.06	–0.38	–3.98	72.52	65.97	0.50	–4.48	0.61	0.91
Louth	67.34	66.22	–6.70	–2.27	67.26	67.17	–6.79	–2.73	–0.09	0.95
Meath	70.94	66.52	–1.73	–1.82	70.97	67.60	–1.64	–2.11	0.03	1.08
Queen's**	73.36	67.62	1.63	–0.21	73.21	69.06	1.46	0.00	–0.16	1.44
Westmeath	70.80	70.10	–1.92	3.46	71.09	71.61	–1.48	3.70	0.29	1.51
Wexford	80.26	74.92	11.18	10.57	80.49	76.05	11.55	10.11	0.23	1.12
Wicklow	79.86	74.43	10.64	9.84	79.78	75.27	10.56	8.99	–0.08	0.84
Munster										
Clare	68.73	59.72	–4.78	–11.87	68.22	63.06	–5.46	–8.70	–0.52	3.34
Cork	69.73	65.11	–3.40	–3.91	69.66	67.06	–3.46	–2.90	–0.07	1.95
Kerry	67.28	61.73	–6.79	–8.90	67.12	63.92	–6.98	–7.44	–0.16	2.19
Limerick	68.78	63.72	–4.71	–5.96	68.39	65.71	–5.22	–4.85	–0.39	1.99
Tipperary	69.03	63.77	–4.36	–5.90	68.48	65.68	–5.09	–4.90	–0.55	1.91
Waterford	69.85	66.24	–3.23	–2.25	69.63	68.18	–3.50	–1.28	–0.22	1.94
Ulster										
Antrim	81.46	80.76	12.85	19.19	81.44	80.73	12.86	16.90	–0.02	–0.03
Armagh	75.43	72.22	4.50	6.59	75.51	72.84	4.64	5.47	0.08	0.62
Cavan	69.82	63.66	–3.28	–6.05	69.92	64.67	–3.11	–6.36	0.10	1.00
Donegal	70.12	64.34	–2.86	–5.04	70.46	65.45	–2.36	–5.24	0.34	1.10
Down	79.31	77.21	9.87	13.95	79.45	77.80	10.10	12.65	0.14	0.59
Fermanagh	75.76	69.78	4.96	2.98	76.00	70.58	5.33	2.19	0.24	0.80
Londonderry	76.22	73.35	5.59	8.25	76.55	73.89	6.09	6.99	0.33	0.54
Monaghan	70.69	66.00	–2.07	–2.60	70.81	66.82	–1.87	–3.25	0.12	0.82
Tyrone	74.17	69.61	2.76	2.73	74.55	70.27	3.32	1.75	0.38	0.66
Connacht										
Galway	64.35	59.69	–10.85	–11.92	64.12	62.29	–11.14	–9.81	–0.23	2.60
Leitrim	73.27	65.06	1.50	–3.99	73.09	66.38	1.29	–3.88	–0.18	1.33
Mayo	66.56	56.93	–7.80	–15.99	66.36	58.58	–8.04	–15.18	–0.20	1.65
Roscommon	67.87	62.60	–5.98	–7.61	67.63	64.32	–6.27	–6.87	–0.23	1.72
Sligo	67.81	61.98	–6.06	–8.53	67.81	63.29	–6.02	–8.36	0.00	1.31
National										
Mean	72.18	67.76			72.16	69.06			–0.03	1.30
Weighted***	71.60	68.54			71.51	69.78				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

Table A3. *Unadjusted and standardised (using US 1900 weights) ABCC indices for men, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	78.85	72.36	5.50	4.29	78.73	73.83	5.30	4.33	–0.12	1.47
Dublin	76.95	81.06	2.95	16.82	76.68	81.13	2.55	14.64	–0.27	0.07
Kildare	79.14	76.46	5.89	10.19	79.08	76.46	5.77	8.05	–0.06	0.01
Kilkenny	75.89	72.25	1.53	4.13	75.53	73.81	1.01	4.30	–0.36	1.56
King's*	76.82	73.02	2.78	5.23	76.88	74.20	2.82	4.86	0.06	1.18
Longford	74.34	67.05	–0.54	–3.37	74.86	68.24	0.12	–3.56	0.52	1.19
Louth	70.56	68.81	–5.60	–0.83	71.04	70.17	–5.00	–0.84	0.47	1.36
Meath	73.53	69.09	–1.62	–0.42	73.69	70.28	–1.45	–0.68	0.15	1.19
Queen's**	76.78	69.00	2.72	–0.56	76.63	70.71	2.49	–0.07	–0.14	1.72
Westmeath	74.59	73.02	–0.20	5.24	74.80	74.26	0.04	4.95	0.21	1.24
Wexford	82.58	74.70	10.48	7.65	82.76	76.00	10.68	7.40	0.18	1.30
Wicklow	80.73	73.28	8.01	5.61	80.73	74.42	7.96	5.17	0.00	1.14
Munster										
Clare	72.94	64.83	–2.41	–6.57	72.27	67.00	–3.35	–5.32	–0.67	2.17
Cork	73.01	68.35	–2.32	–1.49	72.58	69.91	–2.93	–1.20	–0.43	1.56
Kerry	70.66	64.97	–5.47	–6.37	70.32	66.65	–5.96	–5.82	–0.34	1.68
Limerick	72.93	67.86	–2.43	–2.19	72.51	69.40	–3.02	–1.93	–0.42	1.54
Tipperary	73.16	68.21	–2.12	–1.70	72.53	69.69	–3.00	–1.51	–0.63	1.49
Waterford	72.73	67.35	–2.70	–2.93	71.99	69.37	–3.72	–1.96	–0.74	2.02
Ulster										
Antrim	82.11	81.73	9.86	17.79	82.17	82.07	9.89	15.98	0.05	0.34
Armagh	75.86	73.06	1.50	5.30	76.11	74.28	1.79	4.97	0.25	1.22
Cavan	73.05	64.68	–2.27	–6.78	73.34	65.92	–1.91	–6.85	0.30	1.24
Donegal	69.31	63.30	–7.27	–8.77	69.93	65.11	–6.47	–7.98	0.62	1.81
Down	80.24	76.99	7.35	10.96	80.49	78.24	7.65	10.56	0.25	1.25
Fermanagh	77.60	69.03	3.82	–0.51	77.90	70.27	4.18	–0.70	0.30	1.23
Londonderry	76.43	71.54	2.25	3.11	77.01	72.54	2.98	2.51	0.58	1.00
Monaghan	71.94	65.66	–3.75	–5.38	72.40	67.28	–3.17	–4.93	0.46	1.62
Tyrone	74.42	67.70	–0.43	–2.43	75.09	68.93	0.43	–2.59	0.67	1.23
Connacht										
Galway	67.19	62.00	–10.11	–10.64	67.04	64.33	–10.34	–9.09	–0.15	2.33
Leitrim	76.64	66.08	2.54	–4.77	76.68	67.47	2.56	–4.65	0.05	1.40
Mayo	68.49	57.66	–8.37	–16.90	68.38	59.65	–8.55	–15.71	–0.11	1.99
Roscommon	70.97	65.49	–5.05	–5.62	71.04	67.37	–4.99	–4.80	0.07	1.88
Sligo	71.37	63.76	–4.51	–8.11	71.54	65.43	–4.33	–7.54	0.17	1.67
National										
Mean	74.74	69.39			74.77	70.76			0.03	1.38
Weighted***	74.21	70.31			74.15	71.61				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

