

Using Smartphone Polling to Forecast the German Federal Election 2017*

Comparing the performance of digital and traditional polls

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Abstract

Using online surveys to forecast election outcomes imposes severe challenges to pollsters. Non-representative samples and likely-voter bias skew gathered information and require adequate statistical adjustment. This paper compares different weighting methods to obtain a forecast from raw data, collected through smartphone polling and uses the average of leading polling institutes as a benchmark. We find that post-stratification including revealed last votes are an effective tool adjust polls while stratification purely on demographic factors cannot offset the sampling bias for polls with 1000-2000 responses.

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*The r scripts and the large parts of the raw data are available on our [GitHub repository](#). For the remaining raw data please contact the authors, corresponding address: m.hemmerlein@mpp.hertie-school.org.

1 Introduction

The digitalisation is challenging the way polling was done for many decades. Calling people on their landline phones has become difficult as response rates dropped and number of households equipped with landline phones is decreasing (Skibba 2016). In response, pollsters have resorted to other polling-methods ranging from face-to-face interviews to mobile phone calling. However, these methods either face similar difficulties to ensure representativeness or are too expensive for regular polling. In order to tackle these obstacles, pollsters are increasingly using online polls, which are cheap and fast, but can be highly non-representative (e.g. W. Wang et al. 2015).

The eventual aim of pollsters in online as well as traditional polling is to collect sample data that reflects the view of a population of interest. The major difference between both methods is that for various reasons online polls cannot ensure representativeness before the actual poll takes place. For instance, respondents of online surveys are more likely to be from certain demographic groups or share a particular political background depending on the website or app where the survey is conducted. However, such non-representative polls can be statistically adjusted to match the demographic composition of the population.

Additionally, online election polls, like traditional ones, face another problem. Election forecasters are naturally not only interested in the population as such, but in the population of actual voters. By the time a poll is made representative in demographic terms, it is still in question whether it reflects the group of people who actually cast their ballots. This, however, is crucial in order to make an accurate prediction. Traditional polling tries to account for this using likely voter models and could perform fairly well (Gallup 2010, Keeter, Igielnik, and Weisel (2016)). Online surveys will also have to be adjusted to actual voting population in order to provide accurate predictions.

In this paper, we employed different weighting strategies to an online poll, exploiting respondents usage of smartphone apps. We evaluate our methods against the rolling average of polls from leading German polling institutes. While the raw data of the online survey performed fairly poor compared to our benchmark, we show that with proper weighting, we could obtain results that are close to the major polls. Moreover, we compared a rather direct and a indirect method. First, we used information on self-reported vote decision at the German federal election 2013 and data from official exit polls to construct our weights. In a second, more indirect approach, we constructed weights to adjust our demographic clusters to the German census data and subsequently identified so called likely voters to adjust our raw data. As our results show, the direct method performed considerably better than the indirect weighting through census data.

The structure of the paper is as follows: Section two will survey the literature on non-representative polls and presents approaches to employ such data to forecast elections. Subsequently, in chapter three, we present our data and discuss idiosyncratic problems and potential sources of bias. Section four shows the methods we applied to our data. Chapter five is presenting and discussing our

results and their performance against the benchmark data. Chapter six concludes and gives an outlook on practical obstacles and methodological issues that our approach suffers from.

2 Related Literature

Traditional polling and in particular election polling has relied heavily on telephone surveys for the last decades. To ensure representativeness, the standard was randomized digit dialing (RDD). The selection of random respondents was intended to eliminate the sample bias of the survey. However, for several reasons this approach has become unreliable. First, response rates have declined heavily (Keeter et al. 2006; Holbrook, Krosnick, and Pfent 2007). The Pew Research Center (2012) reported that in the U.S. response rates dropped down to 9% in 2012, compared to 36% in 1997. This is fostered by technical changes that, for instance, make it possible to identify the caller before taking the call and increased the likelihood of people not answering survey requests. Second, more and more people do not get land-lines telephones after moving to new places or just give them up as mobile phone and other means of communication have increasingly become popular. As a result, random polls are often exposed to non-response bias mitigating the probabilistic approach of RDD. Hence, classical representative polling is becoming less reliable, a trend that will rather continue than cease. Unsurprisingly, lacking representativeness of surveys has been identified as a core reason for recent election polling failures, e.g. in the UK General elections 2015 (Mellon and Prosser 2015).

