# Demographic Research Submission #4457

# ‘Visualizing fertility trends for 45 countries using composite lattice plots’

# Response to reviewers’ comments

We would like to thank both the guest editors and the three anonymous reviewers for their positive and constructive comments. We have made a number of revisions in response to the comments that we have received, which we believe have strengthened our paper.

We have included line numbering in the text of the revised paper and hope that this will help the reviewers to follow our changes more easily.

We address the comments, ordered by number #, provided by the guest editors (GE) and Reviewer A (RA), Reviewer B (RB) and Reviewer C (RC), as follows:

**GE01: I strongly advise you to take the recommendations of reviewer B related to your color scheme into considerations as we as guest editors share these concerns. The current color scheme does not support readers in intuitively detecting high and low values. In addition, different levels have quite similar colors (e.g. the colors denoting levels around 0.1 are not that different from colors denoting levels above 0.15). In your Shiny App you provide plenty of other color schemes that seem to be better suited for your Composite Fertility Lattice Plots.**

The colour scheme has now been changed to the Viridis colour scheme for all figures. Viridis colour scheme makes use of a large perceptual range of colours on a continuous scale, while preserving uniformity and being colour blindness friendly.

**GE02: I agree with reviewer A that the speculative extension should rather be dropped from the figures as it is indeed quite speculative. You might discuss speculative aspects in the text, but I would not recommend you to plot speculative extensions in a graph. If you strongly prefer to keep it, you would need to provide more background information both in the text and perhaps the annotation of the figures (formulas, motivation for underlying assumptions etc.).**

The ‘speculative extrapolation’ lines have now been removed from figure 1b and figure 2.

To explain, the idea from the speculative extrapolation lines was simply to point out that ages of replacement fertility (and other contour lines) from historic series by cohort tend to look broadly linear, until they pass above around age 43 years, after which they become infinite. This seems a simple and consistent observation, which would be easy to model with a conditional statement, and adapt for forecasting with (say) an ARIMA (0,1,0) specification. However, the focus of the paper is on visualization alone, so we did not expand on this idea further in the manuscript.

**GE03: Reviewer B was confused that you were able to plot cumulative cohort fertility for cohorts for which the ASFRs are not fully plotted in your graphs. I see two possible options to address this. Either you explain somewhere in the text and in the annotations of the figures that you decided to restrict your graphs to the period X onward and that for some countries earlier ASFR data are available allowing you to derive the cohort contour lines. An alternative option would be to fill the empty triangle in the lower left corner of your surface plot in case you have data available for a specific country.**

See our response to comment RA05.

**GE04: In the Shiny App you might also consider to add as an additional option the possibility to add diagonal period lines.**

We have added this as a new feature, and created a corresponding ‘issue’ item on the github repo. This feature request/issue can be found here:

<https://github.com/JonMinton/comparative_fertility/issues/16>

**GE05: It also seems that some text descriptions in the figures are not exactly precise. In the plot on Norway (Fig. 2) you state "Before 1960s: replacement reached by age 31." But in the 1950s replacement seems to have been reached at higher ages, while the age of 31 was rather relevant for the second half of the 1960s. Please carefully recheck such aspects.**

We are aware that the annotation mentioned by the guest editors may be slightly imprecise. The aim of including these annotations was to provide the same kind of information, to a similar degree of detail and precision, as if two people were both looking at the same image, and one person were pointing out features within that image. This necessarily means offering relatively concise and informal comments about features, rather than precise definitions, which would take too many words within the annotations. We have reworded the particular annotation referred to slightly (see figure 2), but not others, as we think the annotations generally strike the right balance between concision and precision.

**GE06: As this manuscript is mostly about the visualization technique, I believe it is fine that the manuscript is providing an extensive description of how the plot is derived. The comments of Reviewer B and Reviewer C regarding further extending the interpretation of the plots go in my eyes in part a bit too far. Nevertheless, it would not harm to slightly adjust these interpretations with the goal to carve even more out how such Composite Fertility Lattice Plots could enrich comparative research on fertility trends.**

We thank both the guest editors and Reviewers B and C for their comments.

We have extended the description of figure 3 and the Conclusion section to provide a discussion of the trends emerging from our results and their links with the explanations offered in the literature. See also our response to comments RB08 and RC01.

