Internet Coverage and Coverage Bias Trends across Countries in Europe and over Time: Background, Methods, Question Wording and Bias Tables

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Abstract

To estimate the coverage error for web surveys in Europe over time, we analyzed data from the Eurobarometer. The Eurobarometer collects data for the European Community across member and applicant states. Each wave consists of *face-to-face* interviews with adults. Since 2005 the Eurobarometer contains a straightforward question on Internet access. As the data for the Eurobarometer are collected using face-to-face surveys and the sampling and data collection do not depend on respondents having Internet, they make it possible to compare respondents with and without Internet access. We estimated coverage bias both for demographic variables (sex, age, length of education) and socio-political variables (left-right position on a political scale, life satisfaction). Countries do differ in Internet penetration and resulting coverage bias. Over time Internet penetration dramatically increases and coverage bias decreases, but the rate of change differs across countries. In addition, the countries' development significantly affects the pace of these changes.

Keywords

Web survey, Internet, under coverage, coverage bias, nonsampling error, Eurobarometer, digital divide

Acknowledgements

The authors thank Bill Blyth for his stimulating ideas and kind support throughout this project.

1. Introduction

Modern society relies on reliable and valid survey data, and almost every country in the world uses surveys to estimate important statistics, such as rate of unemployment, health indicators, opinions about the government and key issues in society, intention to vote in the coming elections, and people's satisfaction with services. Surveys are also one of the most commonly used methods in the social sciences to understand the way societies work and to test theories.

The last decennium has been marked by fast paced technological changes that influence survey methods and survey quality. A dramatic change in survey methodology was caused by the development of Internet surveys (Bosnjak et al., 2006; Couper, 2000). Internet surveys have many advantages, such as low costs, timely data, and more privacy due to self-completion. The latter is especially important when sensitive topics are being surveyed, and mode comparisons consistently show that Internet surveys give rise to less social desirability than interviews (e.g., Kreuter, Presser, and Tourangeau, 2008; Link and Mokdad, 2005; for an overview see De Leeuw and Hox, 2011). In this sense, Internet surveys are indeed more like self-administered questionnaires and do share their benefits as Couper (2008) postulated.

From the onset of Internet surveys, coverage error has been a source of major concern. A main problem with Internet surveys is under-coverage resulting from the 'digital divide', that is, a difference in rates of Internet access among different demographic groups (such as an unequal distribution regarding age and education for those with and without Internet access, Couper, 2000). Although Internet coverage is growing, for instance for Europe as a whole Internet coverage increased from 15% in December 1999 to approximately 58% in March 2011 (Internet World Stats, 2011), it varies widely across countries. For example, at the beginning of the 21st century almost 15% of Europeans had Internet access but, according to the Worldbank (2009) this ranged from less than 4% (e.g., Romania and Turkey) to 44% and 46% (the Netherlands

and Sweden). For a more detailed overview, see Blyth, 2008. This differential coverage would not be a problem, if the covered part would represent the general population with respect to important survey variables. However, even in countries with a high coverage a digital divide can be observed, as Internet access is unevenly distributed over the population with highly educated and younger persons having more often an Internet connection (e.g., Bethlehem & Biffignandi, 2012; Rookey, Hanway, and Dillman, 2008; Couper, Kapteyn, Schonlau, and Winter, 2007). This differential coverage over countries and demographic groups may result in bias in the estimation of substantive variables of interest in a study. To estimate this bias one needs data on both the covered and not covered parts of the population.

In terms of coverage of the household population, face-to-face interviews are often viewed as the gold standard by which other modes are compared (e.g., Groves et al., 2009). Since 2005 the Eurobarometer, which is based on face-to-face interviews, contains a question about Internet access at home. This provides us with a unique data set to analyze coverage figures across European countries and over time. As data collection in the Eurobarometer does not depend on respondents having access to the Internet, survey mode is held constant, and the same battery of questions is asked over time and across countries, this also enables us to investigate how potential *coverage* bias, caused by non-Internet households, could influence the results if the data would have been collected using Internet surveys instead of face-to-face interviews. In other words, this gives us an indication of the coverage bias over time and across countries.

In this study, we compare owners of an Internet connection at home to the whole target group of Eurobarometer face-to-face interviewees (both with and without Internet access at home). It is expected that the coverage bias between the two groups differs between countries and will decrease over time for all countries. We also expect that the rate of decrease may be different in different countries and that social and economic indicators at the country level may explain some of these differences.

In the next sections, we first describe the available data and the analysis methods used. We then present our results on trends in Internet coverage at home and the resulting coverage bias for available demographic variables and socio-political variables. This is followed by a multilevel analysis to model the changes over time and the influence of

socio-economical development on these trends. We end with a critical discussion and implications for research.

2. Method

2.1. Available Data

2.1.1. Eurobarometer

The Eurobarometer collects data for the European Community across EU members and applicant countries four to eight times a year. The Eurobarometer has a separate data collection for East and West Germany, Republic of Cyprus and the Turkish Republic of Northern Cyprus, and Great Britain and Northern Ireland. Therefore, the following 32 countries were included in the analyses: Austria, Belgium, Bulgaria, Croatia, Cyprus (Republic and TCC), Czech Republic, Denmark, Estonia, Finland, France, Germany (East and West), Great Britain, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Northern Ireland, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and Turkey. Since 2005, the Eurobarometer contains a yearly question about Internet access at home.

Each wave of the Eurobarometer consists of *face-to-face* interviews and includes a core questionnaire plus an additional questionnaire with special topics. For each standard Eurobarometer survey new and independent samples are drawn; since October 1989 the basic sampling design is a multi-stage probability sample (for more details, see Gesis Eurobarometer Survey series, 2012).

Every household survey suffers from nonresponse (Bethlehem, Cobben, and Schouten, 2011; De Leeuw and De Heer, 2002; Groves & Couper, 1998), and the Eurobarometer is no exception. Unfortunately, there is no detailed information on response rates made available publicly and on a regular basis by the principal investigator, that is, the European Commission's Eurobarometer unit. Still, there is some indication that response rates vary between countries. For instance, Busse and Fuchs (2012) note that for the 2002 Eurobarometer response rates varied between rates of around 70% for East and West Germany and 40% or less for Ireland, Denmark and the UK. No systematic nonresponse studies are available. However, the Eurobarometer data

do include integrated design and post-stratification weights to adjust the realized samples to EUROSTAT population data (Moschner, 2012). These weights will be used in estimating the coverage bias indicators.

