How does smartphone participation in web surveys differ across Europe? Evidence from 12 European countries

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Abstract
The use of smartphones in web surveys has sparked an on-going discussion on data quality and new measurement opportunities. However, empirical evidence on the status of smartphone participation is rare. We therefore investigate smartphone participation in the CROss National Online Survey 2 (CRONOS-2), a probability-based panel that is part of the European Social Survey (ESS). Using data from 12 European countries, we compare smartphone participation across countries and run multilevel regressions to investigate its drivers. The results reveal a high share of smartphone participation ranging between 35% (Czechia) and 57% (Portugal and Slovenia). Young, female, and lower educated respondents as well as respondents with low digital sophistication are more likely to participate via smartphone. These respondent groups also show high smartphone stability over time. Our study contributes to a better understanding of smartphone participation in contemporary web surveys and provides important knowledge for future web survey studies.

Keywords: web survey; smartphones; mobile devices; survey participation; online panel; European Social Survey

Introduction
Survey research has undergone a methodological shift, transitioning from face-to-face and telephone surveys to self-administered modes (Olson et al. 2021; Wolf et al. 2021). This shift, particularly concerning the increased utilization of the web mode (Callegaro et al. 2015), has brought forth numerous advantages. Self-administered web surveys offer cost efficiencies compared to interviewer-administered modes (Braekman et al. 2022; Mackeben and Sakshaug 2022; Wolf et al. 2021), allow for responsive questionnaire designs (e.g., interactive prompts to

reduce speeding; Conrad et al. 2017; Sun et al. 2023), and facilitate different communication channels for question delivery (e.g., pre-recorded video interviewers; Conrad et al. 2023; Haan et al. 2017). In addition, web surveys offer respondents flexibility by reducing time and location constraints and enabling them to participate with the device (i.e., computer, tablet, or smartphone) of their choice (Callegaro et al. 2015). This flexibility is important, since respondents are increasingly choosing smartphones to participate in web surveys (Gummer et al. 2023; Peterson et al. 2017; Revilla et al. 2016). The increasing use of smartphones to participate in web surveys sparked on-going methodological discussions on smartphone participation in web surveys with a focus on data quality and new measurement opportunities.

Concerns about data quality were triggered by the technical features of smartphones (e.g., limited screen size, processing power, and virtual on-screen keypad) and undesirable respondent behaviors facilitated by smartphones (e.g., multitasking and presence of third parties; Couper and Peterson 2017; Höhne et al. 2020). While some studies found that smartphone participation, compared to computer participation, is associated with lower completion rates (Lambert and Miller 2015; Mavletova 2013; Sommer et al. 2017), shorter answers to open narrative questions (Lambert and Miller 2015; Mavletova 2013), and more straightlining with respect to grid questions (Struminskaya et al. 2015), other studies found no differences in data quality between both devices (Antoun et al. 2017; Lee et al. 2019; Schlosser and Mays 2018).

At the same time, smartphones are equipped with a variety of sensors and apps that introduce new measurement opportunities (Struminskaya et al. 2020; Revilla 2022) spurring a surge in methodological studies that aim to utilize these advantages. Examples of this research include studies using the built-in microphones of smartphones to collect voice answers from respondents (Höhne et al. 2024; Höhne and Claassen 2024; Revilla and Couper 2021), studies augmenting web surveys with GPS and acceleration data (Elevelt et al. 2021; Kern et al. 2021), and studies collecting mobile browsing and app data through web tracking applications (Bach and Wenz 2020; Bosch and Revilla 2022) and digital data donations (Haim et al. 2023; Ohme et al. 2021).

Although internet and smartphone penetration rates are high in many countries (Su et al. 2020; Taylor and Silver 2019), especially in industrialized countries, smartphone participation in web surveys has not necessarily reached its full potential. For instance, approximately 90% of the German population owned a smartphone in 2020 (Deloitte 2020). Yet, in the same year, less than 40 percent of respondents participated in the German Internet Panel via smartphone (Gummer et al. 2023). Although availability of smartphones and internet access are the prerequisites for using these devices in web surveys (Gummer et al. 2019), the ultimate decision to participate via smartphone lies with the respondents (Couper et al. 2017). Previous research indicated that some respondent groups are more likely to participate via smartphone than other respondent groups. In particular, young respondents (Gummer et al. 2019; Lugtig et al. 2016; Revilla and Höhne 2020), female respondents (Bosnjak et al. 2017; Maslovskaya et al. 2019; Sommer et al. 2017), less affluent respondents (Bosnjak et al. 2017), and lower educated respondents (Lugtig et al. 2016) are more likely to participate via smartphone in web surveys.

In addition, habitual use of smartphones to participate in web surveys seems to be rather low. Based on the data of web survey panels, two studies investigated whether individual device preferences change over time (or across multiple web survey waves). Poggio et al. (2015)

analyzed eight web survey waves of the German GESIS Panel in 2011 and 2012, and Lugtig et al. (2016) analyzed seven web survey waves of the American Life Panel in 2014. Both studies found that while the majority of respondents participates via computers persistently across web survey waves, a substantial group of respondents switches between devices, and only a small minority of respondents participates via smartphone consistently.