Table A4. *Unadjusted and standardised (using US 1900 weights) ABCC indices for women, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	75.80	70.37	5.01	3.85	75.65	71.42	4.94	3.66	–0.15	1.06
Dublin	72.32	76.80	0.18	13.34	71.66	76.99	–0.60	11.74	–0.66	0.19
Kildare	75.59	72.82	4.71	7.47	75.60	73.46	4.86	6.62	0.01	0.64
Kilkenny	72.14	69.40	–0.06	2.41	71.97	71.13	–0.17	3.22	–0.18	1.73
King's*	73.33	70.59	1.59	4.18	73.30	71.89	1.68	4.33	–0.03	1.30
Longford	71.91	65.06	–0.38	–3.98	72.44	65.77	0.49	–4.55	0.53	0.71
Louth	67.34	66.22	–6.70	–2.27	67.15	67.00	–6.86	–2.76	–0.20	0.78
Meath	70.94	66.52	–1.73	–1.82	70.90	67.46	–1.66	–2.09	–0.04	0.94
Queen's**	73.36	67.62	1.63	–0.21	73.14	68.87	1.46	–0.06	–0.23	1.25
Westmeath	70.80	70.10	–1.92	3.46	71.03	71.49	–1.47	3.75	0.24	1.38
Wexford	80.26	74.92	11.18	10.57	80.51	75.90	11.68	10.15	0.25	0.97
Wicklow	79.86	74.43	10.64	9.84	79.79	75.08	10.69	8.96	–0.07	0.65
Munster										
Clare	68.73	59.72	–4.78	–11.87	68.17	62.85	–5.43	–8.78	–0.56	3.14
Cork	69.73	65.11	–3.40	–3.91	69.55	66.92	–3.52	–2.88	–0.18	1.81
Kerry	67.28	61.73	–6.79	–8.90	67.04	63.80	–7.00	–7.40	–0.24	2.07
Limerick	68.78	63.72	–4.71	–5.96	68.34	65.58	–5.20	–4.83	–0.44	1.85
Tipperary	69.03	63.77	–4.36	–5.90	68.38	65.45	–5.14	–5.01	–0.65	1.69
Waterford	69.85	66.24	–3.23	–2.25	69.52	68.01	–3.57	–1.29	–0.33	1.77
Ulster										
Antrim	81.46	80.76	12.85	19.19	81.42	80.67	12.94	17.07	–0.04	–0.10
Armagh	75.43	72.22	4.50	6.59	75.43	72.76	4.63	5.60	0.00	0.54
Cavan	69.82	63.66	–3.28	–6.05	69.85	64.48	–3.10	–6.43	0.04	0.81
Donegal	70.12	64.34	–2.86	–5.04	70.38	65.31	–2.37	–5.22	0.26	0.96
Down	79.31	77.21	9.87	13.95	79.41	77.71	10.16	12.78	0.10	0.50
Fermanagh	75.76	69.78	4.96	2.98	75.97	70.49	5.39	2.30	0.21	0.71
Londonderry	76.22	73.35	5.59	8.25	76.50	73.83	6.12	7.15	0.28	0.48
Monaghan	70.69	66.00	–2.07	–2.60	70.71	66.65	–1.92	–3.27	0.01	0.65
Tyrone	74.17	69.61	2.76	2.73	74.46	70.17	3.29	1.83	0.29	0.56
Connacht										
Galway	64.35	59.69	–10.85	–11.92	63.99	62.08	–11.23	–9.91	–0.36	2.39
Leitrim	73.27	65.06	1.50	–3.99	73.02	66.20	1.29	–3.92	–0.25	1.14
Mayo	66.56	56.93	–7.80	–15.99	66.28	58.36	–8.06	–15.31	–0.28	1.43
Roscommon	67.87	62.60	–5.98	–7.61	67.54	64.11	–6.31	–6.96	–0.33	1.51
Sligo	67.81	61.98	–6.06	–8.53	67.76	63.07	–6.01	–8.47	–0.05	1.09
National										
Mean	72.18	67.76			72.09	68.90			–0.09	1.14
Weighted***	71.60	68.54			71.44	69.64				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