The core questionnaire contains trend questions about socio-political orientation and standard demographic questions and since 2005 also a question on having an Internet connection at home, allowing us to estimate Internet coverage at home and the resulting coverage bias. Besides Internet access at home, interview data on the following variables were available for all countries: sex, age, length of education, political left-right self-placement and life satisfaction (see Appendix A for the question wording used); also the year of data collection was recorded. All the data were downloaded in February and March 2011, at which point Eurobarometer data were fully available for the years 2005 to 2009. Hence, our analysis will cover this five year period. To assess coverage bias, we analyze three demographic variables: sex, age, and length of education, and two substantive variables: political left-right self-placement and life satisfaction. The demographic variables age, sex, and education are seen as important indicators for the digital divide (e.g., Couper, 2000) and correlate with many substantive variables typically assessed in academic or market research surveys (Fuchs and Busse, 2009). The substantive variables political left-right self-placement and life satisfaction give us an opportunity to directly investigate the influence of undercoverage on the assessment of two major socio-political indicators.

2.1.2. Additional country-level variables

The data from the Eurobarometer are individual level data, collected through face-to-face interviews in each country. Apart from Internet penetration, the countries involved in the Eurobarometer also differ on socio-economic variables, which may influence Internet coverage. To model this, we collected socio-economic country level data from Eurostat, the World Bank, and the Human Development Report. Contextual country level variables are: life expectancy at birth (in years), country's educational index, duration of primary and secondary education (in years), and urbanization (the percentage of urban population). Economic indices on country level are the percentage of employed (labor force), the Gini coefficient, which measures income inequality, the Gross Domestic

Product growth (GDP), and inflation. For a description of these variables and the data sources including the URL, see Appendix B. It should be noted that these variables are measured at the country level, but they are available for each year, hence they are time-varying predictors.

2.2. Analysis

2.2.1. Coverage and Indicators of Coverage Bias

Coverage is defined as the percentage of the population of interest that is included in the sampling frame; ideally the coverage should be 100%. Furthermore, there should be a one-to-one correspondence between the population of interest or target population and the (sampling) frame population. If this is not the case, *and* if those missing in the frame differ from the target population on a key variable of interest in the study, coverage error occurs (Biemer and Lyberg, 2003; Groves, et al, 2009). Groves (1989, p. 11) describes coverage error as: 'coverage error exists because some persons are not part of the list or frame (or equivalent materials) used to identify members of the population. Because of this they *never* can be measured whether a complete census of the frame is attempted or a sample studied.'

Undercoverage is one of the main concerns for the validity of conclusions based on Internet surveys (Couper, 2000). Although Internet access is growing, there are still many individuals not covered, and if those without Internet access differ on key measures from those with Internet access, the resulting estimators will be biased. For example, if wealthier households are more likely to have Internet access, then a survey about household assets that is based exclusively on the Internet will produce income estimates that are too high (Lohr, 2008).

To investigate *coverage* problems in Internet-based surveys, we compare the responses of the subgroup of Internet-at-home with those of the total group of Eurobarometer respondents. Since the Eurobarometer was conducted face-to-face in all countries and face-to-face surveys have the least coverage problems (Groves et al, 2009, p. 163; De Leeuw, 2008, p. 125), the total Eurobarometer group in this study is regarded as a proxy for the Target Population. Differences between those with an Internet

connection at home and the total Eurobarometer group give an indication of the bias due to *undercoverage* if an Internet survey would have been implemented instead of a face-to-face survey.

The net coverage bias is defined by Lessler & Kalsbeek (1992, p59-60) as

$$\bar{y}_{\text{covered}} - \bar{y}_{\text{target}} = \frac{N_{\text{not covered}}}{N_{\text{target}}}\left(\bar{y}_{\text{covered}} - \bar{y}_{\text{not covered}}\right), \qquad [1]$$

which is used by Bethlehem and Biffignandi (2012, p289) to define bias due to the non-Internet population. Based on equation 1, we use two indices to assess the amount of coverage bias: the relative bias (Lessler & Kalsbeek, 1992, p60) and the absolute relative bias (Groves and Peytcheva, 2008). The relative coverage bias is used for descriptive purposes, as the sign of this estimate indicates the over- or undercoverage of specific groups (e.g., if more men than women have Internet access at home in a certain year and in a certain country). However, when modeling changes over time and across countries, positive and negative values for relative coverage can cancel each other out and the resulting regression coefficients may falsely give the impression that the overall coverage error is close to zero. Therefore, in our multilevel analyses we use the absolute relative coverage bias.

The relative and absolute relative coverage bias due to lack of Internet access are defined as

$$\text{relative coverage bias} = \frac{\bar{y}_{Int} - \bar{y}_{EB}}{\bar{y}_{EB}}, \qquad [2]$$

and

$$\text{absolute relative coverage bias} = \left|\frac{\bar{y}_{Int} - \bar{y}_{EB}}{\bar{y}_{EB}}\right|, \qquad [3]$$

where *EB* represents the total achieved Eurobarometer sample, which is viewed as our target population, and *Int* represents the covered Internet subsample. Analogous $\bar{y}_{EB}$ and $\bar{y}_{Int}$ represent the means of the Eurobarometer target population and the Internet subsample on the variable y.

2.2.2. Statistical Analyses

The relative coverage bias is used for descriptive analyses over countries and time. Positive values indicate that surveys that are exclusively conducted through the Internet will result in estimates that are too high, whereas negative values indicate that these will result in estimates that are too low.