Can non-representative online polls fix this problem? Since the famously failure of the Literature Digest poll in the 1936 U.S. presidential election, pollsters have been sceptical of non-representative polling (Squire 1988; Goel, Obeng, and Rothschild 2017) and this scepticism is still widespread. Yeager et al. (2011), for example, argue that phone surveys are still more accurate than online polls. However, they base their argument on simple correction approaches for non-probability sampled online polls.¹

W. Wang et al. (2015) in contrast are much more optimistic about the possibilities of non-representative polling. They used polling results from Xbox users, which were highly unrepresentative of the population, to forecast the 2012 U.S. presidential elections. By employing a sophisticated multi-stage approach to post-stratify and calibrate the data they were able to generate accurate forecasts of the elections. However, their methodology is mainly suited for large data sets which have sufficient observations for the combined sub-groups (strata) in the sample. Goel, Obeng, and Rothschild (2017) showed that smaller non-representative online surveys can also be accurate. They conducted polls on [Amazon Mechanical Turk](#) and a mobile phone app and achieved a level of accuracy sufficient for most practical applications. These works shows that online survey can be used in a meaningful way, if appropriate methods are used to stratify and

¹Goel, Obeng, and Rothschild (2017 Footnote 2) where able to get more accurate results using the basic approach, but in a different way.

calibrate the non-representative data. Still, how such methods perform for the case of election forecasting remains contested.

3 Data Sources and Quality

3.1 The Dalia Research Europulse poll

In this paper, we are using data from [Dalia Research](#), an online polling firm which is conducting market and opinion research exclusively through smartphones. To ensure to collect data from a broad variety of target populations, Dalia is using a diverse set of app and website categories such as sports, news, entertainment or games. To control that participants answer the survey seriously, an algorithm analyses the consistency and the response behaviour and computes a “trust score” to every respondent. Dalia praises its methodology as distinctively accounting for potential biases such as interviewer effect, social desirability bias or interviewer data entry errors. (Dalia Research 2016)

Our forecasting project utilizes data of Dalia Research’s Europulse Survey which is conducted quarterly in all EU countries. The survey consists of seven waves, but for this project we only use two waves of the survey from December 2016 and March 2017. The first wave is freely available on [Kaggle](#), the second wave was provided to us directly by Dalia Research.² Each wave consists of about 11000 individuals, of which roughly 1900 were from Germany which is the fraction of respondents we will focus on in the following analysis. The data is already pre-stratified by Dalia Research based on micro census data for age, gender.³

The Europulse data is not particularly collected for election forecasting purposes but contains data on a variety of questions such as online behaviour, media consumption and personal views on political and societal development in the European Union and the respondent’s country of origin. Moreover, the survey contains information on the respondent’s personal background, demographic data and his or her financial situation. These data can be utilized in order to improve the representativeness of the survey through weighting. This will be explained more detailed in the methodology section.

The election-related variables collected in the Europulse survey are similar to traditional vote intention polling questions. First of all, the respondents are asked if and for which party they will vote in the upcoming election and for which party they voted in the previous election. Moreover, they are asked to rank political parties and describe the degree of certainty to cast a ballot for a particular party. Important for our analysis is a variable containing self-reported voting decision at

²The data for the first wave was collected between 5th and 15th of December 2016. The second wave was conducted between 13th to 27th of March 2017.

³Dalia Research also provides weights from the micro census in their data. However, since we do not know the methodology used to obtain these weights we will employ our own weighting algorithm for Census adjustment.

the past German federal election. We exploit this data in order to compute survey weights that adjust the data to demographic voter composition of the past election in 2013.

3.2 Raw forecasts and data quality

As with all surveys, the methodology of Dalia Research has several sources of potential biases. In the case of the Europulse survey they are primarily from flawed measurement and representation of the surveyed population, as listed in figure 1 (Groves et al. 2009).

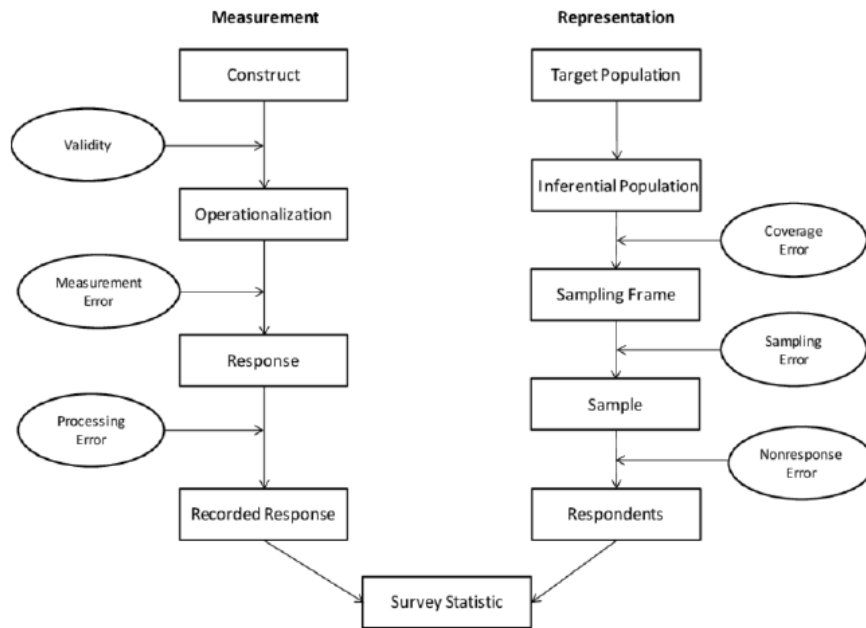
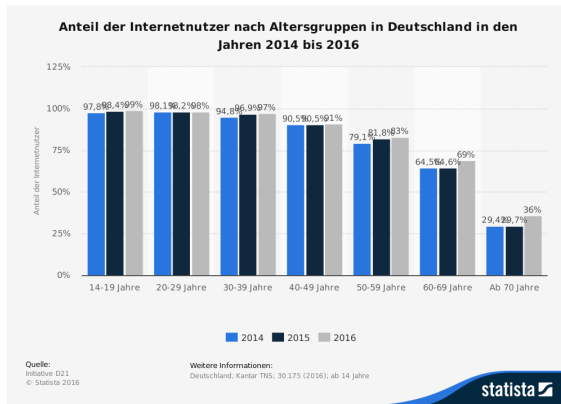


