Boom, echo, pulse, flow

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Abstract

Human population renewal starts with births. Since births can happen at any time in the year and over a wide range of ages, demographers typically imagine the birth series as a continuous flow. Taking this construct literally, we visualize the birth series as a flow. A long birth series allows us to juxtapose the children born in a particular year with the children that they in turn had over the course of their lives, yielding a crude notion of cohort replacement. Macro patterns in generational growth define the meandering path of the flow, while temporal booms and busts echo through the flow with the regularity of a pulse.

1 Introduction

Usually we think of fertiltiy as an age-regulated process. In any case it is bounded by menarche and menopause, both of which are anchored to age. These may move, but not far or fast. And between these bounds fertility patterns appear to conform to some regular schema, best captured by fertility rates. We retreat from rates, the material of projections, to babies, the raw material of population renewal. A picture of the births in a year is for demographers most instinctively broken down by the age of mothers who gave birth in that year, Fig. 1a, or by the year of birth of mothers Fig. 1b. These two distributions are essentially identical, but appear as mirror images if chronological time is enforced in x.

If one disposes of a long-enough time series of births classified by mothers' year of birth, then one may further examine and break down the full reproductive career of the cohort of individuals born in a particular year. As the childbearing of a cohort is spread over a synchronous span of ages and years. Since age and calendar time are synchronous for a cohort, the classification by age (Fig. 2a) or year (Fig. 2b) yields identical and redundant distributions.

The births in a year are classified by mothers' cohort, i.e. cohort *origins* in Fig. 1b, whereas the births *from* a cohort are classified *to* time in Fig. 2b. The two distributions are different in kind, but relatable and both on a common scale. A fuller representation of their relationship would place them as two disjoint distributions on the same timeline, as in Fig 3.

The two distributions in Fig. 3 are related, and of comparable scale, but different in kind. The x coordinate of the left distribution is indexed to mothers's birth cohort, whereas the x coordinate of the right distribution is indexed to child cohort. In this way the x coordinates belong to grandmothers and grandchildren, where the *ego* generation is 1900. These are two quantities that we may wish to compare in various ways to get a better feel and understanding of the Swedish birth series.

For the case of these Swedish data, we have 241 such distribution pairs, making single-axis rendering impractical. An honest attempt might look like Fig. 4, where we reflect the Fig. 3 left distribution over y (**A**), keeping the Fig. 3 right-side distribution on top (**B**). These two distributions are linked by the year 1900, which of course overlaps with neither of them. In this representation, **A** and **B** are re-drawn for

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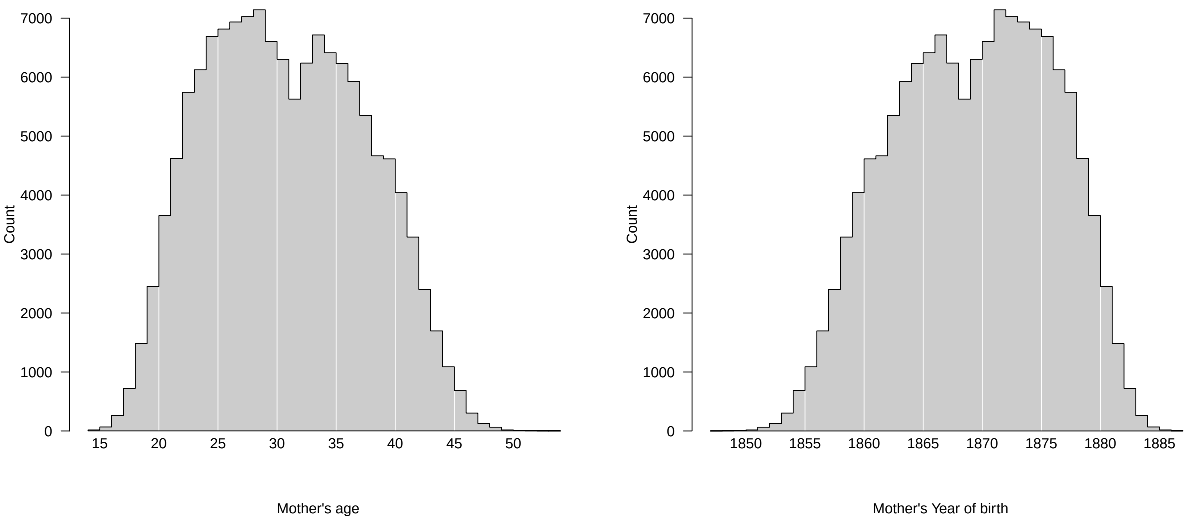
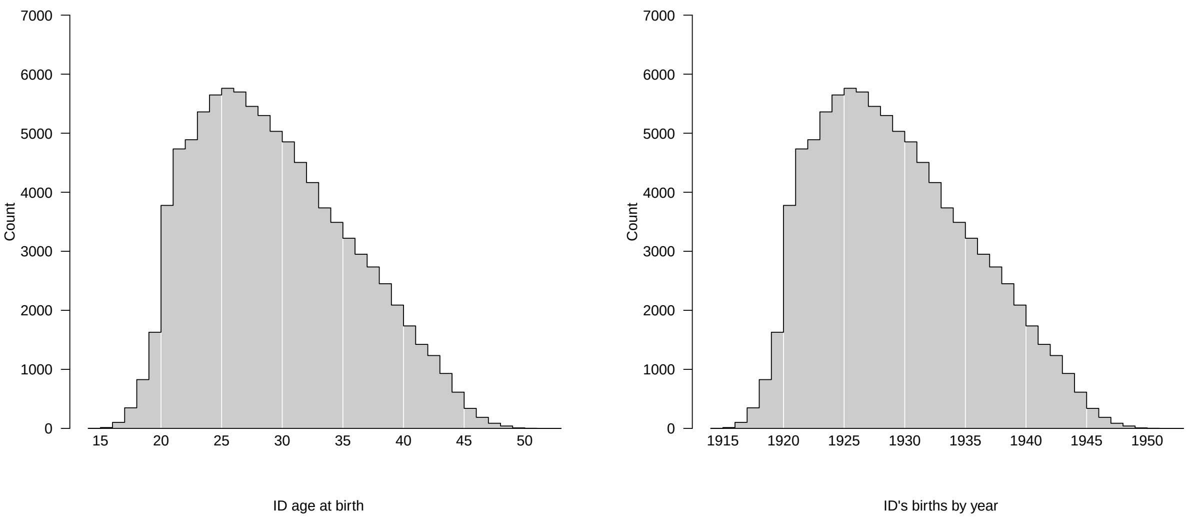