Multilevel analysis on the absolute relative coverage bias is used to model and explain trends over time and country for all bias indicators (sex, age, length of education, political left-right self-placement and life satisfaction). For ease of interpretation the absolute relative coverage bias is expressed as percentage points. In the multilevel model, the lowest level represents the years, indicated by a time variable coded 2005=0, 2006=1, et cetera. To estimate change over time, we analyze a null model that always includes the linear effect of time, and tests whether the variance component for the slope of time is significant. If this random component is not significant using a likelihood ratio test, it is removed from the null model. Since the plots for the effect of time in Figure 1 indicate possible non-linearity, we test for nonlinear effects by analyzing the quadratic effect of time. If the quadratic term is not significant at the conventional 5% level, it is removed from this model; the linear term for time is always retained in the null model.

In a second step, we add country level socio-economic variables. Country level variables model initial differences in bias between countries in the starting year 2005. Since the country level variables vary across time, they may also explain change over time. Because the country level variables are correlated with time, adding them to the model may replace (part of) the explanatory power of the time variable as estimated in the null model.

Finally, differences between countries in the rate of change over the years, as indicated by variation in the slopes of the time variable, are modeled as interactions of country level variables with the time variable. Again, effects that are not significant are removed from the model. A two-sided significance level of alpha = 0.05 is used throughout.

3. Results

3.1. Coverage bias in European countries

Internet-access at home increases over time across Europe, but the rate of increase differs across countries (see Figure 1). The actual proportions per country and per year are presented in Appendix C. These numbers show that for countries with an initial low Internet penetration, for example Bulgaria and Romania, the proportions increase rapidly, while for countries with an initial high penetration, for example Sweden and the Netherlands, the growth is less steep.

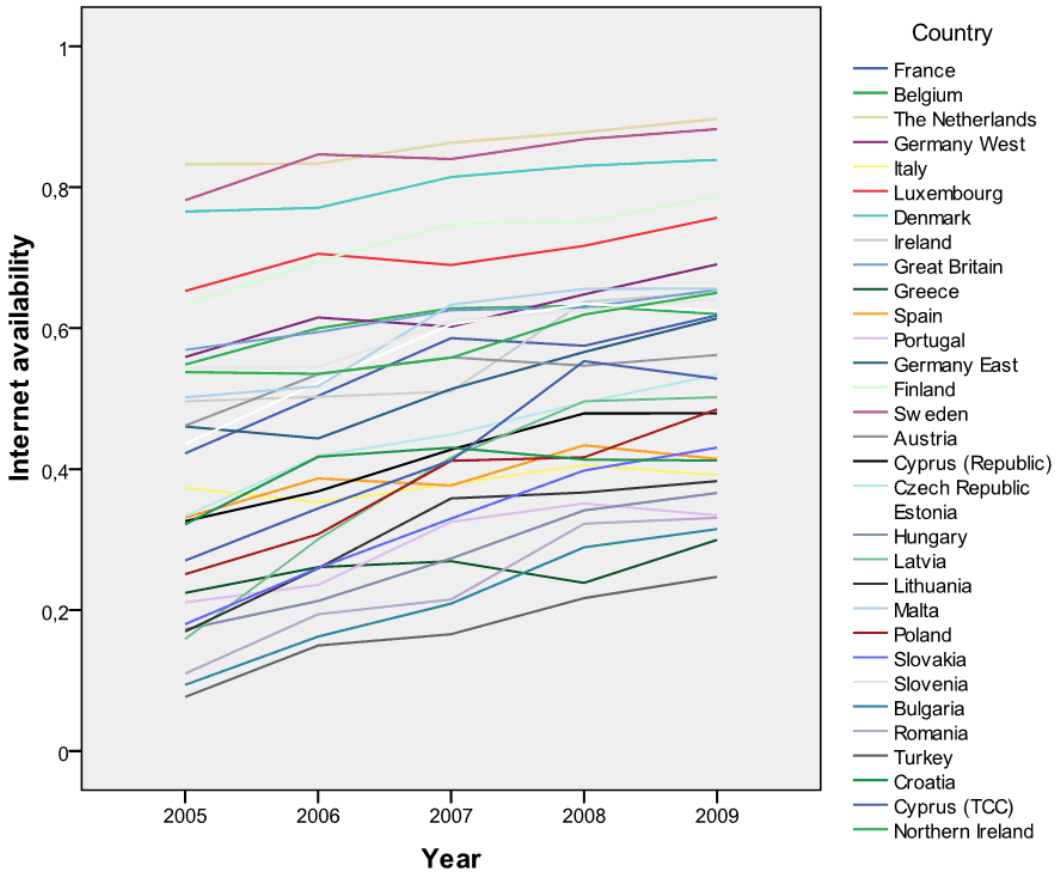

Figure 1: Internet access at home across Europe 2005-2009, based on the Eurobarometer's weighted data

But even with an Internet penetration above 80%, there still may be considerable differences between those with and without Internet access. This is indicated by the relative coverage bias, which is based on the standardized difference between the subgroup of those who do have Internet at home compared to the total (Internet and non-Internet at home) group. Full descriptive tables with the values of the relative coverage bias for each country and each year are depicted in Appendix D.

For the demographic variables sex, age, and length of education, the descriptive tables in Appendix D indicate a digital divide. In Europe, those with Internet at home are more often male, younger, and highly educated (Appendix D, Tables D1-D3); similar patterns have been found in the USA (cf. Couper, 2008). The bias for sex is relatively low and strongly decreasing over time. The highest value was found for Greece with 8.5% more men than women having Internet access in 2006, which decreased to 5.5% in 2009. Lowest values (less than 1 % more men) were found for countries like Sweden, Slovenia, Ireland, and the Netherlands in 2009. In general, the gender gap is closing very fast over time. Also, the age difference is becoming smaller over time; the younger are still overrepresented, but for some countries (e.g., Sweden and the Netherlands) the age bias is really low (around -0.04) in 2009, while for others (e.g., Bulgaria) it is still rather high (-0.22 in 2009). The same can be seen for length of education. It should be noted that countries with the smallest digital divide, regarding the demographics age, sex, and education, are also the countries with the highest Internet penetration. This gives an optimistic outlook on the future that as Internet penetration increases, the digital divide will decrease.