Table A5. *Unadjusted and standardised ABCC indices (using composite weights) for men, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	78.85	72.36	5.50	4.29	78.49	73.56	5.33	4.41	–0.36	1.19
Dublin	76.95	81.06	2.95	16.82	76.55	80.93	2.73	14.88	–0.39	–0.13
Kildare	79.14	76.46	5.89	10.19	78.91	76.12	5.88	8.06	–0.24	–0.34
Kilkenny	75.89	72.25	1.53	4.13	75.24	73.51	0.97	4.35	–0.64	1.26
King's*	76.82	73.02	2.78	5.23	76.64	73.95	2.85	4.98	–0.18	0.93
Longford	74.34	67.05	–0.54	–3.37	74.58	67.97	0.08	–3.51	0.24	0.92
Louth	70.56	68.81	–5.60	–0.83	70.73	69.75	–5.10	–0.98	0.16	0.94
Meath	73.53	69.09	–1.62	–0.42	73.41	69.93	–1.49	–0.73	–0.12	0.84
Queen's**	76.78	69.00	2.72	–0.56	76.39	70.40	2.51	–0.06	–0.39	1.41
Westmeath	74.59	73.02	–0.20	5.24	74.58	73.97	0.07	5.00	–0.02	0.94
Wexford	82.58	74.70	10.48	7.65	82.59	75.75	10.83	7.53	0.01	1.06
Wicklow	80.73	73.28	8.01	5.61	80.55	74.23	8.09	5.37	–0.18	0.95
Munster										
Clare	72.94	64.83	–2.41	–6.57	71.99	66.62	–3.40	–5.43	–0.95	1.79
Cork	73.01	68.35	–2.32	–1.49	72.25	69.45	–3.05	–1.41	–0.76	1.10
Kerry	70.66	64.97	–5.47	–6.37	70.03	66.22	–6.02	–6.00	–0.62	1.25
Limerick	72.93	67.86	–2.43	–2.19	72.19	69.02	–3.13	–2.03	–0.74	1.15
Tipperary	73.16	68.21	–2.12	–1.70	72.25	69.33	–3.05	–1.58	–0.91	1.12
Waterford	72.73	67.35	–2.70	–2.93	71.61	68.92	–3.91	–2.17	–1.11	1.56
Ulster										
Antrim	82.11	81.73	9.86	17.79	82.07	81.91	10.12	16.28	–0.05	0.18
Armagh	75.86	73.06	1.50	5.30	75.94	74.07	1.91	5.14	0.08	1.01
Cavan	73.05	64.68	–2.27	–6.78	73.10	65.60	–1.91	–6.87	0.05	0.92
Donegal	69.31	63.30	–7.27	–8.77	69.63	64.72	–6.56	–8.12	0.32	1.42
Down	80.24	76.99	7.35	10.96	80.36	78.05	7.83	10.79	0.12	1.06
Fermanagh	77.60	69.03	3.82	–0.51	77.70	70.00	4.26	–0.63	0.10	0.97
Londonderry	76.43	71.54	2.25	3.11	76.78	72.27	3.03	2.59	0.35	0.73
Monaghan	71.94	65.66	–3.75	–5.38	72.15	66.99	–3.18	–4.91	0.21	1.33
Tyrone	74.42	67.70	–0.43	–2.43	74.85	68.64	0.43	–2.57	0.43	0.94
Connacht										
Galway	67.19	62.00	–10.11	–10.64	66.70	63.94	–10.50	–9.24	–0.49	1.94
Leitrim	76.64	66.08	2.54	–4.77	76.43	67.16	2.56	–4.66	–0.21	1.08
Mayo	68.49	57.66	–8.37	–16.90	68.05	59.20	–8.69	–15.96	–0.44	1.54
Roscommon	70.97	65.49	–5.05	–5.62	70.77	67.03	–5.04	–4.85	–0.20	1.54
Sligo	71.37	63.76	–4.51	–8.11	71.22	65.06	–4.43	–7.65	–0.15	1.30
National										
Mean	74.74	69.39			74.52	70.45			–0.22	1.06
Weighted***	74.21	70.31			73.90	71.30				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

Table A6. *Unadjusted and standardised ABCC indices (composite weights) for women, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	75.80	70.37	5.01	3.85	75.40	71.20	5.01	3.78	–0.40	0.83
Dublin	72.32	76.80	0.18	13.34	71.45	76.79	–0.48	11.94	–0.86	–0.01
Kildare	75.59	72.82	4.71	7.47	75.36	73.22	4.96	6.73	–0.23	0.40
Kilkenny	72.14	69.40	–0.06	2.41	71.62	70.78	–0.26	3.17	–0.53	1.38
King's*	73.33	70.59	1.59	4.18	73.03	71.64	1.71	4.42	–0.30	1.05
Longford	71.91	65.06	–0.38	–3.98	72.14	65.48	0.48	–4.56	0.23	0.42
Louth	67.34	66.22	–6.70	–2.27	66.82	66.66	–6.94	–2.83	–0.53	0.44
Meath	70.94	66.52	–1.73	–1.82	70.61	67.11	–1.66	–2.17	–0.33	0.59
Queen's**	73.36	67.62	1.63	–0.21	72.85	68.62	1.46	0.02	–0.51	1.00
Westmeath	70.80	70.10	–1.92	3.46	70.73	71.17	–1.49	3.75	–0.07	1.07
Wexford	80.26	74.92	11.18	10.57	80.26	75.67	11.78	10.30	0.00	0.75
Wicklow	79.86	74.43	10.64	9.84	79.59	74.90	10.84	9.18	–0.28	0.48
Munster										
Clare	68.73	59.72	–4.78	–11.87	67.81	62.45	–5.56	–8.96	–0.92	2.74
Cork	69.73	65.11	–3.40	–3.91	69.18	66.51	–3.66	–3.05	–0.56	1.40
Kerry	67.28	61.73	–6.79	–8.90	66.65	63.37	–7.18	–7.63	–0.63	1.64
Limerick	68.78	63.72	–4.71	–5.96	67.93	65.19	–5.39	–4.97	–0.85	1.47
Tipperary	69.03	63.77	–4.36	–5.90	68.03	65.11	–5.26	–5.10	–1.01	1.34
Waterford	69.85	66.24	–3.23	–2.25	69.10	67.61	–3.76	–1.45	–0.75	1.37
Ulster										
Antrim	81.46	80.76	12.85	19.19	81.27	80.53	13.18	17.38	–0.19	–0.24
Armagh	75.43	72.22	4.50	6.59	75.25	72.53	4.80	5.72	–0.18	0.30
Cavan	69.82	63.66	–3.28	–6.05	69.55	64.17	–3.13	–6.46	–0.26	0.51
Donegal	70.12	64.34	–2.86	–5.04	70.08	64.95	–2.39	–5.32	–0.03	0.61
Down	79.31	77.21	9.87	13.95	79.24	77.54	10.36	13.03	–0.07	0.33
Fermanagh	75.76	69.78	4.96	2.98	75.74	70.18	5.48	2.30	–0.03	0.41
Londonderry	76.22	73.35	5.59	8.25	76.29	73.57	6.25	7.24	0.07	0.22
Monaghan	70.69	66.00	–2.07	–2.60	70.45	66.39	–1.89	–3.22	–0.24	0.39
Tyrone	74.17	69.61	2.76	2.73	74.25	69.88	3.41	1.86	0.07	0.27
Connacht										
Galway	64.35	59.69	–10.85	–11.92	63.64	61.73	–11.37	–10.02	–0.72	2.04
Leitrim	73.27	65.06	1.50	–3.99	72.77	65.86	1.35	–4.00	–0.50	0.81
Mayo	66.56	56.93	–7.80	–15.99	65.95	57.98	–8.15	–15.49	–0.61	1.05
Roscommon	67.87	62.60	–5.98	–7.61	67.22	63.80	–6.38	–7.01	–0.65	1.19
Sligo	67.81	61.98	–6.06	–8.53	67.38	62.73	–6.16	–8.56	–0.43	0.75
National										
Mean	72.18	67.76			71.80	68.60			–0.38	0.84
Weighted***	71.60	68.54			71.14	69.34				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