Considering the existing literature on smartphone participation in web surveys, we identify a three-fold research gap: First, empirical research on an increase in smartphone participation in web surveys has only covered limited time periods running until 2014 (see, for example, Peterson et al. 2017; Revilla et al. 2016). A recent exception is a study by Gummer et al. (2023). Based on 128 web surveys conducted in Germany between 2012 and 2020, the authors showed increased smartphone participation in web surveys, decreased computer participation, and a stagnation in tablet participation. Yet, the authors solely focused on Germany and did not take the drivers of smartphone participation into account. Consequently, there is a lack of systematic research investigating smartphone participation in web surveys across countries.

Second, even though previous studies have identified particular respondent groups that are more likely to participate via smartphone in web surveys (Bosnjak et al. 2017; Lugtig et al. 2016; Sommer et al. 2017), there is a lack of contemporary studies examining the drivers of smartphone participation. As smartphones are now adopted more widely and across various demographic groups (Beneito-Montagut et al. 2022), the associations between respondent characteristics and smartphone participation in web surveys may have changed (Gummer et al. 2019). Thus, there is a need for more updated analyses.

Third, only few existing studies have investigated the stability of individual smartphone participation over time (Lugtig et al. 2016; Poggio et al. 2015). However, it is important to know whether the preference for smartphone participation is stable or whether it changes between web survey waves (Maslovskaya et al. 2019). Stability in smartphone participation would facilitate more tailored web survey designs and suggest that device effects remain constant within respondents. Importantly, the global increase in high-speed mobile internet access (Shanahan and Bahia 2023) facilitates higher stability of smartphone participation across web survey waves.

The lack of research on smartphone participation in web surveys is unfortunate because large-scale, cross-national surveys have already started transitioning to web modes or are planning a transition to web modes, such as the European Values Study (Luijkx et al. 2021; Wolf et al. 2021; Gummer et al. 2022). However, it is still unknown whether and to what extent smartphone participation differs across countries. Large differences in smartphone participation can introduce systematic measurement error because of device effects that distort the response behavior of respondents (Krebs and Höhne 2021). In addition, the potential for harnessing the capabilities of smartphones to collect digital data alongside survey data remains uncertain for cross-national survey contexts. These survey contexts may not develop their full potential because of a lack of knowledge on device distributions. Finally, the lack of contemporary research on the drivers of smartphone participation and stability impedes informed decisions on recruitment strategies (e.g., inviting respondent groups with high likelihood of smartphone participation via SMS).

To address the existing research gaps and aid (cross-national) survey research, we utilize the unique data of the CROss National Online Survey 2 (CRONOS-2) that is part of the European Social Survey (ESS). CRONOS-2 is a probability-based web survey panel that consists of seven consecutive web survey waves that were fielded in 12 European countries: Austria, Belgium, Czechia, Finland, France, Hungary, Iceland, Italy, Portugal, Slovenia, Sweden, and the United Kingdom. It is one of the largest web surveys in the world. Considering the fact that CRONOS-2 collected rich paradata, including device information, it lays the foundation for a large-scale investigation of smartphone participation in web surveys across Europe. Building on this data, we investigate the following three research questions (RQs):

RQ1*: How prevalent is smartphone participation in web surveys across Europe?*
RQ2*: What drives smartphone participation in web surveys across Europe?*
RQ3*: How stable is smartphone participation across web survey waves across Europe?*

Our study stands out from previous research in three respects: First and foremost, we utilize probability-based samples from 12 European countries. Previous studies have mostly focused on single countries impeding a comprehensive comparison of smartphone participation. Second, we analyze data from seven consecutive web survey waves that were conducted between October 2021 and March 2023. Existing studies have mostly focused on time periods before 2014. Third, we use mixed effects regressions to investigate drivers of smartphone participation – including its stability – at three levels: survey completion, respondent, and country. Previous studies have only considered the respondent-level focusing on demographic characteristics to explain smartphone participation in web surveys.

Method

Data

We employ data from the probability-based CROss-National Online Survey 2 (CRONOS-2; ESS ERIC, 2024), a web survey panel fielded in 12 European countries between October 2021 and March 2023. Respondents were recruited by inviting eligible respondents (i.e., adults with internet access that are aged 18 years or older) of Round 10 of the European Social Survey (ESS) to participate in seven consecutive web survey waves. These waves addressed various topics, including topics related to economy, politics, and society. CRONOS-2 consists of a short 10-minutes welcome web survey wave and six substantive web survey waves of about 20 minutes. Importantly, the content of the web surveys is identical across countries for all waves, except for the third and sixth substantive waves that included country-specific questionnaires. As the Covid-19 pandemic interfered with the fieldwork, data collection periods partially differ across countries and not all web survey waves were fielded in every country. While some countries, such as Austria, France, and Slovenia, conducted all seven web survey waves, Hungary conducted only three waves. There is also some variation with respect to the field time of the web survey waves. For example, Belgium fielded the fourth and fifth substantive web survey wave simultaneously and Italy did not field the welcome survey wave until June 2022 (see Appendix A for an overview of the web survey waves and fieldwork periods across countries). Respondents received unconditional pre-paid incentives of approximately 5€ per

web survey wave. For more comprehensive information on the methodology of CRONOS-2, we refer interested readers to Bottoni (2023).