**GE07: Also the issue raised by Reviewer B related to potential differences between CFRs based on cumulative ASFRs and real CFRs should at least briefly be discussed.**

We have added a sentence referring to this as an additional form of research within the last paragraph of the conclusion section (see lines 446-448); and a sentence within section 2.2. noting that our CFR estimates will not be identical with real CFRs (see lines 112-115).

**GE08: The labeling of figure 3 could be improved. It starts on page 14, but the explanations that the surfaces actually show age-specific fertility rates and that the lines provide cumulative cohort fertility rates are only given on page 16.**

As a simple solution to this we have moved the ‘notes’ section after each sub-panel of figure 3.

**GE09: Minor point: Please check and modify the following sub-sentence on page 7 as I stumbled over the formulation the first time I read it: "the thin solid 1.5 line will always be lower than and will not intersect with the ..."**

We have amended this sentence to make it clearer. It now reads: “the thin solid line, indicating cumulative fertility of 1.5 children, will always be lower than, and so not intersect with, the thick solid 2.05 replacement fertility line (2.05 children per woman) (see lines 148-150).

**RA01: On page 2 you write: “Low fertility transitions correlate with life expectancy gains (Oeppen and Vaupel 2002; Shkolnikov et al. 2011) and increased international migration (Adserà and Ferrer 2014; Sobotka 2008)” – this should be better explained or dropped.**

We have dropped the sentence mentioned above.

**RA02: On page 9, you offer “speculative extrapolation”, which is not well explained, it is not present in the graphs anyway (neither in Shiny), and is not necessary, so I would recommend to drop it.**

See our response to comment GE02.

**RA03: Page 9: “As many features regarding West Germany have been previously discussed…” – when? Give some references maybe?**

We have modified this sentence as follows: “As many features regarding West Germany have been previously discussed (when referring to Figure 1b), …” (see lines 191-192).

**RA04: Page 9: “Unlike West Germany and the majority of European and other developed countries, East Germany experienced two period effects, rather than just one.” – unclear, do you mean two period shocks? The 1989 shock affected all Central and Eastern Europe.**

We apologise for the lack of clarity in this statement and have modified it slightly to make our meaning clearer (see lines 200-203).

**RA05: Some data from HFD suffer problems that are extensively discussed in HFD country documentation files, and for some countries (e.g. Portugal, Bulgaria), it is recommended to use cohort fertility indicators only with special caution – consider some of these countries better to drop from the dataset you use.**

We have not used any cohort indicators directly, but calculated them from age-specific fertility rates by period.

On the broader issue of data quality, we have provided discussion of which records we use in preference to which other available data, which is based on assumptions about a general hierarchy of data quality, within the methods section (see section 2.1). The code which combines data from multiple sources are publicly available and can be amended.

We have also added additional general comments about why users may wish to drop specific countries and years from their analyses, but also reiterated that our aim in this paper is to apply the method to large amounts of data (see lines 86-92 in section 2.1).

Any clear differences in estimates from different sources and methodologies should be apparent from the visualizations as discontinuities, and we hope the approach could be useful for this too.

**RA06: The Shiny application and its description should be better integrated to the paper. Now it is mainly introduced at the end of the summary section (as something currently under development), but I encourage the author to present it as finalized product that is part of the paper. For this, I have two questions: Now when you change the countries, you shell press the “Click to render figure” button, but when you change the cohort, the change comes immediately which can be quite slow, jumping cohort-by-cohort. Maybe the cohort change could come also only after the button is pressed.**

The Shiny app was developed after the paper had been written, and so the paper is not structured with a focus on the app. We agree with Reviewer A that mention of the app can be better integrated into the paper.

Hence, we have added mention of the app at the end of the methods section of the abstract (see lines 20-21). We have also expanded footnote 2 in the introduction section to describe this app further.

**RA07: Second, when you go to “Linked Plots”, choose “Two surfaces” and then go back to “Composite Plot”, the option “Select second country to visualize” stays there (and should not).**

We thank Reviewer A for identifying this bug. We have added this as a ‘bug’ within the github repo, then corrected it. We also identified a similar issue with the transparency options persisting when moving to the composite plot.