Table A7. *Unadjusted and standardised (using equal weights) ABCC indices for men, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	78.85	72.36	5.50	4.29	76.03	70.44	5.81	5.07	–2.83	–1.92
Dublin	76.95	81.06	2.95	16.82	74.76	78.55	4.05	17.16	–2.19	–2.51
Kildare	79.14	76.46	5.89	10.19	76.85	72.47	6.96	8.10	–2.29	–3.98
Kilkenny	75.89	72.25	1.53	4.13	72.35	70.22	0.69	4.75	–3.54	–2.03
King's*	76.82	73.02	2.78	5.23	74.06	70.98	3.08	5.88	–2.76	–2.03
Longford	74.34	67.05	–0.54	–3.37	71.67	64.67	–0.25	–3.53	–2.67	–2.38
Louth	70.56	68.81	–5.60	–0.83	67.43	65.65	–6.15	–2.08	–3.13	–3.17
Meath	73.53	69.09	–1.62	–0.42	70.54	66.23	–1.82	–1.22	–2.99	–2.87
Queen's**	76.78	69.00	2.72	–0.56	73.79	67.10	2.71	0.09	–2.98	–1.90
Westmeath	74.59	73.02	–0.20	5.24	72.03	70.75	0.26	5.53	–2.56	–2.27
Wexford	82.58	74.70	10.48	7.65	80.66	72.97	12.27	8.84	–1.91	–1.72
Wicklow	80.73	73.28	8.01	5.61	78.65	71.75	9.47	7.03	–2.08	–1.53
Munster										
Clare	72.94	64.83	–2.41	–6.57	69.05	62.76	–3.90	–6.39	–3.89	–2.07
Cork	73.01	68.35	–2.32	–1.49	68.82	65.05	–4.22	–2.97	–4.19	–3.30
Kerry	70.66	64.97	–5.47	–6.37	67.06	62.13	–6.66	–7.33	–3.60	–2.84
Limerick	72.93	67.86	–2.43	–2.19	68.90	65.15	–4.10	–2.82	–4.03	–2.71
Tipperary	73.16	68.21	–2.12	–1.70	69.27	65.51	–3.59	–2.29	–3.89	–2.70
Waterford	72.73	67.35	–2.70	–2.93	67.92	64.54	–5.47	–3.73	–4.81	–2.81
Ulster										
Antrim	82.11	81.73	9.86	17.79	80.74	79.94	12.37	19.24	–1.37	–1.79
Armagh	75.86	73.06	1.50	5.30	73.82	71.52	2.74	6.69	–2.04	–1.54
Cavan	73.05	64.68	–2.27	–6.78	70.50	62.16	–1.88	–7.29	–2.55	–2.53
Donegal	69.31	63.30	–7.27	–8.77	66.51	60.81	–7.43	–9.29	–2.80	–2.49
Down	80.24	76.99	7.35	10.96	78.63	75.73	9.43	12.96	–1.61	–1.26
Fermanagh	77.60	69.03	3.82	–0.51	75.40	67.01	4.95	–0.05	–2.20	–2.03
Londonderry	76.43	71.54	2.25	3.11	74.37	69.35	3.51	3.44	–2.05	–2.20
Monaghan	71.94	65.66	–3.75	–5.38	69.33	63.77	–3.51	–4.88	–2.61	–1.88
Tyrone	74.42	67.70	–0.43	–2.43	72.16	65.45	0.44	–2.37	–2.26	–2.25
Connacht										
Galway	67.19	62.00	–10.11	–10.64	63.23	59.88	–11.99	–10.68	–3.96	–2.12
Leitrim	76.64	66.08	2.54	–4.77	73.81	63.60	2.73	–5.13	–2.83	–2.47
Mayo	68.49	57.66	–8.37	–16.90	64.87	54.70	–9.72	–18.41	–3.62	–2.97
Roscommon	70.97	65.49	–5.05	–5.62	67.85	63.35	–5.57	–5.51	–3.12	–2.14
Sligo	71.37	63.76	–4.51	–8.11	68.09	61.15	–5.23	–8.79	–3.28	–2.61
National										
Mean	74.74	69.39			71.85	67.04			–2.89	–2.34
Weighted***	74.21	70.31			71.15	67.94				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

