KOALA: Estimating coalition probabilities in multi-party electoral systems

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Abstract: Common election poll reporting is often misleading as sample uncertainty is either not covered at all or only insufficiently. For a more comprehensive coverage, we propose shifting the focus towards reporting survey-based probabilities for specific election outcomes. We present such an approach for multi-party electoral systems, focusing on probabilities of coalition majorities. A Bayesian Multinomial-Dirichlet model with Monte Carlo simulation is used for estimation. The method is based on opinion polls conducted by established polling agencies and is accompanied by a pooling approach to summarize multiple current surveys, accounting for dependencies between institutes. Sample uncertainty-based probabilities are estimated, assuming the election was held today. An implementation of the method in `R` is freely available.

Keywords: Election analysis; Opinion polls; Election reporting; Multinomial-Dirichlet; Pooling.

1 Introduction and data

Election polls as surveys conducted by different polling agencies try to represent the public opinion based on a finite sample. Current reporting on such surveys is most often limited to the observed shares, while sample uncertainty is usually ignored. Often e.g., a coalition is stated to "lose" its majority just because the joint poll share drops under 50% (cf. "Umfrage zur Bundestagswahl", 2017). In our opinion, the focus in survey reporting in multi-party electoral systems should be shifted towards the most relevant question, i.e. *how probable* a majority for a specific coalition is. We present our KOALA (Coalition Analysis) approach to estimate such probabilities to bring more value to opinion poll-based reporting. Prior to the German

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federal elections 2013 and 2017, results based on (an earlier iteration of) our approach already entered general media reporting (cf. "Serie: Wahlistik", 2013, or Gelitz, 2017).
As database, we use opinion polls conducted by established polling agencies, quantifying the electoral behavior *if an election was held today*. Our approach is to be differentiated from prediction-aimed methods (cf. Graefe, 2017 or Norpoth & Gschwend, 2010). We focus on the question of quantifying current majority situations, not taking into consideration potential shifts until election day.
A Bayesian Multinomial-Dirichlet model with Monte Carlo simulations is used for estimation. Also, a pooling approach is presented to summarize the results of multiple current opinion polls to reduce sample uncertainty.
All methods were implemented in `R` and are available in the open-source package `coalitions` on GitHub (Bender & Bauer, 2018). Also, an interactive `shiny`-based (Chang et al., 2017) website `koala.stat.uni-muenchen.de` visualizes estimated coalition probabilities and is used to communicate the results to the general public.

2 Calculation of probabilities

As an example, we look at the last opinion poll conducted before the German federal election 2013 (Forsa, 2013), where special interest was on whether CDU/CSU-FDP (also "Union-FDP") would become the governing coalition or not:

TABLE 1. Observed voter shares in the Forsa opinion poll published September 20th, 2013 with $n = 1995$ respondents

Union	SPD	Greens	FDP	The Left	Pirates	AfD	Others
40%	26%	10%	5%	9%	2%	4%	4%

Based on the German election system having a 5% hurdle for passing into parliament one has to redistribute voter shares accordingly to end up with the resulting share of parliament seats per party. Here, Union-FDP would get exactly 50% of parliament seats. Uncertainty-ignoring reporting would in this case conclude that the coalition slightly fails to achieve a majority. However, it is clear that this is only true with a specific probabilitiy and particularly depends on whether FDP and/or AfD pass the 5% hurdle.
For estimating probabilities for specific coalitions, we choose a Multinomial-Dirichlet model with an uninformative prior for the true party shares θ_j

(Gelman et al., 2013):

$$\theta = (\theta_1, \ldots, \theta_k)^{\mathrm{T}} \sim Dirichlet(\alpha_1, \ldots, \alpha_k),$$
$$\text{with} \qquad \alpha_1 = \ldots = \alpha_k = \frac{1}{2}$$

Basing the Bayesian model on one (pooled) survey the posterior also results in a Dirichlet distribution with parameters $\alpha_j = x_j + \frac{1}{2}$ for each party j and its observed voter number x_j.
Probabilities for specific events can now be estimated using Monte Carlo simulations of random election outcomes. One can easily calculate probabilities by taking the share of times some specified event occurs. To adjust for observed survey shares generally being only published as rounded numbers, before applying the Bayesian model we add random noise to x_j.
For visualizing the development of such probabilities together with the underlying uncertainty for a specific coalition we recommend using a density plot for its simulated seat distribution (Fig. 1). Looking at the probabilities based on the last opinion poll before the German election 2013, the posterior distribution ends up to be a bimodal distribution, based on the distinction whether FDP and/or AfD pass the 5% hurdle. The resulting probability for a Union-FDP majority is XXX%, based on XXXX simulations.

