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A NEW VISUALIZATION FOR UNCERTAINTY INTERVALS WITH SURVEY EXAMPLES

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Abstract

We consider different ways to present the uncertainty of the statistical estimates starting from ordinary standard errors and confidence intervals, respectively. Our special attention is in graphical representation. First, we present a commonly used style that often seems to lead to misinterpretations. Hence, we widen it and present a solution that is understandable even for the general public. We further develop this approach to the case when the survey estimates are more or less biased given that the bias can be measured to some extent. Our graphical visualizations are based on the two real survey data sets. We do not concentrate on survey estimation itself but we further use best possible estimates to combine the results.

1. Introduction

Point estimates in statistics are not enough, and need to be extended with interval estimates or accuracy indicators, obtained from a given micro data set. Unfortunately, standard errors may be biased, as well as point estimates

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too. Or at least, we cannot be sure how good they are. We do not go to details in these bias problems but assume that we can get some indicators to measure the bias. This is often possible in survey data since estimates can be calculated with alternative sampling weights. Consequently, there are several alternative estimates.

We illustrate our first results using survey data with two types of domains, that is, four age groups (15-29, 30-44, 45-59 and 60+) and two data collection modes (phone vs. web). The data consist of 3000 respondents. The details of the data are not important to know from the point of view of this study. Our estimates are computed from the following question (variable):

What do you think our country’s economic situation will be like in 12 months’ time compared with the present situation?

much better = 100, somewhat better = 50, the same = 0, somewhat worse = –50, much worse = –100, cannot say = . .

Our point estimates are the averages of these scores for each particular domain. Naturally, sampling weights are applied in estimation. We call this variable as *economic optimism*.

First, we compare the youngest (15-29) and the oldest (60+) age groups, respectively, by those two survey modes. The most common representation is to give the average and the standard error, respectively, but we go directly to the second representation in Table 1 that corresponds to the 95% confidence intervals. Note, that we assume in this first example that the estimates are unbiased, and we thus not have just one average and the standard error, respectively.

Table 1. Tabular 95% confidence intervals (CI) for economic optimism in two age groups by survey mode

Age group	Phone respondents		Web respondents	
	Lower CI	Upper CI	Lower CI	Upper CI
15-29	9.4	20.2	11.2	24.4
60+	–7.5	6.0	–4.0	8.8

These results are not immediately interpretable but graphical tools may facilitate the understanding. A common graphic is presented in Figure 1 that is a conversion from Table 1. It is easy to see which groups differ significantly for each other, just looking whether the intervals are overlapping or not.

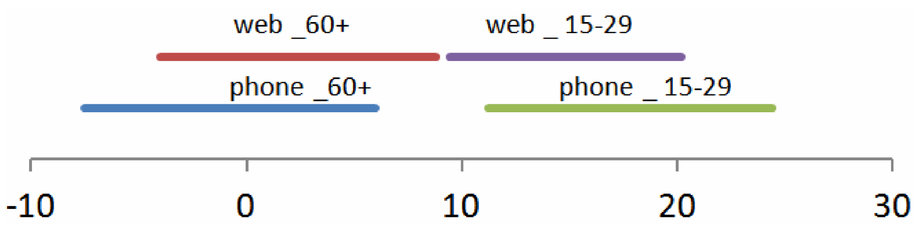

Figure 1. Graphical 95% confidence intervals (CI) for economic optimism in two age groups by survey mode.

2. A More Illustrative Graphical Visualization

The style of Figure 1 facilitates the interpretation essentially when comparing with Table 1. Nevertheless, this graphic may also lead to misinterpretations as we have found. Even many researchers (maybe not statisticians) think that the expectation of the estimate is uniform within the CI. How to avoid this misinterpretation? Our solution is simply to draw the curve that explicitly shows how the expectation probability varies.

There are several formulas behind interval estimates but we here present the corresponding curves using a normal distribution. This is made simply so that we put into the normal distribution formula the mean equal to each point estimate, and the standard deviation equal to the respective standard error. The entire probability mass is naturally equal to 100 percent. The corresponding interval is infinite. When we cut out 2.5 percent from both sides, we have a 95% like in Figure 1. Fortunately, this graphic also shows the variation in probability and any similar misinterpretation that is not possible in the case of Figure 1. Figure 2 corresponds to the representations of Table 1 and Figure 1.

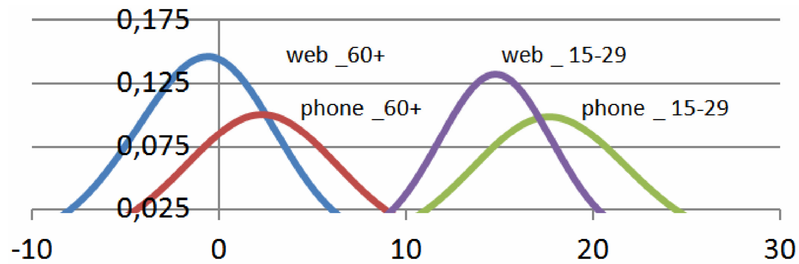

Figure 2. Alternative graphical 95% confidence intervals (CI) for economic optimism in two age groups by survey mode.