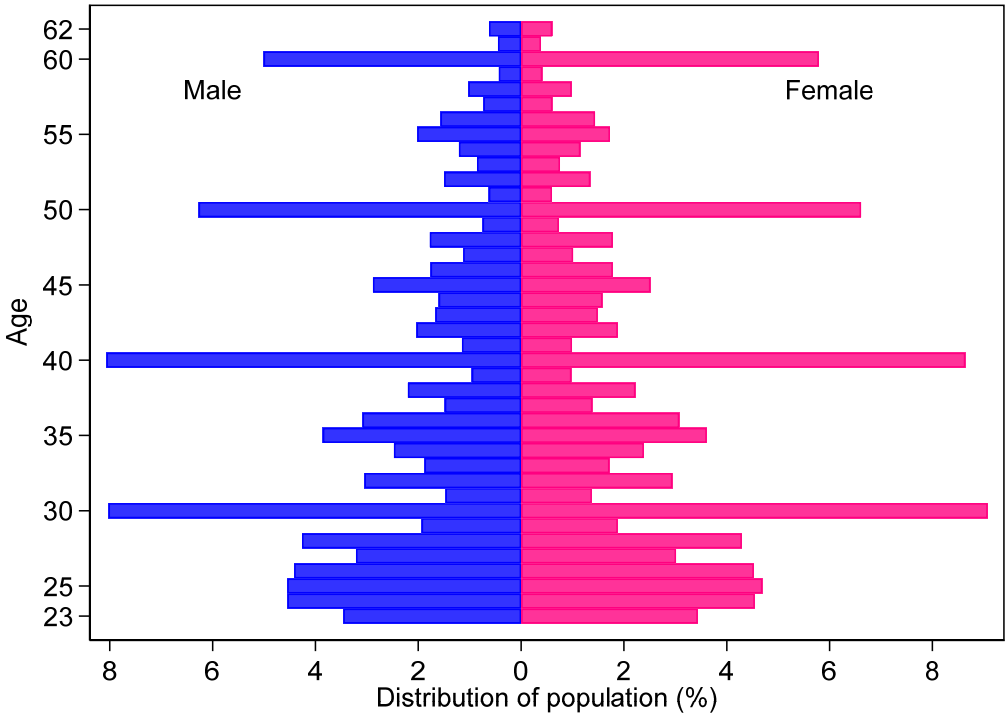
Table A8. *Unadjusted and standardised (using equal weights) ABCC indices for women, by county, 1841 and 1871*

Province / *County*	*Unadjusted indices*				*Standardised indices*				*Difference unadjusted and standardised*	
	ABCC		*Difference with national average*		*Age-standardised ABCC*		*Difference with national average*			
	1841	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*	*1841*	*1871*
	/100		*%*		*/100*		*%*		*p. p.*	
Leinster										
Carlow	75.80	70.37	5.01	3.85	72.82	68.38	5.59	4.57	–2.98	–1.98
Dublin	72.32	76.80	0.18	13.34	69.16	74.38	0.29	13.73	–3.16	–2.42
Kildare	75.59	72.82	4.71	7.47	72.94	70.34	5.77	7.56	–2.64	–2.48
Kilkenny	72.14	69.40	–0.06	2.41	68.29	67.08	–0.97	2.57	–3.85	–2.31
King's*	73.33	70.59	1.59	4.18	70.26	68.70	1.88	5.05	–3.07	–1.89
Longford	71.91	65.06	–0.38	–3.98	69.19	62.26	0.33	–4.79	–2.72	–2.80
Louth	67.34	66.22	–6.70	–2.27	63.54	63.06	–7.86	–3.57	–3.80	–3.16
Meath	70.94	66.52	–1.73	–1.82	67.79	63.54	–1.70	–2.84	–3.15	–2.98
Queen's**	73.36	67.62	1.63	–0.21	69.97	65.67	1.46	0.41	–3.39	–1.95
Westmeath	70.80	70.10	–1.92	3.46	67.82	67.92	–1.66	3.86	–2.98	–2.19
Wexford	80.26	74.92	11.18	10.57	77.90	72.96	12.96	11.57	–2.36	–1.96
Wicklow	79.86	74.43	10.64	9.84	77.55	72.53	12.45	10.90	–2.31	–1.90
Munster										
Clare	68.73	59.72	–4.78	–11.87	64.50	58.42	–6.47	–10.66	–4.23	–1.29
Cork	69.73	65.11	–3.40	–3.91	65.58	62.52	–4.90	–4.41	–4.15	–2.59
Kerry	67.28	61.73	–6.79	–8.90	63.00	59.31	–8.64	–9.30	–4.28	–2.42
Limerick	68.78	63.72	–4.71	–5.96	64.22	61.38	–6.87	–6.15	–4.56	–2.35
Tipperary	69.03	63.77	–4.36	–5.90	64.57	61.35	–6.37	–6.18	–4.46	–2.41
Waterford	69.85	66.24	–3.23	–2.25	65.18	63.65	–5.49	–2.67	–4.68	–2.58
Ulster										
Antrim	81.46	80.76	12.85	19.19	79.58	78.78	15.39	20.46	–1.88	–1.99
Armagh	75.43	72.22	4.50	6.59	73.21	70.03	6.16	7.08	–2.22	–2.20
Cavan	69.82	63.66	–3.28	–6.05	66.66	60.86	–3.34	–6.94	–3.16	–2.80
Donegal	70.12	64.34	–2.86	–5.04	67.16	61.47	–2.61	–6.01	–2.96	–2.87
Down	79.31	77.21	9.87	13.95	77.35	75.49	12.16	15.43	–1.96	–1.72
Fermanagh	75.76	69.78	4.96	2.98	73.38	67.11	6.41	2.62	–2.38	–2.67
Londonderry	76.22	73.35	5.59	8.25	74.05	70.91	7.38	8.44	–2.17	–2.44
Monaghan	70.69	66.00	–2.07	–2.60	67.74	63.58	–1.77	–2.78	–2.95	–2.42
Tyrone	74.17	69.61	2.76	2.73	71.87	66.89	4.21	2.28	–2.30	–2.72
Connacht										
Galway	64.35	59.69	–10.85	–11.92	60.21	58.08	–12.69	–11.19	–4.14	–1.61
Leitrim	73.27	65.06	1.50	–3.99	70.27	62.36	1.90	–4.65	–3.00	–2.70
Mayo	66.56	56.93	–7.80	–15.99	62.93	54.12	–8.74	–17.25	–3.63	–2.81
Roscommon	67.87	62.60	–5.98	–7.61	64.11	60.43	–7.04	–7.60	–3.76	–2.17
Sligo	67.81	61.98	–6.06	–8.53	63.99	59.16	–7.20	–9.54	–3.82	–2.82
National										
Mean	72.18	67.76			68.96	65.40			–3.22	–2.36
Weighted***	71.60	68.54			68.22	66.19				

Note: * King's County is now known as County Offaly. ** Queen's County is now known as County Laois. Underlined constitute the six counties of Northern Ireland from 1921. *** Weighted by county population size (23–62-year-olds).
Source: See Table 2.