When we look at the descriptive tables for the substantive variables political left-right self-placement (Appendix D, Table D4) and life satisfaction (Appendix D, Table D5), we again note that the differences are becoming smaller over time. On average, the coverage bias is very low for political left-right self-placement, where its bias decreases towards zero over time with the largest differences being found in Bulgaria (from 0.23 in 2005 to 0.075 in 2009). It should be noted that the coverage bias for this variable is not in the same direction for all countries. For some countries those with an Internet-connection at home place themselves more on the left (e.g., Austria, West-Germany, Great Britain), for other countries they place themselves more on the right (e.g., Bulgaria). For the

second substantive variable life-satisfaction, we see that in every country and every year there is a positive bias, indicating that those with Internet at home are more satisfied with life than the Eurobarometer population in general. This bias decreases slightly over time.

3.2. Changes in coverage bias over time

The change in coverage bias over time is analyzed using multilevel analysis, with years (coded 2005=0, …, 2009=4) nested within countries. This allows us to test if the change over time is significant and to test if country level variables can predict changes over time. The analysis showed that the effect of time squared was never significant, and therefore only the linear trend of time is included in the model. Table 1 presents the parameter estimates for each dependent variable for two models: a model with only the linear time indicator and a model with the time indicator and the significant country variables.

When we examine the effect of time in the first model, the results show a steady decrease of absolute relative coverage bias across time, as indicated by a negative value for the regression coefficient of time, except for political left-right self-placement where the overall effect of time is not significant. For all five bias indicators, Table 1 shows a significant and sometimes large country level variance, which means that there were clear differences between countries in overall bias in 2005. For three out of five bias indicators, the time variable has significant slope variation (indicated in Table 1 under ‘time slope’), which means that the bias for ‘age’, ‘political left-right self-placement’ and ‘life satisfaction’ decrease at different rates across countries. Compared to the size of the regression coefficient for the time variable itself, these variances are relatively large. This indicates large differences in rate of decline between countries for these bias indicators.

Table 1. Absolute relative coverage bias for selected variables predicted by year and country-level variables. Multilevel model with regression coefficients (b), variance components (s^2), and corresponding standard errors (se).

	Bias Sex Composition		Bias Age Composition		Bias Length of Education		Bias Political Left-Right Self-Placement		Bias Life Satisfaction	
Model	Year (2005-09)	Country predictors	Year (2005-09)	Country predictors	Year (2005-09)	Country predictors	Year (2005-09)	Country predictors	Year (2005-09)	Country predictors
Fixed part	b (se)	b (se)	b (se)	b (se)	b (se)	b (se)	b (se)	b (se)	b (se)	b (se)
Intercept	2.87 (.26)	0.10 (1.34)	16.10 (.83)	82.69 (16.07)	10.11 (.97)	62.91 (12.03)	2.83 (.74)	3.02 (.41)	5.55 (.92)	84.60 (12.46)
Time	-0.27 (.08)	-0.27 ((.08)	-0.60 (.11)	-0.34 (.11)	-0.78 (.11)	-0.69 (.17)	0.05 (.16)[ns]	-	-0.35 (.13)	-
Country variables										
Gini coefficient		0.09 (.04)		0.23 (.08)		-		-		-
Educational index		-		-0.21 (.08)		-0.30 (.12)		-		-
Employment		-		-		-3.82 (1.58)		-		-4.26 (1.23)
Life expectancy		-		-0.59 (.19)		-		-		-0.66 (.17)
Primary school dur.		-		-0.92 (.44)		-		-		-
Urbanicity		-		-0.10 (.05)		-0.15 (.06)		-		-0.1 (.04)
Random part	s^2 (se)	s^2 (se)	s^2 (se)	s^2 (se)	s^2 (se)	s^2 (se)	s^2 (se)	s^2 (se)	s^2 (se)	s^2 (se)
Residual variance	1.96 (.25)	1.96 (.25)	2.13 (.31)	2.45 (.32)	3.98 (.50)	1.84 (.33)	2.80 (.40)	2.80 (.40)	2.77 (.40)	3.57 (.53)
Country variance	0.98 (.35)	0.80 (.32)	20.98 (5.66)	7.64 (2.26)	27.91 (7.29)	22.69 (6.68)	15.64 (4.40)	15.30 (4.26)	25.39 (6.89)	6.67 (2.15)
Time slope variance	-	-	0.15 (.09)	-	-	0.45 (.23)	0.51 (.21)	0.49 (.20)	0.26 (.15)	-

Note: explanatory variables secondary education duration, GDP-growth and inflation had no significant effects, and are omitted.
'-' indicates parameter tested but removed because parameter was not significant at a two-sided alpha of 0.05.
[ns] indicates non-significant coefficient for time

3.3. Coverage bias and country differences

There are differences between countries in size of the coverage bias and for some variables in the rate of decrease of this bias over time. These differences are modeled by the direct effects of the available country level variables: life expectancy, educational index, duration of primary and secondary education, urbanization, employment, Gini index, GDP growth rate, and inflation. The differences in rate of decrease are modeled by interactions of these variables with the time indicator.

The explanatory variables secondary education, GDP-growth rate, and inflation were never significant and are omitted from the model. Table 1 shows for each of the five coverage bias indicators the estimated multilevel model and the significant regression coefficients. The bias for political left-right placement could not be predicted by any of the available country variables. The other four coverage bias indicators can be predicted by different subsets of country level variables. Thus, differences between persons with and without Internet across countries can be predicted using different country level variables.

Table 1 shows that coverage bias for age is higher in countries with a high income inequality as indicated by the Gini-coefficient, while coverage bias for age is lower in countries with a higher educational index, a higher life expectancy, longer duration of primary school education, and high urbanicity. In contrast, coverage bias for sex is only associated with the Gini coefficient; coverage bias for sex is higher in countries with a high income inequality (high Gini). Coverage bias in length of education is lower in countries with a higher educational index, a higher employment level, and a higher urbanicity. Coverage bias in life satisfaction is lower in countries with a higher employment rate, higher life expectance and high urbanicity.

There were no significant interactions with time, meaning that the available country level variables do not predict the differences in rate of bias decrease. When we compare the model with country variables added to the model with only time as predictor, an interesting pattern emerges. For all four bias indicators with a significant effect of time, Table 1 shows that adding country level variables to the model decreases the size of both the regression coefficient for time and the variance across countries.