3. Inclusion of Bias in Uncertainty Graphics

Figure 2 is thus more illustrative than the previous one (Figure 1). The same strategy can be extended to the situations when we have reasonable information about the bias in estimates. This is typically possible if we have non-response or other missingness in data and we are able to adjust for these gaps using better workable weights (see e.g. Laaksonen and Chambers [1] and its references). It is usual that we can create more than one reweight for estimation, but we cannot be definitely sure which is best. In this case, our weights vary since our response propensity model behind the weights is different due to different explanatory variables in the model. Consequently, we obtain several normal distribution curves, that number is three in our example. We illustrate this method with an example from the same data as above but now our age group is 35-44 years old.

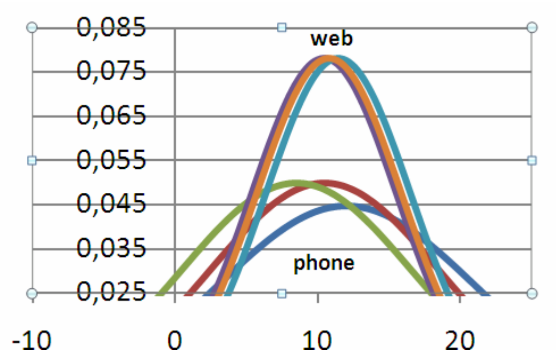

Figure 3. Alternative graphical 95% confidence intervals (CI) for economic optimism for 35-44 years old by survey mode.

This graphic thus gives three estimates computed with different weights but more weights can be used. However, it is not rational to use too many weights, only such a number that is realistic for each particular case. In Figure 3, we see that the curves for phone respondents vary much more than those for web respondents. This is interesting to know. It is not however magnificent to show for users so many curves but sooner just one for each domain. Hence, we take the average of the three normal distribution curve values as a good compromise. The average curve can still be used for uncertainty measurements since the entire mass is still equal to 100%, and 95% of the mass provides the 95% CI's. Figure 4 shows the corresponding curves that are not exactly normal although this is hard to see.

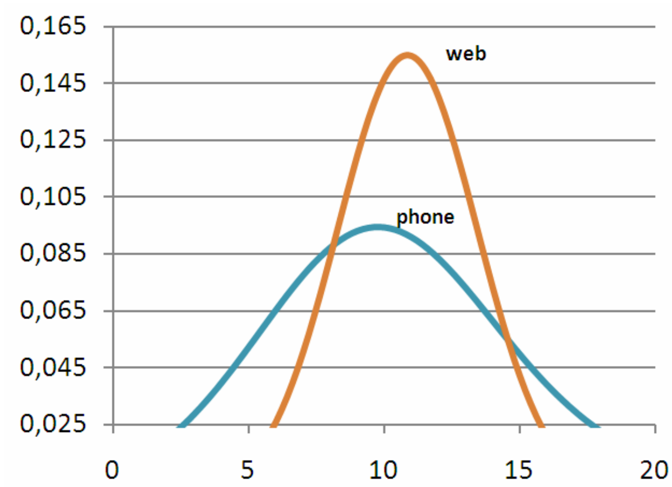

Figure 4. The compromise 95% confidence intervals (CI) for economic optimism for 35-44 years old by survey mode.

This figure shows that the estimates themselves do not differ substantially but the uncertainty intervals do. We continue the analysis and include all age groups in Figure 5. There are in this figure maybe too many domains, but a careful consideration helps interpretation.

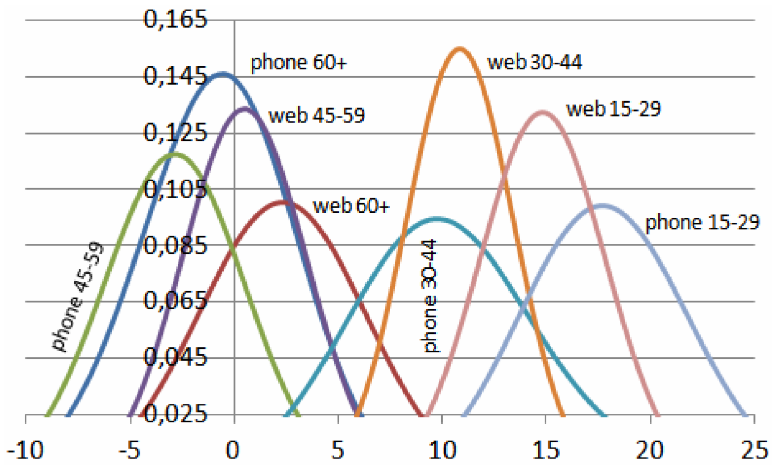

Figure 5. The compromise 95% confidence intervals (CI) for economic optimism for four age groups by mode.