Figure 1: Potential sources of survey error

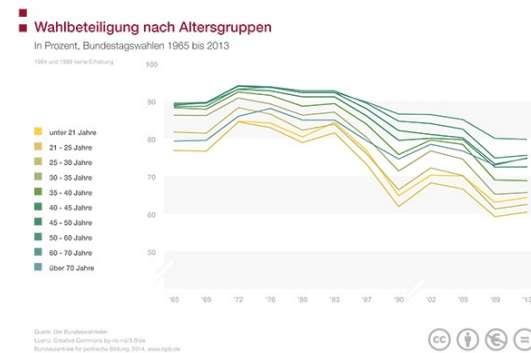
With regard to measuring vote intention for a particular party, the Europulse survey uses a similar approach as traditional surveys: it asks respondents directly which party they intent to vote for at the upcoming election. Whether such questions measure correctly the actual voting behaviour at the election day is questionable but the approach does not differ significantly from traditional polling methods.⁴ However, online surveys, such as Europulse, can reasonably claim to avoid some sources of measurement error such as social desirability bias or interviewer bias. Since such surveys are often anonymous, the social pressure on the respondent is presumably negligible, and interaction with the interviewer does not bias the response.

Regarding representativeness, the Europulse survey has some limitations in comparison to face-to-face or RDD interviews. First of all, Europulse' framework does not select participants at random

⁴The exact question used for instance by *infratest dimap*, a major german polling firm, is: "What party would you vote for if there would be a Federal election next Sunday." (dimap 2017) This wording is slightly different than in the Dalia questionnaire but evaluating the impact of the formulation of questions shall not be content of this study.



(a) Internet usage by age



(b) Voter turnout by age

Figure 2: Internet usage and turnout by age

but offers visitors of certain websites or app-users the opportunity to participate. Hence, this approach carries the risk of self-selection. Moreover, representativeness would require that the Europulse survey in principle should be available to the entire population. However, not everyone is using smartphones and even if they are, they might not use the applications Dalia targets for its surveys. The users Dalia Research actually tends to reach are likely to be much younger and technology oriented than the general population would be (see figure). This is in particular a problem for election polling, as older voters are systematically underrepresented in such online methodologies while turnout amongst the elderly tends to be higher compared to the young population.

Dalia Research tries to account for these problems. First, as we have mentioned, they try to increase the diversity of their respondents by presenting their surveys on various apps and platforms targeting different user groups. Second, they pre- and post-stratify their data. Pre-stratification is done on the basis of age and gender, using self-reported demographic information. For each age and gender strata they target a certain number of respondents so that their sample resembles roughly the German population. In a second step, they use data from the German Census and compute weights for cluster of age, gender, education and whether the respondent lives in an urban or rural area. The methodology how Dalia obtained these weights was not available to us. For that reason we used our own approach for post-stratification that specifically addressed our purpose of election forecasting. Finally, Dalia tries to reduce selection bias since they do not inform respondents that they are answering an election related survey before they actually start it and in general Dalia Research has high completion rates, hence participants are only rarely dropping out after they started a survey.

Despite these efforts, it is questionable whether the data can be regarded as representative. Below we present a simple frequency table of the self-reported past vote in the Federal Election 2013. The second figure shows that the Dalia sample significantly diverging from the actual voting results.