Thus, part of the effect of time is the result of changes over time in country level variables. The signs of the regression coefficients for the country variables suggest that in general coverage bias decreases when education, employment, life expectancy, and urbanicity increase. In other words, differences between persons with and without Internet access decrease when these variables increase. In contrast, the differences between persons with and without Internet access increase when the income distribution is more unequal.

4. Conclusion and Discussion

As expected, Internet penetration has increased over time in all countries included in this study. As a result, the absolute relative bias in the estimates of four out of five variables has also decreased; only political left-right self-placement does not show this trend. In other words, differences in age, sex, education, and life satisfaction between those with and without Internet access are diminishing. Multilevel analyses show that for those four bias indicators, the decrease in coverage bias over time differs across countries and that the countries' development affects the pace of this decrease. For age and life satisfaction, the variation in decrease is fully explained by the country level variables in the model, for sex and education only partially.

The general trend is that higher levels of economic development, education, and health are associated with lower coverage bias, whereas a higher income inequality is associated with higher levels of bias. Given the general economic and demographic trends, one conclusion of our study is that coverage bias due to low Internet penetration is disappearing across countries in Europe. The multilevel analyses also show variation across countries in both initial level and rate of decrease of coverage biases for demographic variables. This shows that the 'digital divide' (Couper, 2000) not only differs between countries, but also is diminishing at different rates over time in these countries.

Our measure of Internet penetration and coverage bias is based on a question in the Eurobarometer that inquires specifically about Internet access at home. However, there are alternative ways to access the Internet, for instance at work, in libraries, or on mobile devices. Therefore, our analyses are based on the assumption that for surveys that

consist of more than a couple of pop-up questions, respondents will prefer to answer in an environment where they have time, feel comfortable and have privacy. Although mobile Internet is promising, only one third of the population was covered by mobile Internet in Europe in 2007. Furthermore, coverage biases for demographic variables for the mobile web were larger than for landline Internet (Fuchs and Busse, 2009). The use of mobile Internet on telephones and tablet devices is likely to increase further in the near future, which necessitates a change in the measurement of Internet access. Provided that survey methodologists adapt their surveys to these new devices (e.g., Callegaro, 2010), this will not change our conclusion that coverage bias for Internet surveys is decreasing over time.

This study focuses on coverage bias. Good coverage is a necessary but not a sufficient condition high quality survey data. Other error sources exist, such as nonresponse error or mode effects. Meta-analyses (Cook, Heath & Thompson, 2000; Lozar Manfreda, Bosnjak, Berzelak, Haas & Vehovar, 2008) show that Internet surveys yield on average 11% lower response rate than other modes. Clearly, measures should be taken to increase this response rate. For a discussion of such measures we refer to Dillman, Smyth & Christian (2009). Compared to face-to-face interviews, responses to Internet surveys may differ due to mode-effects, especially when sensitive topics are addressed. For a discussion we refer to De Leeuw & Hox (2011), Dilman et al. (2009), and Kreuter et al. (2008).

In our study we treat the data from the face-to-face Eurobarometer samples as a representative sample of the total target population, and our results are conditional on the selection and nonresponse processes in the Eurobarometer. Therefore, in estimating the bias indicators, we used the design and post-stratification weights included in the Eurobarometer data. Nevertheless, nonresponse in the Eurobarometer samples can still affect our results. The use of adjustment weights amounts to treating nonresponse as missing at random (MAR, cf. Little and Rubin, 2002). However, if the nonresponse in the Eurobarometer would be related to Internet access itself (and therefore be missing not at random or MNAR), there is a potential for nonresponse bias. Hence, we view our findings as an indication of a generally decreasing coverage bias in the countries studied, but not as precise estimates of this bias.

A potential alternative data source for a future follow-up study would be the European Social Survey (ESS), which recently added a question on Internet access to the core module. As all surveys, the ESS also has differential nonresponse across countries, but the ESS response rates and sources of nonresponse are well documented and available for more in-depth analyses (Stoop, Billiet, Koch & Fitzgerald, 2010). Ideally, in some countries it may be possible to validate survey based information on Internet access with registry data.

Concluding, even if Internet coverage is not complete, Internet surveys may still compete with other survey modes. For instance, in 2008 The Netherlands had an 86% Internet coverage, while the landline telephone coverage was around 60-70% (Bethlehem, Cobben & Schouten 2011, p100 & p102). The same trend can be found in other countries; for instance, Smyth and Pearson (2011, p16 & p17) report that in 2008 the US had an Internet coverage of just over 70%, and random digit dialing landline telephones had a coverage of about 78%. But, landline telephone coverage is decreasing (cf, Busse & Fuchs, 2012; Mohorko, De Leeuw, & Hox, 2013), while Internet coverage is rapidly increasing over time as this study shows.

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Appendices:

All URLs in these appendices were checked November 21, 2011

Appendix A: Variables used in analysis (individual level). Original text of Eurobarometer question including response options plus data source including URL. *Note: these questions were posed by an interviewer in a face-to-face interview.*

1. **Internet-access at home**

D46 Which of the following goods do you have?

Television	1
DVD player	2
Music CD player	3
Computer	4
An Internet connection at home	5
A car	6
An apartment/a house which you have finished paying for	7
An apartment/a house which you are paying for	8
None (SPONTANEOUS)	9
DK	10

2. **Gender**

D10 Gender

Male	1
Female	2

3. **Age**

D11 How old are you?

4. **Length of education**

D8 How old were you when you stopped full-time education?

5. **Political left-right self-placement**

D1 In political matters, people talk of "the left" and "the right". How would you place your views on this scale?

Left									Right	Refusal	DK
1	2	3	4	5	6	7	8	9	10	11	12

6. Life satisfaction

QA3 On the whole, are you very satisfied, fairly satisfied, not very satisfied or not at all satisfied with the life you lead?