Panel Recruitment and samples

Of all invited respondents from ESS Round 10, between 16% (Czechia) and 80% (Iceland) could be successfully recruited for the CRONOS-2. In this study, we use data from all seven web survey waves (i.e., the welcome wave and the six substantive waves). Importantly, we only considered respondents who participated in at least one CRONOS-2 web survey wave. In total, our sample consists of 8,147 respondents participating in up to seven web survey waves, resulting in 39,840 observations (or survey completions). Across countries, the sample size varies between 367 (Czechia) and 1,149 respondents (Sweden) and between 1,091 (Hungary) and 5,989 (Sweden) survey completions. Table 1 includes information on respondent recruitment and sample characteristics for all 12 European countries.

Considering the sample characteristics displayed in Table 1, the samples of the CRONOS-2 countries differ markedly with respect to demographic characteristics. In particular, mean age varies between 44 years (Slovenia) and 53 years (Sweden). The share of female respondents is lowest in Italy (47%) and highest in Czechia (62%). Between 37% (Belgium, Iceland, Portugal, and United Kingdom) and 74% (Czechia) have medium education. High education varies between 22% (Czechia) and 54% (Belgium). The share of respondents with high income is lowest in Iceland (52%) and highest in Austria, Belgium, and Finland (70%). In addition, self-reported average daily internet use ranges from 1.7 hours (Belgium) to 4.9 hours (Sweden). When it comes to digital sophistication (measured from 1 "Low" to 5 "High"), mean values are between 3.1 (Iceland) and 4.0 (Austria and Finland).

Analytical strategy

Before data analysis, we created a new variable for smartphone participation (1 = "Yes") based on the device variable available for every CRONOS-2 survey completion. In line with previous research (Peterson et al. 2017), we consider tablets as similar to computers and thus do not count them as smartphones.[1] To examine our first research question, we report descriptive statistics of the share of respondents participating via smartphone across the seven web survey waves and 12 European countries. Specifically, we calculate the mean smartphone participation rate across web survey waves for each country. Then, we group countries into quartiles.

To examine our second research question, we investigate what aspects drive smartphone participation in web surveys. As survey completions (level 1) are nested in respondents (level 2) and respondents are nested in countries (level 3), we use mixed effects logistic regressions with random intercepts and smartphone participation (1 = "Yes") as dichotomous dependent variable. We estimate four sequential models, stepwise adding independent variables at the three levels to isolate their impact on the model, and report odds ratios. Model 1 is a null-model and does not include any independent variables. We examine the Intraclass Correlation Coefficients (ICCs) to determine the variation in smartphone participation accounted for by respondent and country characteristics, respectively. Model 2 includes months since the first CRONOS-2 web survey wave as single independent variable (level 1) to examine whether

[1] Previous research has indicated that computers and tables facilitate similar survey completion behavior (Couper and Peterson, 2017).

Table 1. CRONOS-2 recruitment information and sample characteristics

Country	Recruitment rate (in %)	Number of respondents in all waves	Number of survey completions	Age (mean)	Female (in %)	Medium education (in %)	High education (in %)	High income (in %)	Internet use (mean)	Digital sophistication (mean)
Austria	43.8	739	4,372	48.2	49.9	62.7	33.3	70.1	4.7	4.0
Belgium	61.3	719	3,051	47.8	49.9	36.6	53.7	70.0	1.7	3.6
Czechia	16.3	367	1,970	49.5	61.6	74.1	22.3	62.7	3.7	3.5
Finland	69.8	982	4,588	50.6	53.1	45.1	48.1	70.0	4.0	4.0
France	50.5	855	4,601	47.0	52.8	59.4	31.8	68.4	3.7	3.7
United Kingdom	61.3	606	2,808	54.1	56.6	37.0	44.9	52.8	4.4	3.4
Hungary	23.0	535	1,091	49.6	58.1	63.7	30.7	66.0	3.1	3.7
Iceland	79.7	650	3,482	50.4	59.9	36.9	43.4	52.0	4.7	3.1
Italy	21.1	390	1,457	44.7	46.7	51.8	31.3	67.4	3.5	3.7
Portugal	42.3	521	2,702	45.2	58.9	36.7	34.6	65.8	4.7	3.6
Sweden	52.3	1,149	5,989	52.8	52.0	50.3	37.3	68.0	4.9	3.4
Slovenia	62.9	634	3,729	44.3	55.1	58.8	37.1	63.3	3.9	3.5

Note. Recruitment rate = Share of invited respondents of ESS Round 10 that participated in at least one CRONOS-2 web survey wave. Age (in years), female (1 = "Yes"), medium education (1 = "Yes"), high education (1 = "Yes"), high income (1 = "Yes"), internet use (in average hours per day), and digital sophistication (1 "Low" to 5 "High"). Footnotes 2, 3, and 4 provide further information on the education, income, and digital sophistication variables.