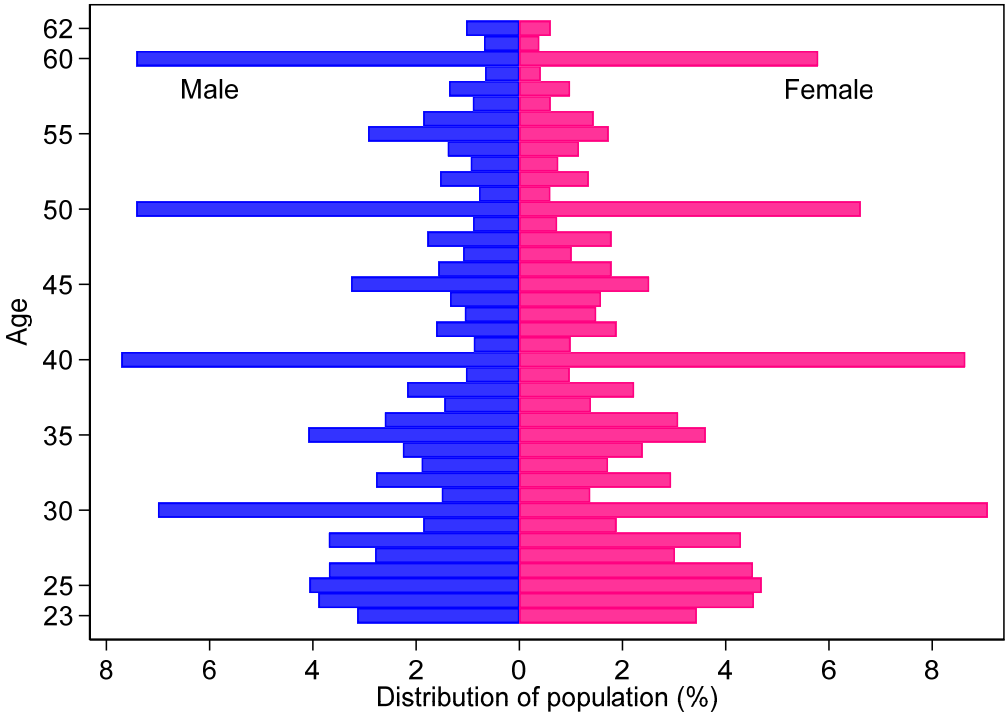
Figure A1. *Population pyramids*

Panel A. *Ireland, 1841*



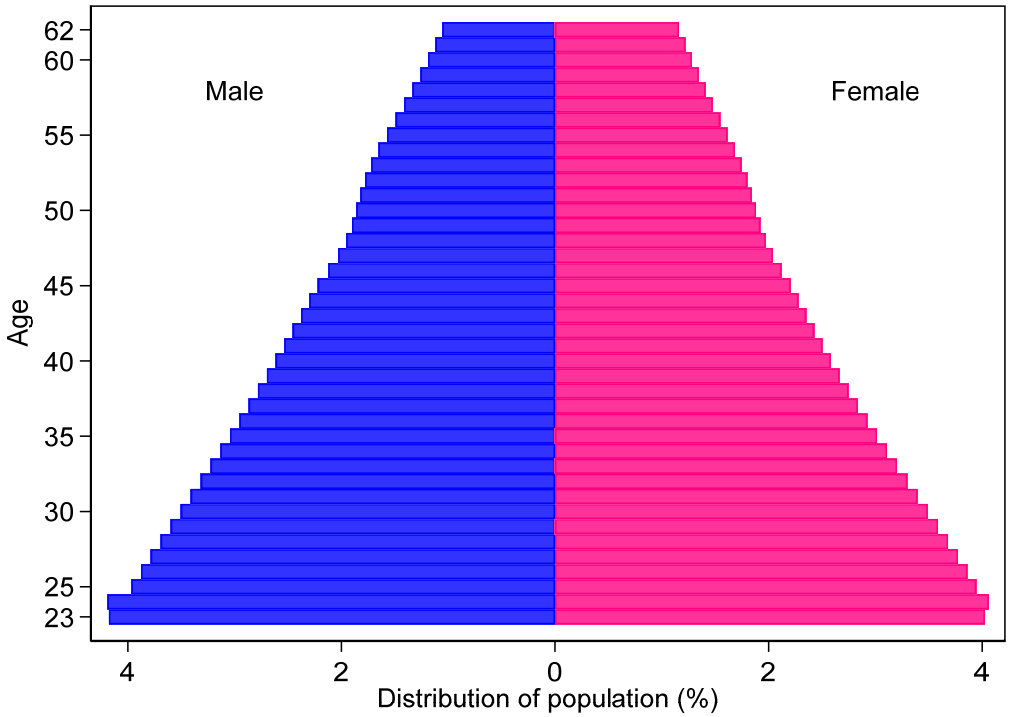
Source: Census of Ireland (P.P. 1843, XXIV).