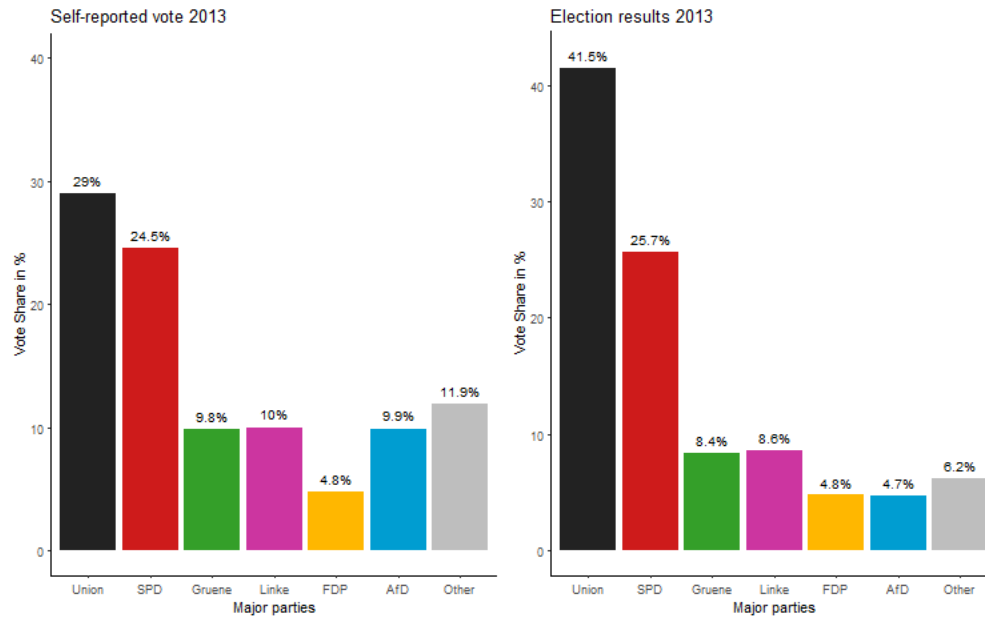


Figure 3: Self-reported vote 2013 and 2017 (Europulse March 2017)

The large divergence from actual results can be due to a variety of flaws that bias Europulse. First of all, even if the sample represents the German population in terms of age groups and gender, it can be question whether the old female or male users are truly representative of their age group. Moreover, not revealing the survey content might sort out political motivated respondents, but interest in political matters is likely correlated to general willingness to respond to surveys. Further problems with the raw data are indicated by the high share of past votes for other parties. This could be a sign of unwillingness to report the true vote intention or unfamiliarity with the German party system. Hence, in order to utilize the data to election forecasting further weighting and post-stratification will be necessary.

3.3 Official election statistics and Census

The data used for post-stratification and weighting come from several sources. Our primary secondary data is obtained from the German official election statistics (Der Bundeswahlleiter 2017). It contains combined information of turnout and voting decision by gender and age. Age is clustered in groups of 18-25, 26-35, 36-45, 46-60 and 60 plus. This data is the closest estimate of the actual voting population available and is a common measure to account for likely voter bias.

To adjust our sample to demographic composition of the German population we use data of the German [Zensus 2011](#). The data is freely available and we obtained combined frequencies for age, gender and religion. The Census claims to reflect the actual demographic distribution of the German population and hence is suitable in order to post-stratify our sample to demographic criteria. Both, election statistics and Census is the basis on which we adjust our raw data to obtain

representative results.

Finally, in order to set our forecasts into context we will use polling data from other institutes. Based on the idea of polling the polls (Jackman 2005) we benchmark our adjusted election forecast with the rolling average of other polls. The daily newspaper [Süddeutsche Zeitung](#) has recently started to publish aggregated polling data similar to Nate Silver's [fivethirtyeight.com](#). We are using their data as they have made it publically available on GitHub.

Finally, as well as the Dalia data, the weighting data suffers from a variety of problems. Most important, the exit poll data we use to compute our weights is not clustered for voters of the *Alternative für Deutschland* (AfD). In order to compute the vote share among groups of age and gender we took the share of the total election results that the AfD got among all parties that are summarized among *Others*. The weak spot of this approach is that it assumes a equal distribution of AfD voters across all groups of age and gender. While this assumption is very unlikely it is the best approximation we can get with the data at hand.

Moreover, the Census as well as the election statistics do not provide combined frequencies of more than three dimensions of demographic variables. This makes it impossible to weight the data on a large set of criteria. Yet, since our Dalia dataset is too small to compute more than three-dimensional cluster anyways that has no severe impact on our methodology.

4 Methodology

We want to employ two approaches to generate election forecasts from our data. In the first approach, the survey data is adjusted in a two step procedure: First, the representativeness of survey data to the general population is increased by finding appropriate weights. Then, a likely voter model is used to obtain an election forecast. Our second approach does this in one step: The survey data will be directly adjusted to the likely voter population based on exit poll data from the German federal election in 2013.

4.1 Post-stratification

In order to follow both procedures, we need methods to compute weights for different strata of the survey sample aiming at increased representativeness. A classical way to get these weights is *raking*. With raking weights are assigned to each respondent in order to match the marginal distribution of characteristics in the 'true' population. For example, if we know the distribution of education level and employment status in the population we can compute a weight for each so that the weighted survey sample has the same distribution of the characteristics as the 'true' population. Basically, raking estimates a joint distributions for each combination of characteristics.