smartphone participation increases over time. Following previous research on smartphone participation in web surveys (Bosnjak et al. 2017; Gummer et al. 2019; Lugtig et al. 2016; Maslovskaya et al. 2019; Revilla and Höhne 2020; Sommer et al. 2017), we add the following independent variables (level 2) in Model 3: age (in years), female (1 = "Yes"), medium education (1 = "Yes"), high education (1 = "Yes")[1], high income (1 = "Yes")[2], internet use (in self-reported average hours per day), and digital sophistication (1 "Low" to 5 "High")[3]. Our descriptive analysis of the sample composition revealed marked differences between countries for these variables (see Table 1), making the inclusion of these variables necessary. Finally, Model 4 additionally includes two independent variables at the country level (level 3): smartphone share (share of citizens who access the internet via smartphone, in %) and share of other device (share of citizens who access the internet via computer or tablet, in %). Data for both country-level variables were retrieved from Eurostat (2024) and merged to the CRONOS-2 dataset using the country variable. We report the marginal effects at the mean for all independent variables in Appendix B.

To examine our third research question, we investigate the stability of individual smartphone participation across web survey waves. For the following analyses, we only consider respondents that participated in at least two web survey waves (n = 7,326). In a first step, we group respondents into respondents who have always participated via smartphone (group 1), respondents who have participated via smartphone at least once but not always (group 2), and respondents who have never participated via smartphone (group 3). We then determine the share of these groups across countries. In a second step, we exclude respondents who have never participated via smartphone (group 3). We then determine the stability of smartphone participation across web survey waves for each respondent by dividing the number of smartphone participations by all survey completions. We multiply stability by 100 to ease the interpretation of the coefficients in the regression models (i.e., the share of web survey waves in which a respondent participated via smartphone in %). As respondents (level 1) are nested within countries (level 2), we estimate mixed effects linear regressions with stability (in %) as the dependent variable. In doing so, we examine the extent to which smartphone stability is driven by respondent and country characteristics. Overall, we estimate three sequential models, stepwise adding independent variables at the two levels. Model 1 is again a null-model and does not include any independent variables. We examine the Intraclass Correlation Coefficient (ICC) to determine the variation in stability accounted for by respondent characteristics and country characteristics, respectively. In Models 2 and 3, we add the same independent variables as before (see above).

Data preparations were conducted with R Studio (version 2024.04.01) and data analyses with STATA (version 18.0). CRONOS-2 data is accessible through the ESS data portal (see https://www.europeansocialsurvey.org/).

[1] Educational levels were defined as follows: Low = lower secondary education or less, medium = upper secondary or advanced vocational education, high = tertiary education.
[2] High income was defined as having an income above the country-specific median income.
[3] Respondents were asked to rate each of the terms "preference settings," "advanced search," and "PDF" on a scale from 1 "Not at all familiar" to 5 "Completely familiar." We generated the digital sophistication variable by calculating the mean rating across the three terms.

Results

Research Question 1

In a first step, we examine the prevalence of smartphone participation in the CRONOS-2. Figure 1 displays the share of respondents that participated via smartphone across the web survey waves and 12 European countries. We grouped these countries into quartiles based on their mean smartphone participation rate across web survey waves. In most countries, the mean smartphone participation rate is about 50% or higher, except for Finland, Austria, Belgium, and Czechia. While the third and fourth quartiles overlap considerably, we observe different levels of smartphone participation when comparing the first quartile to the third and fourth quartile. More specifically, in Austria, Belgium, and Czechia (1st quartile) the mean smartphone participation rate is only between 35% and 44%. In contrast, in Slovenia, Portugal, and Italy (4th quartile) and Sweden, United Kingdom, and Hungary (3rd quartile) the mean smartphone participation rate is about 55%. Although these results show that smartphone participation is overall high, there are also some clear differences between the European countries under investigation.