Panel B. *Ireland, 1871*



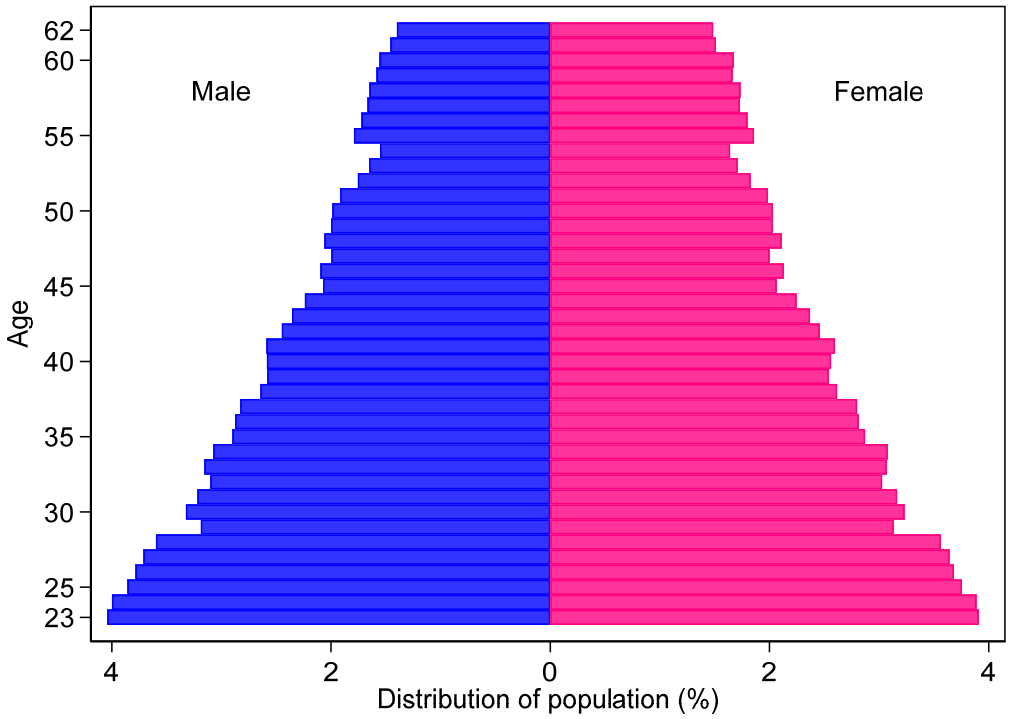
Source: Census of Ireland (P.P. 1876, LXXXI).

Panel C. *England and Wales, 1901*



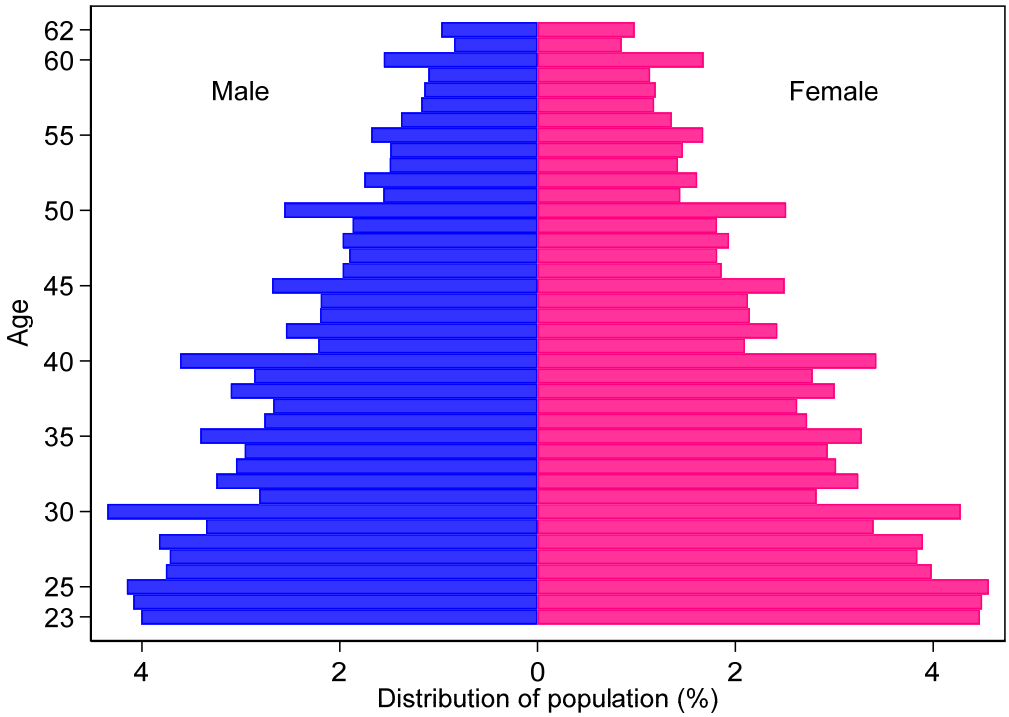
Source: Census of England and Wales (P.P. 1904, CVIII).

Panel D. *Belgium, 1900*



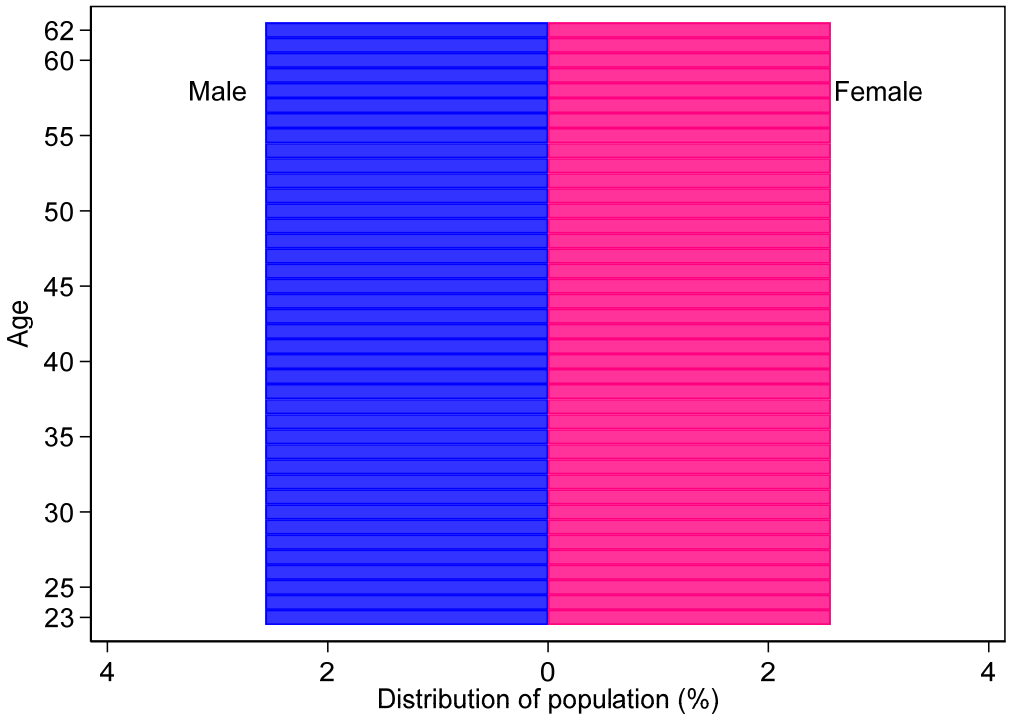
Source: *Recensement général* (1903).