However, raking is not ideal. It is often used if only marginal probabilities are available. However, if the joint distribution of characteristics is known we can use *post-stratification* instead. In contrast to raking, post-stratification takes the distribution of combinations of characteristics in the population into account. In other words: It sub-divides the population into groups according to their characteristics. Formally, the post-stratification estimator can be expressed as follows (Goel, Obeng, and Rothschild 2017, Lohr (2010, 142f.)):

$$\hat{y}^{post} = \frac{\sum_{j=1}^J N_j \hat{y}_j}{\sum_{j=1}^J N_j} \text{ where } \hat{y}_j = \frac{1}{n_j} \sum_{i=1}^{n_j} y_i, \quad (1)$$

where \hat{y}^{post} is the estimator of y in the strata j , N_j the size of the j -th strata in the population and n_j the size of the j -th strata in the sample. From the equation it is obvious that post-stratification is only feasible if we have at least one observation for each strata ($n_j > 0$). But even for small strata sizes in the sample ($n_j < 30$) the standard errors will be large. This is a serious issue as the number of strata grows rapidly with each characteristic included. If we use for instance two gender categories and four age groups we have eight strata, if we add past vote (7 categories) we already have 54. As a result, we might only have a few individuals for each strata or even none. This has severe consequences: For example, estimating the population frequency of the strata female, old (60+) and FDP voter in 2013 with only few respondents in the sample will come with a large error.

Furthermore, our effort to post-stratification comes with another problem: Publically available data often only includes the distribution of pairs of characteristics or, in rare cases, triples (e.g. age, gender and past vote). Yet, the ideal would be to have the frequencies of strata of all variables that is correlated to the voting behaviour of a person. These would be certainly gender and age but also employment status, income, education and religion.⁵ Knowing this distribution would enable us to fine tune our forecast. However, as they are not available we will concentrate on combination of characteristics where we have the joint distributions. These are in particular age, gender and past votes (from exit polls) as well as combinations of age, gender and religion from the census.

The prior mentioned problem of empty strata can be address in two ways: *Filling strata by aggregating* or with *model-based post-stratification*. Aggregation works simple: If a strata is empty, it has to be combined along one variable with another one. For example: In the December 2016 data set there was no female women above 60 who voted FDP in 2013. In order to address this problem, the age groups 45-59 and 60+ were combined. This is ad-hoc, but a common practice to address empty stratas. There is one alternative: In the model-based post-stratification approach the estimates for each strata are not based on the average in the strata as in the equation above, but the result of a multinomial logistic regression. In order to arrive at this regression results, demographic variables in the sample can be used. We did not implement this because the necessary

⁵Formally speaking, we need to know the number of individuals in each strata N_j

packages for this are not yet released by Goel, Obeng, and Rothschild (2017).⁶

4.2 Likely voter models

By the time we post-stratified and weighted our sample to resemble the population (first approach), we have not yet accounted for the problem of likely voter bias. Surveys tend to either include voters who say they will vote but eventually do not do so, or include voters who say they will not vote but finally cast a ballot (Bernstein, Anita, and Montjoy 2001). Since this behaviour of individuals has turned out to be correlated across party preferences it is likely to bias our forecast (Keeter, Igielnik, and Weisel 2016)

Two families of methods are proposed by Keeter, Igielnik, and Weisel (2016) to account for likely voter bias - *deterministic* and *probabilistic* methods. The former was initially proposed in Perry (1960) and Perry (1979) and tries to identify criteria that describe a voter as a likely voter on a scale from 0-7. Using a distinct set of questions such as “How likely are you to vote at the next national election?” respondents are assigned points on the likely voter scale and are eventually ranked. Using an estimate of the upcoming election turnout, a cut-of criteria determines which rank on the likely voter scale is needed to be included in the sample measuring the actual voting population.

The downside of such methods is that people below the threshold value of the scale have no affect at all on the actual forecast. This is addressed by probabilistic methods. Such an approach estimates on the basis of a set of predictor variables like demographic characteristics, partisanship or ideology a probability of a person to cast a ballot. By using this probability even people with a very low likelihood of voting affect the actual estimate to a certain degree. The downside of such methods is that it requires data on turnout and the predictor variables of the past election. Moreover, such models assume that turnout is time-stable for the population groups across past and future elections.(Keeter, Igielnik, and Weisel 2016)

For the purposes of our calibration we decided to use the simplest deterministic approach: Self-reported vote intention. For further fine-tuning we could employ other approaches, but our analysis (see below) showed that for our data set the post-stratification is more crucial.