This figure also shows the classical CI's and the classical statistical significances between domains. These CI's are thus broader since they indicate not only about sampling errors but about some realistic biases as well. The alternative is thus to give several results and a reader has to make his/her statistical inference by him/herself.

4. A More Complex Case

A reader maybe wonders how regular the curves of Figure 5 are, and they look like as normal distributions (although they thus are not). However, this methodology does not always give as regular curves. We present an example that is from a survey on voting intentions before parliament elections. About 4000 potential voters were interviewed and the voting intentions were received from about 3000. The survey organization also inquired which party the respondents voted in the previous election. That information was used for estimating opinion changes and correspondingly for correcting the preliminary estimates based on the ordinary survey weighting.

Since there were many who did not tell their earlier voting behavior but told the current voting intention, the correction weights are not easy to calculate, and not in one way only. Hence, we applied (as in the first examples) the three competitive weights and took their average as a compromise of these. The point estimates (support in percentage for each political party) vary in some cases dramatically due to a higher uncertainty in weights. The variation in sampling errors is in general much smaller than that in point estimates.

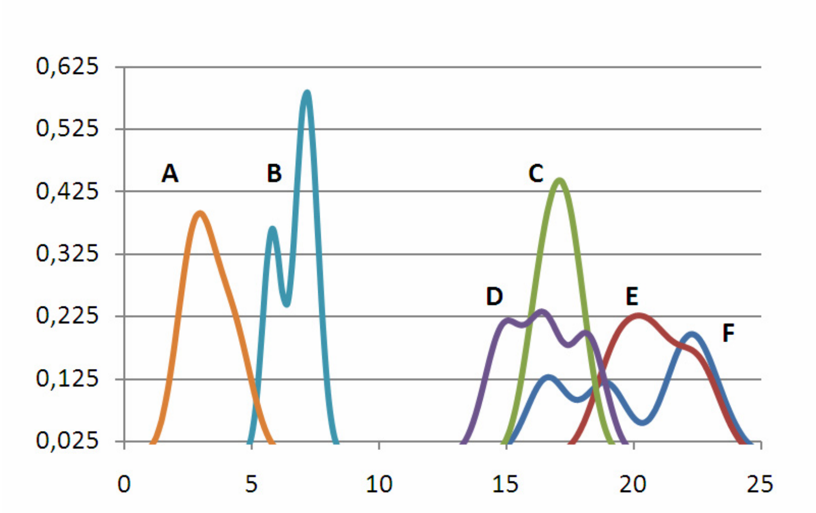

Figure 6. Uncertainty intervals of voting intentions (%) for six parties A, B, C, D, E and F.

The curves for parties A and C are fairly regular. This means that the alternative weights provide quite similar rates of voting intentions. For the other four parties, the curves are more irregular, and the curve for party F is very peculiar. This was expected in some sense since the popularity of this party was changing dramatically during recent months. The survey organization only published one rate (based on a more or less subjective correction weight), and also a general-level margin of error that corresponds to a 95% CI. Our compromise illustration in a graphical form told the truth better than such a simple presentation.

5. Conclusion

We present a basically simple methodology for the statistical uncertainty by including both the sampling error and the bias in one indicator. Of course, to estimate the bias or the systematic uncertainty component is only partially possible since full information is missing. We have for our examples some useful information for this purpose by using alternative strategies for estimating survey weights. This is in all surveys possible if appropriate auxiliary data are available. One common strategy is to present several estimates and their confidence intervals for each particular estimate. This is not pleasant for ordinary users. Hence, we present a compromise that gives just one estimate and one confidence interval for it. This compromise is made by averaging the alternative estimates. When presenting everything with graphical visualization, the illustration improves further.

Our strategy does not change substantially the estimates of ordinary human surveys, since the variation of the alternative and realistic estimates is limited. This has been shown in our first data. Our second example is more dramatic. Here the estimates are factually concerned forecasts (of voting intentions of people). Naturally, no true values are available for such estimates, or they are changing rapidly. Our strategy is workable for such a case extremely well, since the systematic uncertainty is included in this indicator too. This approach often widens the uncertainty intervals and their probability distribution is not always very normal either. But this does not matter, since this voting intention indicator will give a more objective view of the reality.

Reference

[1] S. Laaksonen and R. Chambers, Survey estimation under informative non-response with follow-up, Journal of Official Statistics 22 (2006), 81-95.