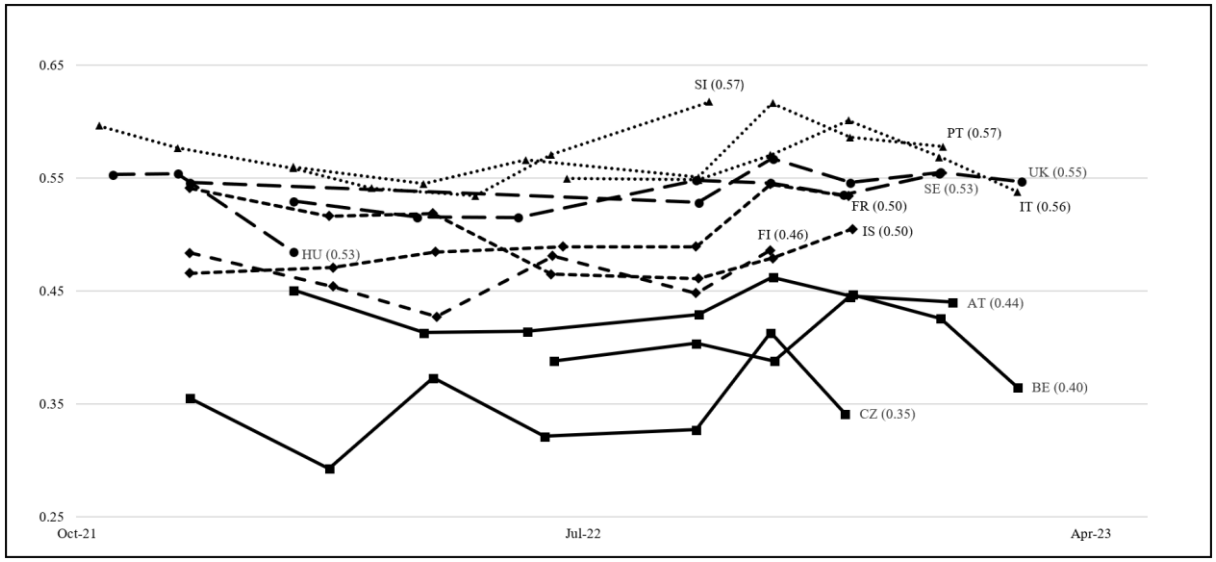

Figure 1. Share of respondents participating via smartphone across web survey waves and European countries

Note. Mean smartphone participation rate across web survey waves in parentheses. Solid line + square = 1st quartile, dashed line + rhombus = 2nd quartile, dashed line + square = 3rd quartile, dotted line + triangle = 4th quartile. AT = Austria, BE = Belgium, CZ = Czechia, FI = Finland, FR = France, HU = Hungary, IS = Iceland, IT = Italy, PT = Portugal, SI = Slovenia, SE = Sweden, UK = United Kingdom.

Research Question 2

In a second step, we now investigate variables that are associated with smartphone participation in the CRONOS-2. To do so, we run three-level mixed effects logistic regressions with random intercepts and smartphone participation (1 = "Yes") as the dichotomous dependent variable. We estimated four sequential models, stepwise adding independent variables at the three levels: survey completion, respondent, and country. Table 2 presents the results.

Looking at model 1, the ICCs indicate that variation in smartphone participation is mostly accounted for by the respondent level (ICC = 0.76) but only marginally by the country level (0.02). This suggests that respondent characteristics are more important for explaining

Table 2. Three-level mixed effects logistic regressions with random intercepts and smartphone participation as the dependent variable

	Model 1		Model 2		Model 3		Model 4	
	OR	SE	OR	SE	OR	SE	OR	SE
Constant	0.12	0.16	0.89	0.15	75.39***	25.01	26.77	99.9
Months since first web survey wave			1.02**	0.00	1.03**	0.00	1.03**	0.00
Age					0.93**	0.00	0.93**	0.00
Female					2.88**	0.24	2.88**	0.24
Medium education					0.72	0.11	0.72	0.11
High education					0.38**	0.06	0.38**	0.06
High income					1.31*	0.12	1.31*	0.12
Daily internet use					0.95**	0.01	0.95**	0.01
Digital sophistication					0.79**	0.04	0.79**	0.04
Smartphone share							1.02	0.05
Other device share							0.99	0.02
Country-level ICC	0.02		0.02		0.03		0.03	
Respondent-level ICC	0.76		0.76		0.73		0.73	
Observations	36,517		36,517		36,517		36,517	

Note. ** $p < 0.001$, * $p < 0.01$. OR = Odds ratio. SE = Standard error. Model 1 is our null model. Exclusion of respondents with missing values for any of the independent variables. Dependent variable: Smartphone participation (1 = "Yes"). Independent variables: Months since first web survey wave (in months), age (in years), female (1 = "Yes"), medium education (1 = "Yes"), high education (1 = "Yes"), high income (1 = "Yes"), internet use (in self-reported average hours per day), digital sophistication (1 "Low" to 5 "High"), smartphone share (in %), and other device share (in %). The latter two variables were retrieved from Eurostat (2024) and merged using the country variable

smartphone participation than country characteristics. In the second model, we add months since the first CRONOS-2 web survey wave as an independent variable at the survey completion level (level 1). The variable is positively associated with smartphone participation. This indicates that smartphone participation increases over time. In the third model, we now include independent variables at the respondent level (level 2). In line with previous findings, female respondents were more likely to participate via smartphone, while higher age and high education are negatively associated with smartphone participation. In contrast to previous findings, however, we find that respondents with higher income were more likely to participate via smartphone. Both daily internet use and digital sophistication are negatively associated with smartphone participation. In the fourth model, we additionally include two independent variables at the country level (level 3). Neither the smartphone share nor the share of other devices is associated with smartphone participation.

The results of the regression analyses also have important implications for our first research question. Time is consistently associated with smartphone participation, even when controlling for covariates and differences in the sample composition between countries. Specifically, for each month since the first CRONOS-2 web survey wave, the probability of smartphone participation increases by 3% on average (see Table B1 for marginal effects at the mean for all independent variables).

Research Question 3

Finally, we investigate the stability of smartphone participation across web survey waves. Figure 2 displays the shares of the three groups (i.e., respondents who have always participated via smartphone, respondents who have participated via smartphone at least once but not always, and respondents who have never participated via smartphone) across the 12 European countries.