The bug issue is logged here: [https://github.com/JonMinton/comparative\_fertility/issues/17.](https://github.com/JonMinton/comparative_fertility/issues/17)

[**RB01:**](https://github.com/JonMinton/comparative_fertility/issues/17) **As the focus is on the graphical representation then my comments start there. Many demographers, including this one, are geographers and so we have set ideas about colour schemes for “low” and “high”: these tend to progress blue, turquoise, green, yellow, orange, red, brown. If you get to the top of high mountains then you might reach purple and even white. I would be happier with a similar progression for the plots you have. In particular, the purple for mid-values seems odd.**

We have now changed the main colour scheme used to Viridis in all manuscript figures. We think that this colour scheme is more clearly gradated.

We previously used the ‘paired’ colour scheme as a way of providing a reasonable way of looking up values on the colour bar, as use of intensity/’shade’ alone can lead to misinterpretation due to the perceptual issues highlighted by the checker shadow illusion.

Previously we used contour lines to help correct for this perceptual error, but as contours are used to map a 4th attribute, we also amended the ‘paired’ colour scheme to make it more colour-blind friendly.

**RB02: The aim of visualization is to make patterns clearer and so at the outset you need to spell out how age, period and cohort appear on the graphs. People who like graphs often don’t like words. See Figure 1 in Campbell and Robards for a suggestion of what would be helpful before you start presenting the graphs. In visualizations of Lexis diagrams of mortality then it’s usually period on the x-axis and age on the y-axis and so cohorts are seen as diagonals bottom left to top right. Your graphs have cohort on the x-axis and age on the y-axis: but this means that periods are then diagonals going from bottom right to top left, which I found confusing at first. You do mention it in the text, but only in brackets at the bottom of page 7.**

We appreciate the use of birth cohort rather than period on the x-axis is unusual, but hope the trapezoid appearance of the shaded cells, the term ‘birth year’ on the x axis label, and reference to ‘cumulative cohort fertility’ throughout the text would all be sufficient to make this clear to the reader.

To aid clarity we have added reference to cohorts rather than periods to the end of the caption labels for figures 1b, 1c, 2 and 3.

**RB03: I’m not quite sure whether making these period lines semi-transparent is so clear – I wonder whether a dashed line would be easier to understand? However, whatever method, then it would be good to label what years they refer to, e.g. on Figure 1c.**

Solid lines are currently used to track the ages at which cumulative fertility are achieved, and previously we also used dashed lines for this purpose, which is one reason why within this annotation we did not use lines, but a shaded polygon.

Though the use of shaded polygons may not be perfect, we think it would likely be less confusing for viewers than if some lines - mainly going left to right - were used to indicate cumulative fertility contours, whereas others - going from bottom to top - were used as annotations within these introductory figures. We think this could give a misleading impression to viewers as to what the lattice plots can be expected to contain.

**RB04: As for what to plot, I wonder whether instead of plotting raw ASFRs it would be even more interesting/useful to plot cumulative ASFRs for cohorts by age (i.e. for age x and cohort y, the sum of the ASFRs up to that age – using the same axes as your existing plots). You would only be able to start the plots for cohorts where you have their ASFRs from age 15 (but not necessarily right through to 44). Then you wouldn’t need to plot contours. The 1.5 and 2.05 contours are interesting to see, but they seem a bit untidy/distracting on the colour plots. Probably both types of graphs would tell interesting stories (ASFR and cumulative ASFR).**

The main aim of this paper, and key novelty of the method it proposes, is to demonstrate that, by mapping colour/hue to age-specific fertility rates, and contour lines to specific cumulative cohort fertility ‘milestones’, both linked demographic attributes can be visualized for one or many populations within a single image. Therefore, either excluding contour lines, or using both shade and contour to refer to the same attribute appears to lose this novelty.

However, the app we have produced does allow additional Lexis surface representations to be produced, and the associated github repository contains an ‘Issues’ page where additional feature requests, like those suggested by Reviewer B, can be added.