(a) Births in 1900 by age of mother

(b) Births in 1900 by year of birth of mother

Figure 1: Births in a year structured by mothers' age versus mothers' year of birth are a reflection over y and shift over x.



(a) Births from mothers born in 1900 by age of mother

(b) Births from mothers born in 1900 by year

Figure 2: Births of a cohort structured by mothers' age versus mothers' year of birth are a reflection over y and shift over x.

each possible ego year (1775-2015), and therefore imply a large sequential set of overlapping distributions. Each 20th distribution is highlighted, that is, this is an honest attempt to make this graph legible, but i) the high degree of overlapping and ii) the spatial dissociation of each **A** — **B** pair makes the intended comparison difficult over the series.

Fig. 4 produces at least two noteworthy artifacts that we may wish to preserve or clarify. 1) First order differences in the top series appear to cascade into the lower series— This merely points out that larger cohorts have more offspring than smaller neighboring cohorts and vice versa, sudden fertility rate

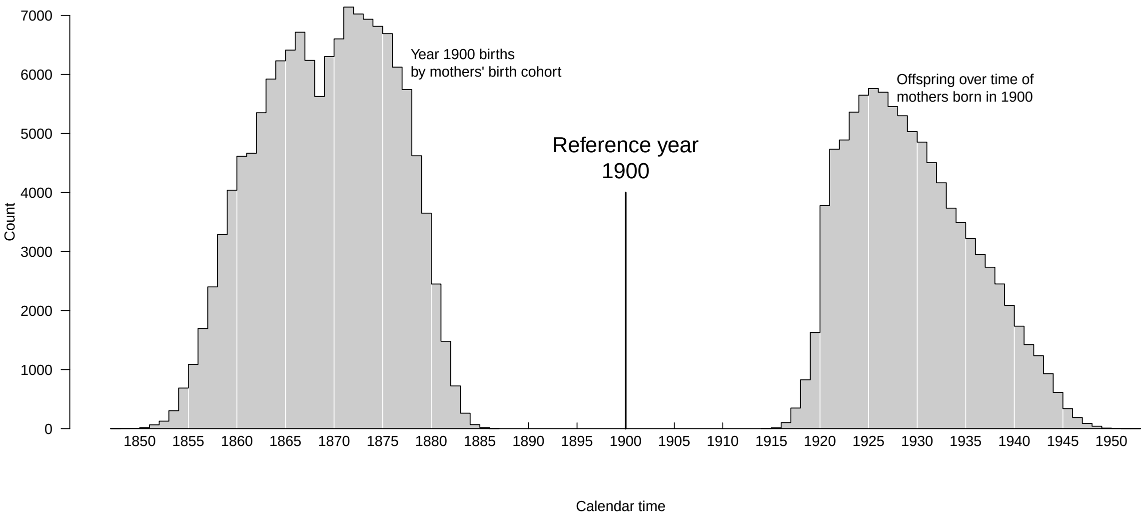


Figure 3: Births from mothers born in 1900 by year

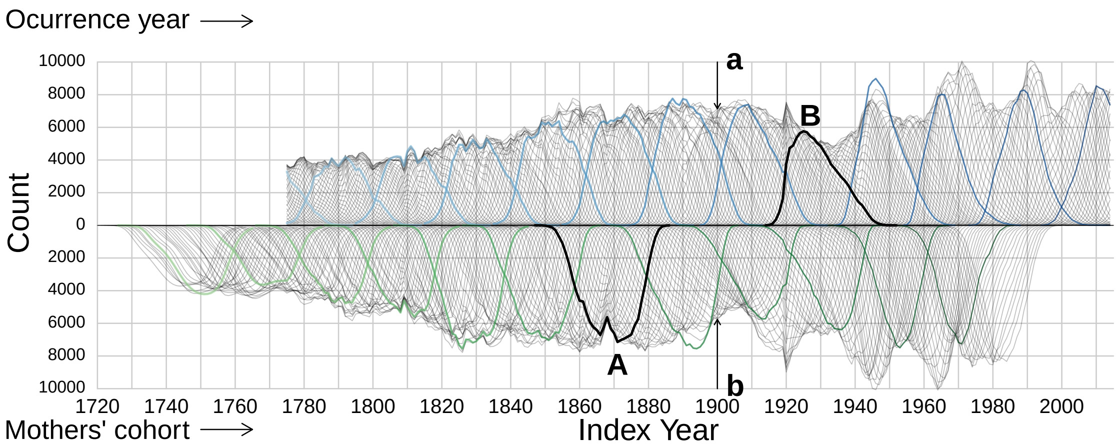


Figure 4: Two time series of birth count distributions. The top series is composed of offspring distributions, indexed to ocurrence years. The bottom series is composed of birth cohorts indexed by mothers' birth cohorts. **B** is the offspring of mothers from the 1900 cohort indexed in x to ocurrence year, and **A** are the births ocurred in 1900 indexed in x to mothers' birth cohorts. The cross-section **a** gives **A** and the cross-section **b** gives **B**.

changes notwithstanding. 