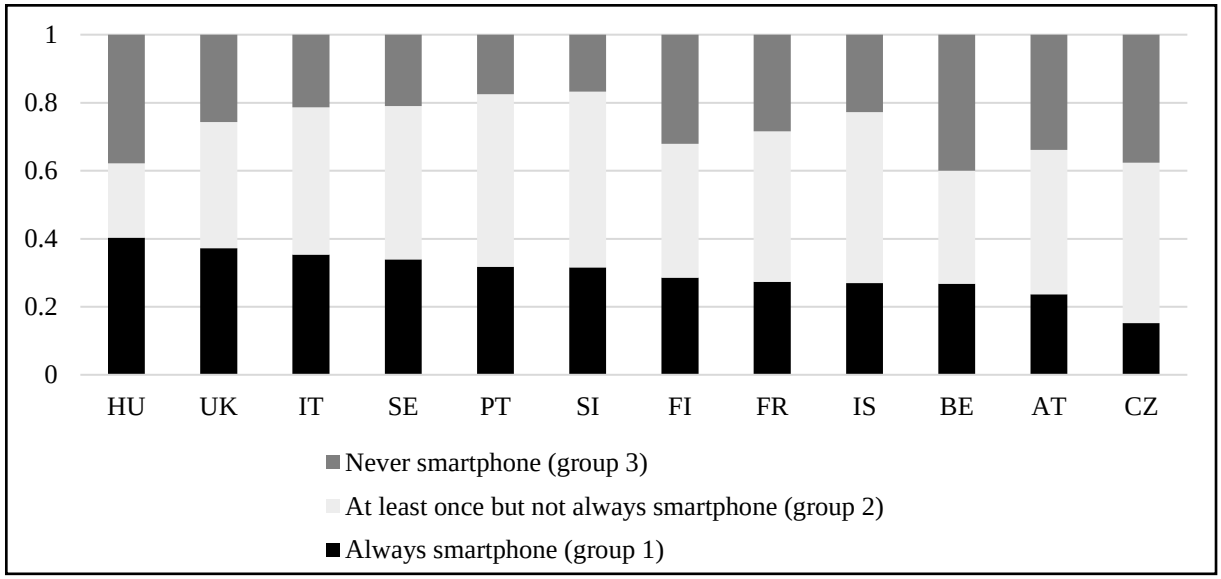

Figure 2. Stability in smartphone participation across European countries

Note. We only considered respondents that participated in at least two web survey waves. Countries are ordered by the share of respondents that always participated via smartphone. AT = Austria, BE = Belgium, CZ = Czechia, FI = Finland, FR = France, HU = Hungary, IS = Iceland, IT = Italy, PT = Portugal, SI = Slovenia, SE = Sweden, UK = United Kingdom.

The share of respondents who answered all waves of the CRONOS-2 via smartphone differs substantially between European countries. While in Hungary and United Kingdom about 40% of respondents have participated via smartphone in all web survey waves, in Czechia only 15% of respondents did so. In most countries, the group of respondents who switched devices and participated via smartphone at least once but not always represents the largest group. The share of group 2 respondents ranges from about 50% (Portugal, Slovenia, and Iceland) to about 20% (Hungary). Still, in all countries, a substantive share of respondents who never participated via smartphone remains. The share of group 3 respondents ranges from about 40% (Hungary, Belgium, and Czechia) to about 20% (Italy, Sweden, Portugal, Slovenia, and Iceland). To put it differently, while a substantive group of respondents show high stability of smartphone participation in all 12 European countries, an equally large group of respondents show high stability of non-smartphone participation.

To further investigate what drives stability in smartphone participation, we now only consider respondents that have participated via smartphone at least once. Thus, we excluded group 3 respondents from the subsequent analysis. We conduct two-level mixed effects linear regressions with random intercepts and stability (in %) as dependent variable. We estimate three sequential models, stepwise adding independent variables at the two levels: respondent and country. Table 3 shows the results.

Table 3. Two-level mixed effects linear regression with random intercepts and smartphone stability as dependent variable

	Model 1		Model 2		Model 3	
	b	SE	b	SE	b	SE
Constant	69.44**	0.97	100.01**	3.11	127.49**	25.76
Age			-0.44**	0.03	-0.44**	0.03
Female			7.42**	0.88	7.41**	0.88
Medium education			-2.17	1.51	-2.18	1.51
High education			-7.98**	1.59	-7.98**	1.59
High income			0.21	0.95	0.21	0.95
Daily internet use			-0.29	0.15	-0.28	0.15
Digital sophistication			-2.63**	0.49	-2.66**	0.49
Smartphone share					-0.39	0.34
Other devices share					0.08	0.14
Country-level ICC	0.01		0.02		0.01	
Observations	4,811		4,811		4,811	

Note. ** $p < 0.001$, * $p < 0.01$. b = Unstandardized coefficient. SE = Standard error. Model 1 is our null model. Exclusion of respondents with missing values for any of the independent variables. Dependent variable: Stability (in %). Independent variables: Age (in years), female (1 = "Yes"), medium education (1 = "Yes"), high education (1 = "Yes"), high income (1 = "Yes"), internet use (in self-reported average hours per day), digital sophistication (1 "Low" to 5 "High"), smartphone share (in %), and other devices share (in %). The latter two variables were retrieved from Eurostat (2024) and merged using the country variable.