**RB05: In your introduction you mention briefly 5 other papers which plot Lexis surfaces, but 3 of these relate to mortality, so are probably not really relevant to your work. There is, however, another document which you could usefully check out and cite which plots cohort fertility which you may not have seen:**

**Calot, G. and Confesson, A., 1998. Two centuries of Swiss demographic history: graphic album of the 1860-2050 period. Swiss Federal Statistical Office. Check out Figure 5.2 A/B/C.**

We thank Reviewer B for suggesting this additional reference, which we have added to the introduction (see line 37).

At the level of abstraction of the definition of a Lexis surface as showing a third attribute as a function of relative time (usually age) and absolute time (period or cohort), we think references to Lexis surfaces to mortality rates are still relevant. However, we are glad to see this additional reference to fertility rates.

**RB06: In your conclusion you may wish to critique the previous visualizations of ASFRs and say what your visualizations offer that is different from those? In particular do they show any different features / patterns / trends?**

In section 4, we have added the following paragraph: “Previous studies using visualization techniques of the Lexis surface either focused on data from a single country [(Calot et al. 1998)](http://f1000.com/work/citation?ids=7579179&pre=&suf=&sa=0), sub-national regions [(Campbell and Robards 2014; Rau et al. 2018)](http://f1000.com/work/citation?ids=6944737,6944738&pre=&pre=&suf=&suf=&sa=0,0) or a more limited number of countries [(Burkimsher 2017)](http://f1000.com/work/citation?ids=6944719&pre=&suf=&sa=0). Compared to previous research, our paper combines different tools of the Lexis surface in a novel way and explores a large number of countries, supporting a more fine-grained comparison of multiple pieces of information for the exploration of fertility trends over time and across geographic regions.” (see lines 388-394).

**RB07: As I said before, graph-lovers can be put off by words, and I found the title of the paper quite off-putting. Can you make it much simpler and attractive for even non-experts to want to read? It’s really about pretty pictures showing fertility trends… but you may want it to be a bit more formal than that! Perhaps “Fertility trends visualized for 45 developed countries”? The term “composite fertility lattice plots” can be introduced later, perhaps even after the abstract.**

We agree with Reviewer B: the title is long and can be off-putting. We have shortened the title to: “Visualizing fertility trends for 45 countries using composite lattice plots”.

**RB08: I’m not sure how much of the technical description of how you produced the plots is necessary – it’s sort of obvious, isn’t it? However, adding much more discussion on the trends you see on the plots would be interesting, especially for the countries shown in Figure 3. Do the plots highlight any trends that have not been documented elsewhere? Or, at least, what trends are really clear to see on the plots?**

We have expanded section 3.3 ‘All countries’ (see lines 269-378).

**RB09: In introducing Figure 3 then do state in the text, not just in the notes under the text (3 pages later) what order the graphs appear, i.e. in descending order of CCFR. I was really surprised to see Taiwan and S Korea among the countries with highest CCFR knowing that their period TFRs are currently the lowest in the world!**

We have moved the note mentioning that the countries are arranged in descending order of CCFR at the end of each sub-panel figure of figure 3.

**RB10: The CCFRs are calculated as the sum of the ASFRs of the cohorts as they are tracked through their fertile life (I believe, from your formulae). You may want to mention why these values may not agree with actual CCFRs of cohorts when they reach age 45-50. If the populations were closed (and there was no mortality) then the values would be correct – but migration can mean there are significant mismatches. Immigration can cause the fertility rates of women in their 20s to be ‘impossibly’ high (if they come into the country childless) and so countries/cohorts which have experienced strong immigration will have CCFRs which may exceed actual fertility. Similarly for countries with strong emigration: their fertility rates can be distorted downwards. You may want to have a quick look at other data sources to see how the calculated CCFRs compare to actual completed cohort fertility.**

We have added a brief discussion of this point within the methods section (see lines 112-115 in section 2.2).

**RB11: Figure 1b – says “complete schedule from age 12”, though in the text (section 2.2) it says that age 15 was used.**

We thank Reviewer B for pointing out this discrepancy. The cumulative schedules were produced for all cohorts with records available from age 15, but for some records data were available from age 12. The availability of data from at least age 15 was a requirement for producing the cumulative schedules.

We have amended the description in the text to include the term “at least” in the sentence (see line 105).