2) The composition of **A** in the bottom series is implied by the cross-section **a** of the top series, and the composition of **B** is implied by the cross-section **b**. To reiterate: **A** are all the births in 1900 indexed back to mothers' cohorts. Each possible *slice* of **A** comes from a different top distribution as it crosses the year 1900 (and vice versa for the bottom). **a** and **b** are in a sense already juxtaposed for us, as they share an x coordinate. The "problem" with the cross-sections **a** (**b**) is that each *slice* of the corrsponding distribution **A** (**B**) is perfectly overlapped, such that it is just about impossible to imagine what **A** might look like if presented only with **a** and its surroundings.

In this way the two distributions that we might wish to compare for a given ego year are already available at a like coordinate, but comparison is stifled by overplotting. If instead we stack the slices that are indecipherably overlapped in **a** (and likewise for **b**) we get something like that shown in Fig. 5. Here the total bar length is proportional to the total cohort (offspring) size, and stacked bins reflect 5-year cohorts (ocurrence years). From this representation it is clear that mothers born in the 20 years between 1875 and 1855 produced the bulk of the 1900 cohort, which itself produced the majority of its offspring in the 20 years between 1920 and 1940. It is also quite visible that the 1900 cohort did not replace itself in a crude sense: 138,139 babies formed a cohort whose mothers gave birth to 95,379 babies over their lifecourse, a crude replacement of 69%. Other perspectives on reproduction that account for survival would give a more optimistic assessment. The key point about Fig. 5

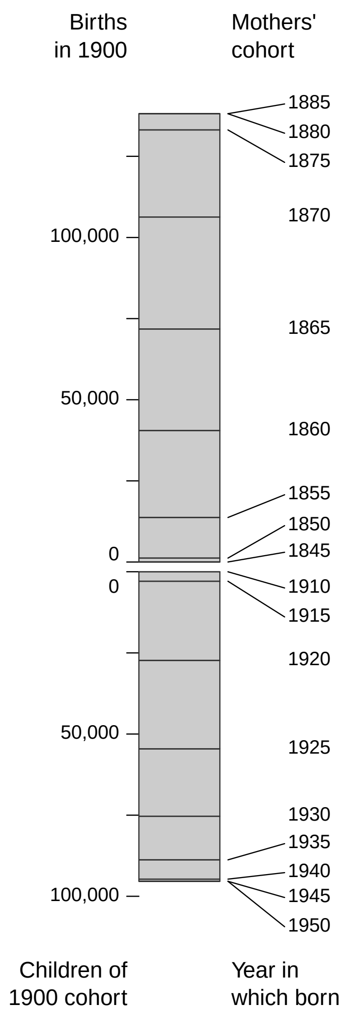


Figure 5: The 1900 cohort as a composite bar with its offspring reflected over y. The size of each bar stacked in the top composition is proportionate to the area of its corresponding polygon in the left distribution of Fig. 3. The size of each bar stacked in the lower composition is proportionate to the area of its corresponding polygon in the right distribution of Fig. 3.

References

R.R. Kuczynski. *Fertility and reproduction: methods of measuring the balance of births and deaths.* Falcon Press, 1932.