As before, the ICC for Model 1 indicates that stability is only marginally accounted for by the country level (ICC = 0.01). This suggests that respondent characteristics are more important to explain stability than country characteristics. In Model 2, we include independent variables at the respondent level (level 1). In line with the analysis of smartphone participation, female respondents show higher stability, while age, high education, and digital sophistication

are negatively associated with stability. In contrast, we find no associations for high income and daily internet use. Finally, we add two independent variables at the country level (level 2). Again, smartphone share and the share of other devices are not associated with stability.

Discussion and conclusion

The aim of this study was to investigate the prevalence, drivers, and stability of smartphone participation in web surveys across Europe. Starting with our first research question on the prevalence of smartphone participation in web surveys across Europe, we found an overall high rate of smartphone participation (above 50% in most countries). Comparing our results to those of Revilla and Höhne (2020), who found mean smartphone participation rates between 15% and 30% for the first CRONOS (from 2016 to 2018), it is evident that smartphone participation has increased substantially. It appears that smartphones are on the way of becoming the predominant participation device for web surveys in Europe. This highlights further the need to optimize web surveys for smartphones (Antoun et al. 2018).

Even though smartphone participation is overall high, we found variations in smartphone participation across countries. While some countries, such as Slovenia, Italy, and the United Kingdom, have mean smartphone participation rates of about 55%, some other countries, such as Czechia, have smartphone participation rates of only 35% on average. Consequently, some European countries have the potential to harness the new measurement opportunities introduced through smartphones, such as the collection of sensor and other digital data. At the same time, the observed differences in smartphone participation between countries have the potential to introduce systematic measurement error in cross-national web surveys due to the impact of smartphone participation on answering processes. This error could be mistaken for substantive differences between countries. We therefore urge researchers who conduct cross-national web surveys to acknowledge country-specific differences in smartphone participation and to check for possible device effects.

Turning to our second research question on the drivers of smartphone participation, we examined independent variables at three levels: survey completion, respondent, and country. At the survey completion level, we found that months since the first CRONOS-2 web survey wave were positively associated with smartphone participation. In line with Gummer et al. (2023), this indicates that smartphone participation generally increases over time. While smartphone participation was mostly accounted for by the respondent level, it was only marginally accounted for by the country level, suggesting that the observed differences in smartphone participation between countries are mainly driven by respondent characteristics.

Young, female, and lower educated respondents as well as respondents with high income were more likely to participate via smartphone. Going beyond previous research, we showed that daily internet use and digital sophistication were negatively associated with smartphone participation. Our findings on young and female respondents can be partly explained by the fact that young people and females show higher smartphone usage in general (Busch and McCarthy 2021). Relatedly, young respondents have been socialized in the digital world (Smith et al. 2015) and thus might be more comfortable with using smartphones to participate in web surveys. When it comes to lower educated respondents, smartphone-only respondents (i.e., having no other device than a smartphone to participate in web surveys) might be overrepresented in this group because computers are more expensive than smartphones

(Rowsell et al. 2017). Similarly, respondents with low daily internet use and digital sophistication might be less likely to own a computer. This facilitates smartphone participation among these respondent groups. Somewhat in contrast to this reasoning, we found that high income is positively associated with smartphone participation even though it can be expected that respondents with high income tend to own multiple devices. Therefore, the associations between our independent variables and smartphone participation need further, more refined investigation to disentangle these relationships. Specifically, it would be worthwhile to measure smartphone and computer ownership and usage in future studies to shed light on this phenomenon.

Finally, with respect to our third research question on the stability of smartphone participation, we found that between 50% (Portugal, Slovenia, and Iceland) and 20% of respondents (Hungary) switched between devices and participated via smartphone at least once but not always. The remaining respondents either showed high stability of smartphone participation or high stability of non-smartphone participation. These findings indicate that it is important to design web surveys for both smartphones and computers, because they are used consistently by a substantive group of respondents. This finding is in contrast to older studies that found low stability for smartphone participation (Lugtig et al. 2016; Poggio et al. 2015). For the drivers of smartphone stability, we found a very similar picture as for the drivers of smartphone participation. The only exception were high income and daily internet use. Importantly, these results indicate that young, female, and lower educated respondents as well as respondents with low digital sophistication are not only more likely to participate via smartphone, but also more likely to do so consistently across web survey waves.

This study has some methodological limitations providing avenues for future research. First, we did not identify any country-level drivers of smartphone participation and stability. This might be because European countries show low variance regarding the share of citizens who access the internet via smartphone and the share of citizens who access the internet via computer or tablet. Future research should address this shortcoming by investigating smartphone participation across countries with larger differences. We recommend going beyond solely European data by utilizing cross-national datasets that include multiple continents. Second, we were not able to include variables of smartphone and computer ownership in our analyses because device ownership was not measured in the CRONOS-2 and ESS Round 10. As discussed, smartphone and computer ownership and usage may be important moderating variables between our independent variables and smartphone participation. This similarly applies to information on respondents' device-related skills (i.e., how well they can operate an electronic device, such as smartphone). Third, we investigated smartphone participation – including its stability – across seven web survey waves covering a comparatively short period (between October 2021 and March 2023). Future studies should examine smartphone participation and stability over longer periods in longstanding web survey panels (see Gummer et al. 2023). This would allow for analyses of the impact of changes in respondent characteristics, such as income and daily internet use, on subsequent smartphone participation. In addition, further variables at the survey completion level, such as length of the previous web survey, should be included to analyze their impact on smartphone participation and stability. In the CRONOS-2, each web survey wave lasted for about 20 minutes, except for the welcome web survey wave. Fourth, it was beyond the scope of this study to investigate methods to nudge

respondents to shift their device preferences. To evaluate the potential of harnessing new measurement opportunities introduced through smartphones, future studies may investigate whether respondents with high stability of non-smartphone participation can be motivated to engage in smartphone participation. For instance, this could be done by motivational statements stressing the importance of smartphone participation for scientific research or by providing additional incentives for smartphone participation.