Panel E. *United States, 1900*



Source: Twelfth census of the United States (1903).

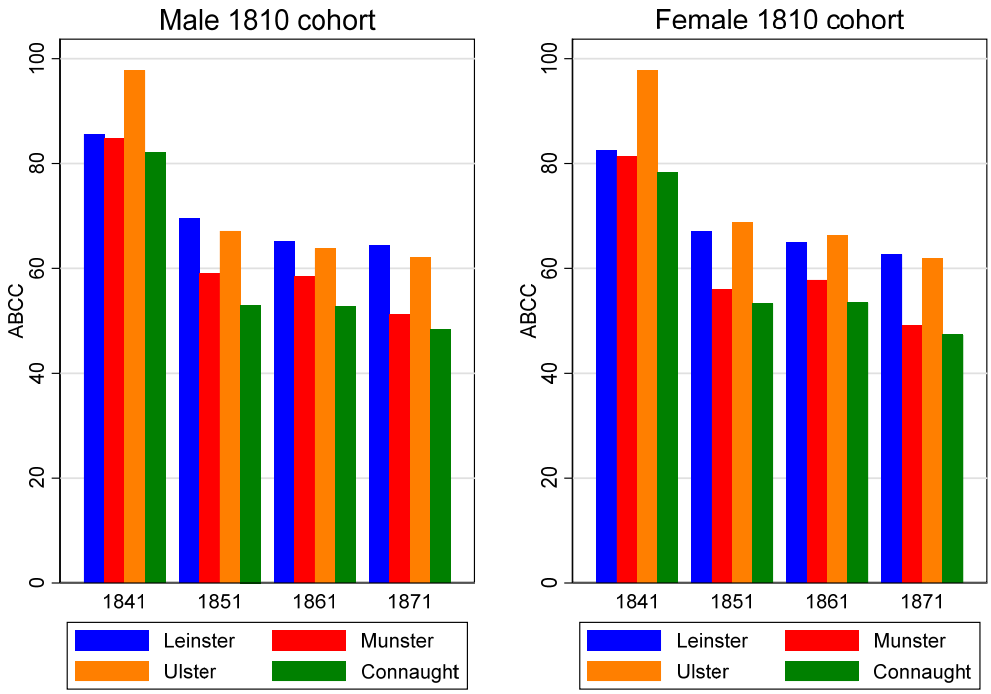
Panel F. *Equal weights population "rectangle"*



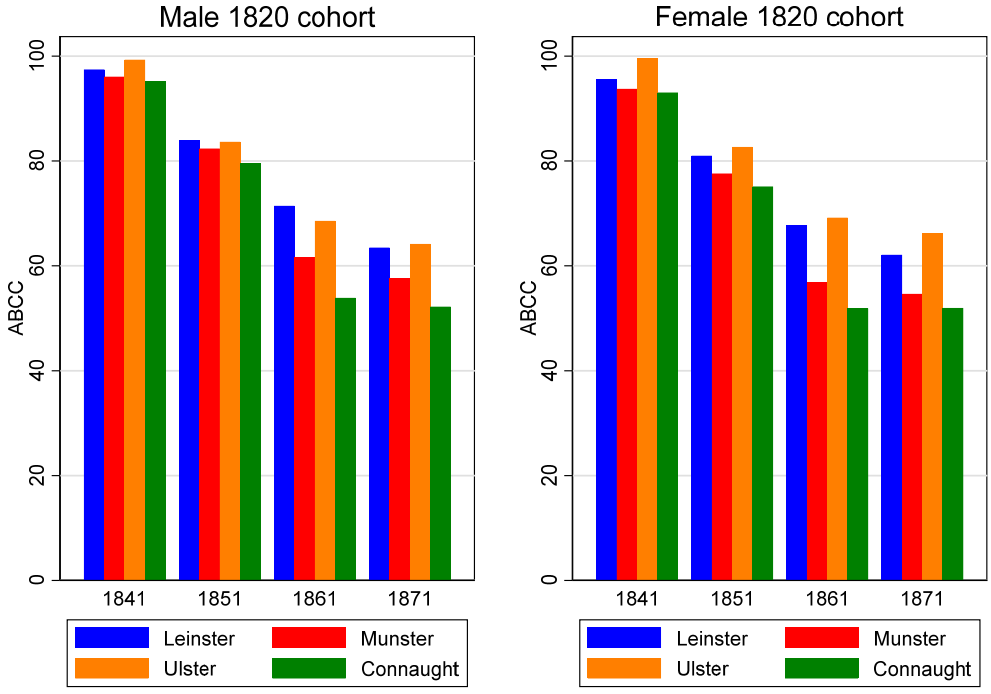
Source: Implied by A'Hearn et al., 'Rethinking age heaping', footnote 38.

Figure A2. *Age heaping by birth cohort across censuses, 1841–1871*

Panel A. *1810 cohort*



Panel B. *1820 cohort*



Panel C. *1830 cohort*

Source: Census of Ireland (P.P. 1843, XXIV); *Census of Ireland* (P.P. 1851, XXXI); *Census of Ireland* (P.P. 1863, LVII); *Census of Ireland* (P.P. 1863, LXI); *Census of Ireland* (P.P. 1876, LXXXI).

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