Very satisfied	1
Fairly satisfied	2
Not very satisfied	3
Not at all satisfied	4
DK	5

The Eurobarometer data for the years 2005-2009 were retrieved from:

- Eurobarometer 71.1. (2009). *European Parliament and Elections, Economic Crisis, Climate Change, and Chemical Products*, January-February 2009 [Data file and questionnaire]. Retrieved from http://zacat.gesis.org/webview/index.jsp;
- Eurobarometer 69.2. (2008). *National and European Identity, European Elections, European Values, and Climate Change*, March-May 2008 [Data file and questionnaire]. Retrieved from http://zacat.gesis.org/webview/index.jsp;
- Eurobarometer 68.1. (2007). *The European Parliament and Media Usage*, September-November 2007 [Data file and questionnaire]. Retrieved from http://zacat.gesis.org/webview/index.jsp:
- Eurobarometer 66.1. (2006). *European Values and Societal Issues, Mobile Phone Use, and Farm Animal Welfare*, September-October 2006 [Data file and questionnaire]. Retrieved from http://zacat.gesis.org/webview/index.jsp;
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Appendix B: Description of country-level variables used. Source and URL.

1. **Life expectancy at birth (years)**

Full title: Life expectancy by age and sex [demo_mlexpec]. Source: Eurostat
URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_mlexpec&lang=en

2. **Educational Index**

Full title: Combined gross enrolment ratio in education (both sexes). Source: Human Development Reports. URL: http://hdr.undp.org/en/data/trends/

3. **Primary education, duration (in years)**

Full title: Primary education, duration (years). Source: Worldbank.
URL:http://databank.worldbank.org/ddp/home.do?Step=2&id=4&hActiveDimensionId=WDI_Series

4. **Secondary education, duration (in years)**

Full title: Secondary education, duration (years). Source: Worldbank
URL:http://databank.worldbank.org/ddp/home.do?Step=2&id=4&hActiveDimensionId=WDI_Series

5. **Urbanization (Urban Population, % of total)**

Full Title: Urban Population (% of total). Source: Worldbank
URL: http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS

6. **Employment (Labor force, % of total)**

Full title: Labor force, total. Source: Worldbank
URL: http://data.worldbank.org/indicator/SL.TLF.TOTL.IN

7. **Gini coefficient**

Full title: Gini coefficient Standard economic measure of income inequality, based on Lorenz Curve. (A society that scores 0.0 on the Gini scale has perfect equality in income distribution. The higher the number over 0, the higher the inequality, and a score of 1.0 (or 100) indicates total inequality where only one person corners all the income. Source: SILC). Source: Eurostat
URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di12&lang=en

8. **GDP (Gross Domestic Product) Growth**

Full title: GDP growth (annual %). Source: Worldbank
URL: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

9. **Inflation (consumer prices yearly)**

Full title: Inflation, consumer prices (annual %). Source: Worldbank
URL: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

Sources were: Eurostat, the statistical office of the European Union with a task of providing statistics at European level that enable comparisons between countries and regions. The World Bank, which is a source of financial and technical assistance to developing countries around the world and offers – among other things – access to high quality national and international statistics. The Human Development Report, which is an independent publication commissioned by the United Nations Development Programme (UNDP).

Appendix C: Growth of Internet access at home across Europe: 2005-2009
Based on the Eurobarometer weighted data for that time period

Country\Year	2005	2006	2007	2008	2009	Grand Total
Austria	0.46	0.53	0.56	0.55	0.56	**0.53**
Belgium	0.55	0.60	0.63	0.63	0.62	**0.61**
Bulgaria	0.09	0.16	0.21	0.29	0.32	**0.21**
Croatia	0.32	0.42	0.43	0.41	0.41	**0.40**
Cyprus Rep.	0.33	0.37	0.43	0.48	0.48	**0.42**
Cyprus (TCC)	0.27	0.34	0.41	0.55	0.53	**0.42**
Czech Rep.	0.33	0.42	0.45	0.49	0.53	**0.44**
Denmark	0.77	0.77	0.81	0.83	0.84	**0.80**
Estonia	0.44	0.52	0.61	0.63	0.62	**0.56**
Finland	0.63	0.69	0.75	0.75	0.79	**0.72**
France	0.42	0.50	0.59	0.57	0.62	**0.54**
Germany East	0.46	0.44	0.51	0.57	0.61	**0.52**
Germany West	0.56	0.62	0.60	0.65	0.69	**0.62**
Great Britain	0.57	0.59	0.63	0.63	0.65	**0.61**
Greece	0.22	0.26	0.27	0.24	0.30	**0.26**
Hungary	0.17	0.21	0.27	0.34	0.37	**0.27**
Ireland	0.50	0.50	0.51	0.64	0.65	**0.56**
Italy	0.37	0.35	0.38	0.41	0.39	**0.38**
Latvia	0.16	0.30	0.42	0.50	0.50	**0.38**
Lithuania	0.17	0.26	0.36	0.37	0.38	**0.31**
Luxembourg	0.65	0.71	0.69	0.72	0.76	**0.71**
Malta	0.50	0.52	0.63	0.66	0.66	**0.59**
Northern Ireland	0.54	0.54	0.56	0.62	0.65	**0.58**
Poland	0.25	0.31	0.41	0.42	0.48	**0.37**
Portugal	0.21	0.24	0.33	0.35	0.33	**0.29**
Romania	0.11	0.19	0.22	0.32	0.33	**0.23**
Slovakia	0.18	0.26	0.33	0.40	0.43	**0.32**
Slovenia	0.54	0.54	0.61	0.63	0.64	**0.59**
Spain	0.33	0.39	0.38	0.43	0.41	**0.39**
Sweden	0.78	0.85	0.84	0.87	0.88	**0.84**
The Netherlands	0.83	0.83	0.86	0.88	0.90	**0.86**
Turkey	0.08	0.15	0.17	0.22	0.25	**0.17**
Grand Total	**0.40**	**0.45**	**0.50**	**0.53**	**0.55**	**0.49**

Appendix D: Relative Coverage Bias Values per Country and per Year
Tables for sex, age, length of education, political left-right self placement and life satisfaction, calculated according to equation 1 using Eurobarometer weighted data

Table D1: Values of Relative Coverage Bias for the variable *Sex*
Scale: 1 (Male), 2 (Female);
Negative sign: overrepresentation of men with Internet access at home