This study contributes to the state of research and provides new evidence on smartphone participation and stability in web surveys across Europe. Importantly, it shows that smartphone participation is comparatively high and keeps increasing. By showing that some respondent groups are more likely to participate via smartphone our findings have important implications for cross-national web surveys. Specifically, researchers should acknowledge different smartphone participation levels across countries and tailor web survey designs to their respondents.

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Appendix A

Table A1. CRONOS-2 web survey waves and data collection periods across European countries

Country	WS	W1	W2	W3	W4	W5	W6
Austria	26.01.2022-23.02.2022	01.04.2022-04.05.2022	27.05.2022-29.06.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	18.11.2022-21.12.2022	09.01.2023-15.02.2023
Belgium	10.06.2022-13.07.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	-	23.11.2022-21.12.2022	23.11.2022-21.12.2022	20.02.2023-22.03.2023
Czechia	30.11.2021-23.12.2021	14.02.2022-16.03.2022	11.04.2022-11.05.2022	10.06.2022-13.07.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	18.11.2022-21.12.2022
Finland	30.11.2021-23.12.2021	14.02.2022-16.03.2022	11.04.2022-11.05.2022	10.06.2022-13.07.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	-
France	30.11.2021-23.12.2021	14.02.2022-16.03.2022	11.04.2022-11.05.2022	20.06.2022-18.07.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	21.11.2022-21.12.2022
United Kingdom	30.11.2021-23.12.2021	31.08.2022-29.09.2022	10.10.2022-09.11.2022	-	21.11.2022-21.12.2022	09.01.2023-08.02.2023	20.02.2023-22.03.2023
Hungary	20.10.2021-10.11.2021	22.11.2021-22.12.2021	24.01.2022-23.02.2022	-	-	-	-
Iceland	30.11.2021-23.12.2021	14.02.2022-16.03.2022	11.04.2022-11.05.2022	10.06.2022-13.07.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	18.11.2022-21.12.2022
Italy	20.06.2022-13.07.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	-	21.11.2022-21.12.2022	09.01.2023-08.02.2023	20.02.2023-22.03.2023
Portugal	26.01.2022-23.02.2022	01.04.2022-04.05.2022	27.05.2022-29.06.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	18.11.2022-21.12.2022	09.01.2023-08.02.2023
Sweden	26.01.2022-23.02.2022	01.04.2022-04.05.2022	27.05.2022-29.06.2022	31.08.2022-29.09.2022	10.10.2022-09.11.2022	18.11.2022-21.12.2022	09.01.2023-08.02.2023
Slovenia	13.10.2021-10.11.2021	22.11.2021-22.12.2021	24.01.2022-23.02.2022	08.03.2022-06.04.2022	03.05.2022-01.06.2022	10.06.2022-13.07.2022	05.09.2022-05.10.2022

Note. WS = Welcome web survey wave. W1-W6 = Substantive web survey waves 1 to 6.

Appendix B

Table B1. Three-level mixed effects logistic regressions with random intercepts and smartphone participation as the dependent variable (MEM)

	Model 1		Model 2		Model 3		Model 4	
	MEM	SE	MEM	SE	MEM	SE	MEM	SE
Months since first web survey wave			0.02**	0.00	0.03**	0.00	0.03**	0.00
Age					-0.07**	0.00	-0.07**	0.00
Female					1.06**	0.08	1.06**	0.08
Medium education					-0.33	0.15	-0.33	0.15
High education					-0.98**	0.15	-0.98**	0.15
High income					0.27*	0.09	0.27*	0.09
Daily internet use					-0.05**	0.01	-0.05**	0.01
Digital sophistication					-0.24**	0.05	-0.24**	0.05
Smartphone share							0.02	0.05
Other device share							-0.01	0.02
Country-level ICC	0.02		0.02		0.03		0.03	
Respondent-level ICC	0.76		0.76		0.73		0.73	
Observations	36,517		36,517		36,517		36,517	

Note. ** $p < 0.001$, * $p < 0.01$. MEM = Marginal effects at the mean. SE = Standard error. Model 1 is our null model. Exclusion of respondents with missing values for any of the independent variables. Dependent variable: Smartphone participation (1 = "Yes"). Independent variables: Months since first web survey wave (in months), age (in years), female (1 = "Yes"), medium education (1 = "Yes"), high education (1 = "Yes"), high income (1 = "Yes"), internet use (in average hours per day), digital sophistication (1 "Low" to 5 "High"), smartphone share (in %), and other device share (in %). The latter two variables were retrieved from Eurostat (2024) and merged using the country variable.