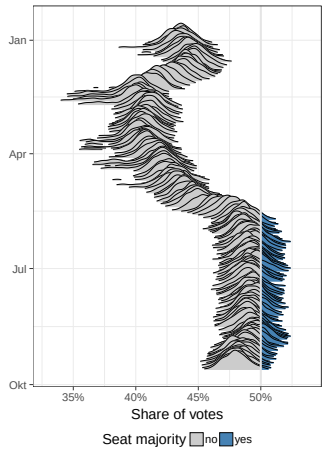

FIGURE 1. Development of simulated parliament seat share densities for the coalition Union—FDP before the German federal election in September 2013 based on Forsa. The density area colored blue marks the part of the density encoding for seat majorities. Bimodale, letzte Umfrage muss noch in die Grafik. Und die Grafik muss auf Forsa basieren, nicht auf gepoolt! Und xlab = share of parliament seats

3 Pooling approach

In the presence of multiple published opinion polls, pooling is used to summarize the observed results in order to reduce sample uncertainty. To assure a reliable pooling regarding the current public opinion, we only use polls published within the past 14 days and only use the most recent survey published by each polling agency.
Based on the multinomial distribution of the voter number X_{ij} of party j in poll i with underlying true party share θ_j, pooling over multiple polls representing independent random samples would lead to a multinomial distribution for the summed number of votes $\sum_i X_{ij}$.
Further investigations however show that polls published by the main German polling agencies show a certain amount of correlation and the independency assumption does not hold. To account for this, we adjust the resulting multinomial distribution by using an *effective sample size* (Hanley et al. ,2003).
Looking at the party-specific correlations between 20 surveys conducted by the two most regular German polling agencies, Emnid and Forsa, we on average end up with a medium high correlation, based on the formula

$$Cov(X_{Aj}, X_{Bj}) = \frac{1}{2} \cdot \left(Var(X_{Aj}) + Var(X_{Bj}) - Var(X_{Aj} - X_{Bj})\right),$$

taking $Var(X_{Aj})$ and $Var(X_{Bj})$ as the theoretical variances of the binomially distributed, observed voter numbers and estimating $Var(X_{Aj} - X_{Bj})$ based on the observed differences between the party shares. Other institute comparisons were not performed as too few surveys were conducted over comparable time frames. For simplicity, we set the correlation used in our methodology to 0.5. For calculating n_{eff} we base the calculation on the result of the biggest party, as the specific party choice only marginally affects n_{eff}, and define it as the ratio between the estimated variance for the pooled sample and the theoretical variance of a sample of size one:

$$n_{\text{eff}} = \frac{Var(\text{pooled})}{Var(\text{sample of size 1})}.$$

4 Conclusion

We presented an approach to estimate probabilities for specific election outcomes based on publicly available opinion polls. Pooling allows for the inclusion of information from multiple surveys. Visualizing the results on a publicly available website for chosen elections, our long-term goal is to make proper uncertainty assessment standard in general opinion poll-based reporting.

References

Bender, A. and Bauer, A. (2018). *adibender/coalitions (Version v0.5.7)*. Zenodo. http://doi.org/10.5281/zenodo.1172595

Chang, W. et al. (2017). *shiny: Web Application Framework for R*. R package version 1.0.5. URL https://CRAN.R-project.org/package=shiny

Forsa (2013, September 20). Last retrieved 15/02/18, http://archive.is/f9vse.

Gelitz, C. (2017, September 20). *Können die aktuellen Umfragen noch falschliegen?*. Last retrieved 15/02/18, http://archive.is/JydHd.

Gelman, A. et al. (2013). *Bayesian Data Analysis, 3rd edition*. Boca Raton, FL: CRC press.

Graefe, A. (2017). The PollyVote's long-term forecast for the 2017 German federal election. *PS: Political Science & Politics*, **50.3**, 693 – 696.

Hanley, J. A. et al. (2003). Statistical analysis of correlated data using generalized estimating equations: an orientation. *American journal of epidemiology*, **157(4)**, 364 – 375.

Norpoth, H. and Gschwend, T. (2010). The chancellor model: Forecasting German elections. *International Journal of Forecasting*, **26(1)**, 42 – 53.

Serie: Wahlistik (2013, September 17). Last retrieved 15/02/18, http://archive.is/1SU1I.

Umfrage zur Bundestagswahl: Schwarz-Gelb verliert die Mehrheit (2017, August 9). Last retrieved 15/02/18, http://archive.is/SuXVt.