Country/Year	**2005**	**2006**	**2007**	**2008**	**2009**	Average
Austria	-0.024	-0.025	-0.016	-0.024	-0.018	-0.021
Belgium	-0.027	-0.028	-0.031	-0.013	-0.007	-0.021
Bulgaria	-0.036	-0.085	-0.010	-0.021	-0.034	-0.037
Croatia	-0.032	-0.008	-0.001	-0.011	-0.017	-0.014
Cyprus Rep.	-0.001	-0.038	-0.018	-0.010	-0.014	-0.016
Cyprus TCC	-0.008	-0.058	-0.030	0.015	-0.011	-0.019
Czech Rep.	-0.040	-0.037	-0.036	-0.025	-0.022	-0.032
Denmark	-0.014	-0.017	-0.009	-0.004	-0.011	-0.011
Estonia	-0.008	-0.013	-0.016	-0.028	-0.017	-0.016
Finland	-0.006	-0.029	-0.022	-0.015	-0.013	-0.017
France	-0.041	-0.001	-0.010	0.001	-0.008	-0.012
Germany East	-0.028	-0.035	-0.029	-0.035	-0.029	-0.031
Germany West	-0.016	-0.029	-0.013	-0.021	-0.015	-0.019
Great Britain	-0.045	-0.018	-0.023	-0.028	-0.010	-0.025
Greece	-0.027	-0.085	-0.076	-0.075	-0.055	-0.064
Hungary	-0.019	-0.033	-0.025	-0.024	-0.022	-0.024
Ireland	-0.006	-0.006	-0.010	-0.021	-0.008	-0.010
Italy	-0.040	-0.005	-0.025	-0.035	-0.017	-0.024
Latvia	-0.014	0.007	-0.027	0.007	-0.002	-0.006
Lithuania	-0.014	-0.048	0.006	-0.025	-0.012	-0.019
Luxembourg	-0.025	-0.027	-0.017	-0.011	-0.016	-0.019
Malta	-0.011	-0.047	-0.008	-0.022	0.003	-0.017
Netherlands	-0.003	-0.013	-0.014	-0.011	0.001	-0.008
North Ireland	-0.043	-0.057	-0.017	0.012	-0.042	-0.030
Poland	-0.041	-0.015	-0.035	-0.027	-0.022	-0.028
Portugal	-0.055	-0.042	-0.029	-0.023	-0.070	-0.044
Romania	-0.063	-0.014	-0.026	-0.025	-0.008	-0.027
Slovakia	-0.067	-0.063	-0.006	-0.007	-0.011	-0.031
Slovenia	-0.018	-0.005	-0.016	-0.005	-0.001	-0.009
Spain	-0.040	-0.010	-0.027	-0.041	-0.031	-0.030
Sweden	-0.011	-0.011	-0.015	-0.006	-0.003	-0.009
Turkey	-0.050	-0.046	-0.003	-0.033	0.035	-0.020
Average	**-0.027**	**-0.029**	**-0.020**	**-0.018**	**-0.016**	**-0.022**

Table D2: Values of Relative Coverage Bias for the variable *Age*

Negative sign: overrepresentation of younger persons with Internet access at home

Country/Year	**2005**	**2006**	**2007**	**2008**	**2009**	Average
Austria	-0.192	-0.172	-0.156	-0.135	-0.139	-0.159
Belgium	-0.129	-0.147	-0.128	-0.110	-0.094	-0.121
Bulgaria	-0.198	-0.229	-0.220	-0.235	-0.222	-0.221
Croatia	-0.169	-0.188	-0.151	-0.188	-0.176	-0.174
Cyprus Rep.	-0.195	-0.186	-0.184	-0.161	-0.155	-0.176
Cyprus TCC	-0.182	-0.201	-0.144	-0.092	-0.128	-0.149
Czech Rep.	-0.169	-0.163	-0.203	-0.160	-0.163	-0.172
Denmark	-0.088	-0.077	-0.069	-0.067	-0.073	-0.075
Estonia	-0.189	-0.192	-0.200	-0.159	-0.155	-0.179
Finland	-0.125	-0.115	-0.110	-0.115	-0.084	-0.110
France	-0.139	-0.120	-0.110	-0.119	-0.133	-0.124
Germany East	-0.146	-0.139	-0.125	-0.121	-0.128	-0.132
Germany West	-0.139	-0.134	-0.111	-0.120	-0.130	-0.127
Great Britain	-0.108	-0.109	-0.104	-0.108	-0.088	-0.103
Greece	-0.207	-0.224	-0.206	-0.217	-0.202	-0.211
Hungary	-0.196	-0.198	-0.144	-0.190	-0.167	-0.179
Ireland	-0.102	-0.072	-0.065	-0.074	-0.077	-0.078
Italy	-0.152	-0.156	-0.146	-0.124	-0.118	-0.139
Latvia	-0.230	-0.187	-0.166	-0.172	-0.146	-0.180
Lithuania	-0.258	-0.263	-0.208	-0.217	-0.202	-0.230
Luxembourg	-0.112	-0.111	-0.121	-0.106	-0.087	-0.107
Malta	-0.139	-0.148	-0.123	-0.135	-0.136	-0.136
Netherlands	-0.071	-0.071	-0.068	-0.053	-0.040	-0.061
North Ireland	-0.137	-0.121	-0.132	-0.104	-0.096	-0.118
Poland	-0.194	-0.178	-0.181	-0.192	-0.196	-0.188
Portugal	-0.209	-0.208	-0.184	-0.206	-0.214	-0.204
Romania	-0.243	-0.221	-0.216	-0.215	-0.214	-0.222
Slovakia	-0.114	-0.193	-0.166	-0.142	-0.138	-0.150
Slovenia	-0.163	-0.172	-0.155	-0.162	-0.120	-0.154
Spain	-0.185	-0.179	-0.214	-0.180	-0.179	-0.188
Sweden	-0.066	-0.067	-0.069	-0.058	-0.044	-0.061
Turkey	-0.134	-0.151	-0.126	-0.145	-0.122	-0.135
Average	**-0.159**	**-0.159**	**-0.147**	**-0.143**	**-0.136**	**-0.149**