**RB12: Figure 1c: on the East German plot, it says “Initial fertility fell in late 1960s similar to East Germany” – should be “similar to West Germany”.**

We thank Reviewer B for pointing out this error, which we have now corrected.

**RB13: Figure 2, USA plot. The contour lines go back to the cohorts before the 1920s. But these must be extrapolated contours as complete fertility histories are only available for cohorts born after about 1930. I’m also not convinced that the US will keep replacement fertility for upcoming cohorts – but that’s just conjecture…**

One of the strengths of the approach seems to be in developing more informed conjectures. We hope that the addition of a projected cohort trajectory line in figure 2 has been useful in suggesting the hypothesis that you are challenging, and so for generating and focusing on specific questions in an evidence-based manner.

The cumulative cohort fertility lines are only shown where, within the HFC and HFD combined, there exists estimates for age-specific fertility for the cohort indicated on the x axis. However, these will only be as reliable as data source, which in the HFC may be of a lower quality than for the HFD.

**RC01: I think the paper needs some additional development in the second objective. I believe the authors could developed and contextualize a little better how the paper contributes to the discussion of fertility trends and improve the substantive discussion of the results based on the improve contextualization and discussion of the literature. I understand that it is not the idea to discuss one country in particular, but there are some additional literature that might help to developed the discussion and situate the paper in the broader literature. For instance, I would like to see a better discussion why "East Germany will not sustain fertility rates above 1.5 in later years" and more comparison from West and East Germany.**

**For instance, some references that might help the discussion and situating the paper in a broader discussion.**

**Skirbekk, V. (2008). Fertility trends by social status. Demographic research, 18(5), 145-180.**

**Witte, James C., and Gert G. Wagner. "Declining fertility in East Germany after unification: A demographic response to socioeconomic change." Population and development review 21.2 (1995): 387-397.**

**Goldstein, Joshua R., and Michaela Kreyenfeld. "Has East Germany overtaken West Germany? Recent trends in order‐specific fertility." Population and Development Review 37.3 (2011): 453-472.**

**Lechner, Michael. "The empirical analysis of East German fertility after unification: An update." European Journal of Population/Revue Européenne de Démographie 17.1 (2001): 61-73.**

**Klüsener, S., & Goldstein, J. R. (2016). A long‐standing demographic East–West divide in Germany. Population, Space and Place, 22(1), 5-22.**

**Demeny, Paul. "Sub-replacement fertility in national populations: Can it be raised?." Population studies 69.sup1 (2015): S77-S85.**

**Lutz, Wolfgang, Vegard Skirbekk, and Maria Rita Testa. "The low-fertility trap hypothesis: Forces that may lead to further postponement and fewer births in Europe." Vienna Yearbook of Population Research 2006 4 (2007): 167-192.**

We thank Reviewer C for raising this point. We have extended our substantive discussion of the results and how these relate to some interpretations offered in the literature (see lines 395-439). This includes a section discussing the case of East and West Germany (see lines 406-421).

**RC02: Sometimes it is hard to follow in the figures for several countries thin solid line and thick solid line. Wouldn't be better to use other scheme instead of thick and thin? I would also explore some different results such as Czech Republic, Sweden, Estonia, Japan, Austria. And what happen to Russia? It never reaches cumulative cohort fertility of 2.05? Just highlight with some short discussion what happen in those particular years.**

We have addressed this comment by adding the following part to section 3.3: “Amongst the many complex patterns and features shown here is an apparent cohort effect for Russian women born in the late 1940s, apparent as a brief ‘uptick’ in the cumulative cohort line. As this paper is largely methodologically focused we have not explored the possible causes of this feature further, but suggest it may be useful to investigate further whether this is a genuine cohort effect or a data artefact” (see lines 354-358).

We have experimented with varying numbers of lines and various graphics aesthetics, and feel that, once viewers have developed some familiarity with the approach, the thick/thin line distinction is relatively straightforward. The aesthetics of the lines always play a ‘supporting role’ in helping the viewer distinguish between lines, and are not strictly necessary because, being cumulative, the lines will always appear in the same monotonic order from bottom to top.

We had not noted the unusual feature in Russian fertility before, an apparent cohort effect affecting women born in the late 1940s, and thank Reviewer C for pointing this out.