5 Results

Our results show that the choice of weighting method has a considerable effect on the performance of the forecast against our benchmark data. Moreover, we could show that proper and transparent weighting with publicly available elections statistics and Census data is feasible to obtain a representative and reasonable forecast from the online poll. Table 1 displays the SZ’ rolling average for

⁶They are developing an r package for this (postr) and already announced to make it public.

March 2017 and December 2016, our weighted results and the raw polling data together with the calculated root mean squared error (RMSE) as indicator of accuracy of prediction.

Table 1: Raw, weighted and benchmark estimates

December								
Method	Union	SPD	FDP	Gruene	Linke	AfD	Other	RMSE
SZ Rolling Average	35.50	22.20	5.70	10.60	9.70	11.60	4.70	
GAV Exit Polls	32.50	21.10	8.70	8.60	9.60	11.70	7.80	2.17
GAR Census Data	24.60	21.60	5.50	10.60	9.50	14.00	14.20	5.55
Dalia Unweighted	23.80	20.90	6.10	10.50	10.50	13.80	14.40	5.83
March								
Method	Union	SPD	FDP	Gruene	Linke	AfD	Other	RMSE
SZ Rolling Average	33.10	31.40	5.80	7.60	7.70	9.30	5.10	
GAV Exit Polls	36.70	28.10	4.90	7.50	8.60	7.80	6.40	2.05
GAR Census Data	23.10	30.00	5.80	8.40	9.00	13.80	10.00	4.61
Dalia Unweighted	23.60	28.40	5.60	7.70	9.80	14.50	10.30	4.75

Notes: The benchmark is the rolling average of all german major polls as computed by *Süddeutsche Zeitung*. GAV stands for Strata combined of the variables gender, age and self-reported vote at the last election. GAR indicates Strata of gender, age and religion. The last row of each month represents the raw results without weighting as collected by Dalia Research.

As the table shows, the divergence of the raw data was relatively high compared to the average of official polls. The raw forecast has a RMSE of 5.83 for December and 4.75 in March. Yet, with our weighting approach using Census data we were able to improve this performance only by a negligible amount. Employing clusters of gender, age and religion our forecast shows an RMSE of 5.55 and 4.61 respectively. The weak performance might be due to several reasons. As stated earlier the Dalia data is stratified with age and gender by the time the poll is conducted. We decided, however, to account for age and gender through census data since we did not transparently evaluate Dalia's procedure for stratification. Yet, the very low difference of our estimate with Census data and the original data shows that our approach did not significantly differ from Dalia's approach. Moreover, the variable religion does not seem to have a reasonable impact on vote since its impact is negligible as well. Additionally, the approach using exclusively Census data, does not account for likely voter bias at all.

In contrast, our approach using the election statistics does account for demographics of likely voter and thus performs very well compared to Census data. Weighting with cluster of age, gender and vote decision and taking into account self-reported vote at the past election yields results with only 2.17 and 2.05 RMSE respectively compared to our benchmark. Figure 4 contrasts the raw data with our weighted estimates for December and March data.

The results are very promising. They show the possibility of adjusting weakly representative raw data from online polling with publicly available election statistics in a way that the results are close to professionally conducted traditional polls. While our results are not conclusive to state the equal

What the result is of making it representative

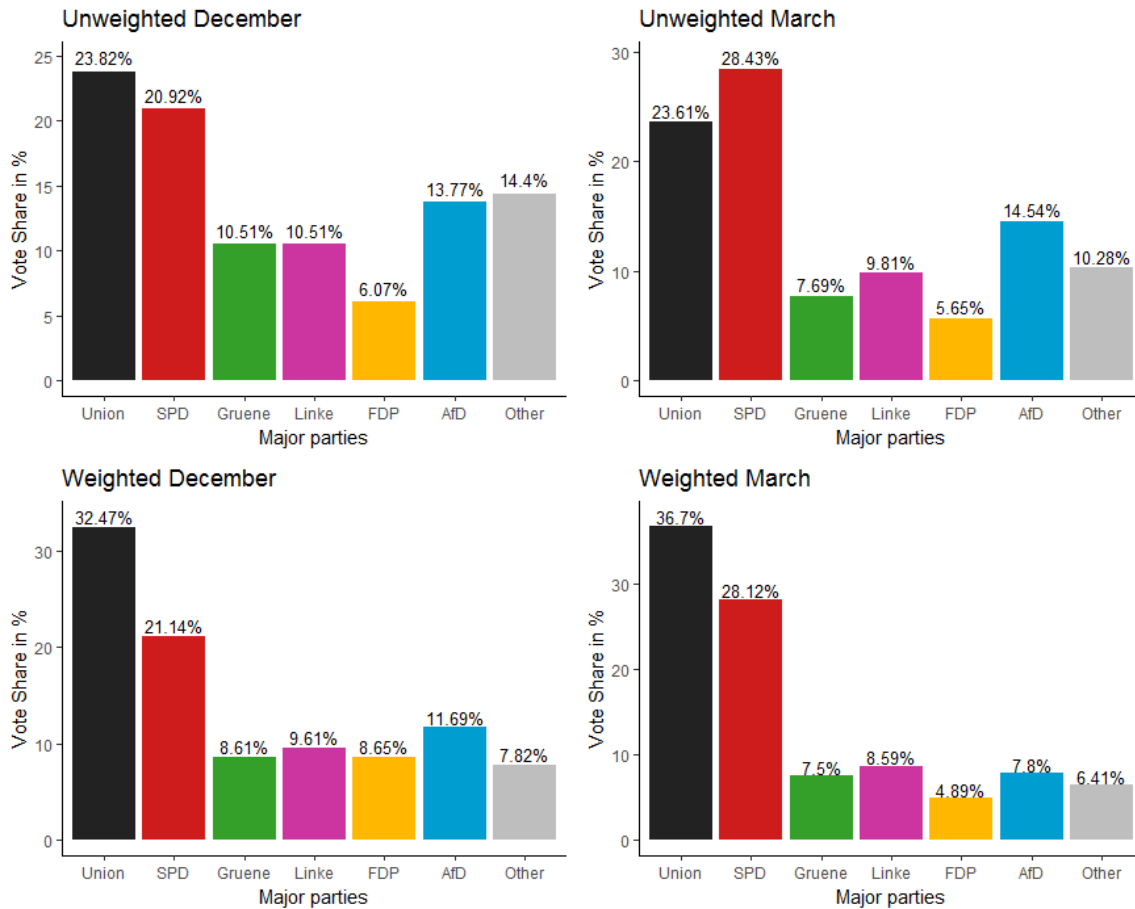


Figure 4: Weighted and unweighted polls

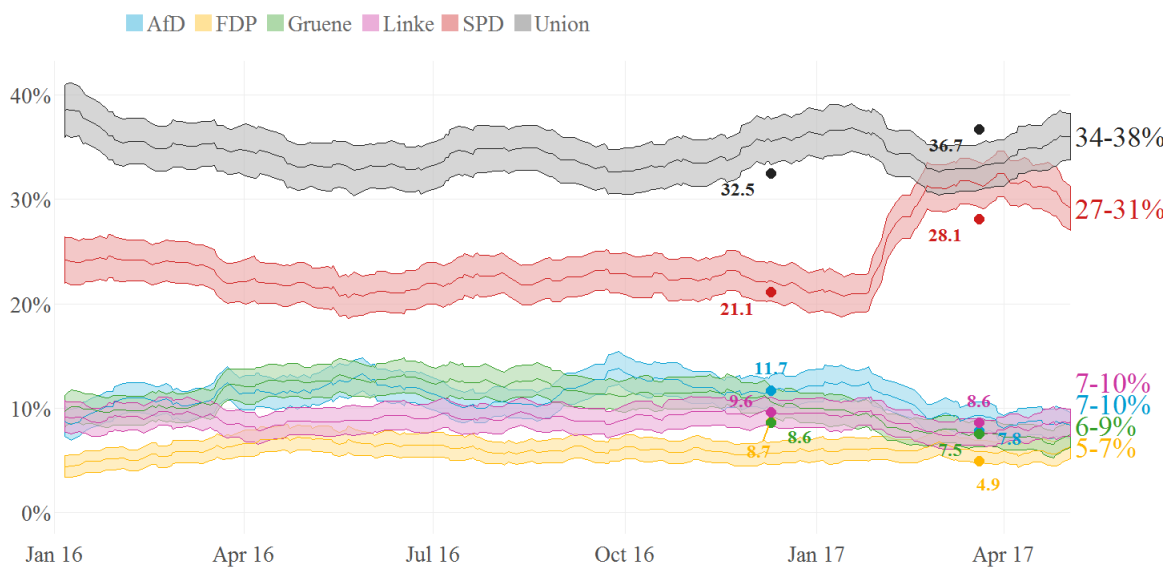


Figure 5: Weighted polls benchmarked to overall poll's rolling average

1. Election forecast Weighted with exit polls
2. Election forecast weighted with election statics
3. Election forecast weighted with zensus

Compare the three different weighten approaches

Comment Moritz: I think we have to weight the data with Zensus data in any case at least for gender and age as long we don't want to use the Dalia weights; then we can either use election statistics or exit poll data (that we don't have)

My approach would be:

1. Weighting with Zensus (accounts for self-selection of the survey)
2. Different mixes of weighting with election statistics with education (accounts for likely voter bias)

6 Conclusion

Blablabla

Zusammenfassung

Shortcomings

Alternative Methoden und Vorgehen: AfD data More detailed demographic data More sophisticated identification of likely voter more waves for fitting purposes; structural

References

Bernstein, Robert, Chadha Anita, and Robert Montjoy. 2001. "Overreporting Voting: Why It Happens and Why It Matters." *Public Opinion Quaterly* 65: 22–44.

Dalia Research. 2016. "Dalia Research Methodology." <https://daliaresearch.com/wp-content/uploads/2016/08/Methodology-PDF-1.pdf>.

Der Bundeswahlleiter. 2017. "Ergebnisse Der Representativen Wahlstatistik." <https://www.bundeswahlleiter.de/bundestagswahlen/2013/ergebnisse/repraesentative-wahlstatistik.html>.

dimap. 2017. "Allgemeine Informationen Zur Sonntagsfrage." infratest dimap. <https://www.infratest-dimap.de/service/faqs/faqs-zur-sonntagsfrage/>.

Gallup. 2010. "Understanding Gallup's Likely Voter Models." <http://www.gallup.com/poll/>

[143372/understanding-gallup-likely-voter-models.aspx?version=print](https://doi.org/10.1002/9780470173404.ch23).

Goel, Sharad, Adam Obeng, and David Rothschild. 2017. "Online, Opt-in Surveys: Fast and Cheap, but Are They Accurate?" Working Paper.

Groves, Robert M., Floyd J. Fowler Jr., Mick P. Couper, James M. Lepkowski, Eleanor Singer, and Roger Tourangeau. 2009. *Survey Methodology*. 2nd ed. New Jersey: John Wiley & Sons Inc.

Holbrook, Allyson L., Jon A. Krosnick, and Alison Pfent. 2007. "The Causes and Consequences of Response Rates in Surveys by the News Media and Government Contractor Survey Research Firms." In *Advances in Telephone Survey Methodology*, edited by James M. Lepkowski, Clyde Tucker, J. Michael Brick, Edith D. de Leeuw, Lilli Japac, Paul J. Lavrakas, Michael W. Link, and Roberta L. Sangster, 499–528. Hoboken, NJ, USA: John Wiley & Sons, Inc. doi:[10.1002/9780470173404.ch23](https://doi.org/10.1002/9780470173404.ch23).

Jackman, Simon. 2005. "Pooling the Polls over an Election Campaign." *Australian Journal of Political Science* 40 (4): 499–517. doi:[10.1080/10361140500302472](https://doi.org/10.1080/10361140500302472).

Keeter, Scott, Ruth Igielnik, and Rachel Weisel. 2016. "Can Likely Voter Models Be Improved? Evidence from the 2014 U.S. House Elections." Pew Research Center.

Keeter, Scott, Courtney Kennedy, Michael Dimock, Jonathan Best, and Peyton Craighill. 2006. "Gauging the Impact of Growing Nonresponse on Estimates from a National RDD Telephone Survey." *The Public Opinion Quarterly* 70 (5): 759–79. <http://www.jstor.org/stable/4124225>.

Lohr, Sharon. 2010. *Sampling: Design and Analysis*. Brooks/Cole.

Mellon, Jonathan, and Chris Prosser. 2015. "Investigating the Great British Polling Miss: Evidence from the British Election Study." *SSRN Electronic Journal*. doi:[10.2139/ssrn.2631165](https://doi.org/10.2139/ssrn.2631165).

Perry, Paul. 1960. "Election Survey Procedures of the Gallup Poll." *Public Opinion Quarterly* 24: 531–42.

———. 1979. "Certain Problems in Election Survey Methodology." *Public Opinion Quarterly* 43: 312–25.

Pew Research Center. 2012. "Assessing the Representativeness of Public Opinion Surveys." Pew Research Center. <http://www.people-press.org/files/legacy-pdf/Assessing%20the%20Representativeness%20of%20Public%20Opinion%20Surveys.pdf>.

Skibba, Ramin. 2016. "The Polling Crisis: How to Tell What People Really Think." *Nature* 538 (7625): 304–6. doi:[10.1038/538304a](https://doi.org/10.1038/538304a).

Squire, Peverill. 1988. "Why the 1936 Literary Digest Poll Failed." *The Public Opinion Quarterly* 52 (1): 125–33. <http://www.jstor.org/stable/2749114>.

Wang, Wei, David Rothschild, Sharad Goel, and Andrew Gelman. 2015. "Forecasting Elections with Non-Representative Polls." *International Journal of Forecasting* 31 (3): 980–91.

doi:[10.1016/j.ijforecast.2014.06.001](https://doi.org/10.1016/j.ijforecast.2014.06.001).

Yeager, D. S., J. A. Krosnick, L. Chang, H. S. Javitz, M. S. Levendusky, A. Simpser, and R. Wang. 2011. "Comparing the Accuracy of Rdd Telephone Surveys and Internet Surveys Conducted with Probability and Non-Probability Samples." *Public Opinion Quarterly* 75 (4): 709–47. doi:[10.1093/poq/nfr020](https://doi.org/10.1093/poq/nfr020).