Table D3: Values of Relative Coverage Bias for the variable *Length of Education*

Positive sign: overrepresentation of higher educated with Internet access at home

Country/Year	**2005**	**2006**	**2007**	**2008**	**2009**	Average
Austria	0.058	0.052	0.049	0.054	0.049	0.053
Belgium	0.062	0.060	0.052	0.059	0.044	0.056
Bulgaria	0.193	0.165	0.106	0.125	0.092	0.136
Croatia	0.087	0.094	0.082	0.093	0.067	0.085
Cyprus Rep.	0.162	0.158	0.155	0.108	0.099	0.136
Cyprus TCC	0.118	0.171	0.083	0.055	0.114	0.108
Czech Rep.	0.064	0.048	0.042	0.038	0.026	0.044
Denmark	0.015	0.035	0.018	0.022	0.041	0.026
Estonia	0.049	0.049	0.042	0.033	0.030	0.041
Finland	0.068	0.054	0.054	0.058	0.025	0.052
France	0.100	0.074	0.067	0.064	0.061	0.073
Germany East	0.101	0.068	0.059	0.055	0.079	0.072
Germany West	0.084	0.051	0.060	0.048	0.052	0.059
Great Britain	0.063	0.056	0.047	0.051	0.037	0.051
Greece	0.220	0.241	0.220	0.222	0.162	0.213
Hungary	0.133	0.144	0.102	0.086	0.085	0.110
Ireland	0.074	0.072	0.058	0.046	0.052	0.061
Italy	0.124	0.110	0.126	0.114	0.118	0.118
Latvia	0.091	0.063	0.039	0.032	0.031	0.051
Lithuania	0.079	0.100	0.073	0.094	0.056	0.080
Luxembourg	0.052	0.056	0.063	0.033	0.035	0.048
Malta	0.057	0.058	0.059	0.040	0.059	0.054
Netherlands	0.027	0.021	0.020	0.021	0.015	0.021
North Ireland	0.059	0.064	0.059	0.051	0.046	0.056
Poland	0.096	0.114	0.076	0.093	0.070	0.090
Portugal	0.272	0.221	0.204	0.157	0.210	0.213
Romania	0.236	0.160	0.147	0.150	0.100	0.159
Slovakia	0.100	0.067	0.054	0.047	0.036	0.061
Slovenia	0.060	0.063	0.064	0.057	0.045	0.058
Spain	0.136	0.120	0.128	0.113	0.138	0.127
Sweden	0.019	0.022	0.026	0.017	0.016	0.020
Turkey	0.253	0.168	0.165	0.169	0.276	0.206
Average	**0.104**	**0.094**	**0.081**	**0.075**	**0.074**	**0.086**

Table D4: Values of Relative Coverage Bias for the variable *Political Left-Right Self-placement*

Scale: 1 (Left) – 10 (Right); Negative sign: overrepresentation 'left' with Internet access at home

Country/Year	**2005**	**2006**	**2007**	**2008**	**2009**	Average
Austria	-0.024	-0.005	-0.015	-0.018	-0.017	-0.016
Belgium	-0.006	0.020	0.005	-0.004	0.003	0.004
Bulgaria	0.231	0.144	0.157	0.080	0.075	0.137
Croatia	0.007	-0.022	0.006	-0.031	-0.059	-0.020
Cyprus Rep.	0.042	-0.035	0.020	0.064	0.057	0.030
Cyprus TCC	-0.058	-0.051	-0.022	-0.039	-0.072	-0.049
Czech Rep.	0.075	0.104	0.078	0.102	0.048	0.082
Denmark	-0.011	-0.011	-0.009	-0.009	-0.015	-0.011
Estonia	0.036	0.023	0.022	0.031	-0.022	0.018
Finland	0.016	0.013	-0.006	0.018	0.012	0.011
France	0.004	-0.003	-0.020	-0.039	-0.010	-0.013
Germany East	-0.009	-0.013	0.026	-0.021	0.017	0.000
Germany West	-0.023	-0.023	-0.034	-0.011	-0.028	-0.024
Great Britain	-0.004	-0.005	-0.002	-0.008	-0.015	-0.007
Greece	-0.025	-0.031	-0.032	-0.058	-0.061	-0.041
Hungary	0.003	-0.009	0.000	-0.016	0.030	0.002
Ireland	0.001	-0.002	0.002	0.005	-0.024	-0.003
Italy	-0.017	-0.035	-0.023	-0.005	-0.049	-0.026
Latvia	0.002	-0.001	-0.005	-0.004	-0.030	-0.008
Lithuania	0.049	0.022	0.003	-0.008	-0.007	0.012
Luxembourg	-0.017	-0.014	-0.003	-0.027	-0.034	-0.019
Malta	0.003	0.054	0.015	-0.015	-0.026	0.006
Netherlands	0.001	0.001	-0.004	0.000	-0.005	-0.002
North Ireland	0.004	-0.051	-0.015	-0.019	-0.003	-0.017
Poland	0.018	0.018	-0.028	-0.047	-0.062	-0.020
Portugal	0.004	0.006	-0.026	-0.007	0.026	0.001
Romania	0.063	0.123	0.052	0.094	0.037	0.074
Slovakia	0.068	0.076	0.073	0.035	0.053	0.061
Slovenia	0.017	-0.017	-0.005	0.004	-0.014	-0.003
Spain	-0.023	-0.043	-0.006	-0.063	0.005	-0.026
Sweden	0.001	0.001	0.000	0.000	0.003	0.001
Turkey	-0.036	-0.050	-0.043	-0.138	-0.061	-0.066
Average	**0.012**	**0.006**	**0.005**	**-0.005**	**-0.008**	**0.002**

Table D5: Values of Relative Coverage Bias for the variable *Life Satisfaction*

Scale: 1 (Not at all satisfied) – 4 (Very satisfied);

Positive sign: overrepresentation 'more satisfied' with Internet access at home

Country/Year	**2005**	**2006**	**2007**	**2008**	**2009**	Average
Austria	0.016	0.028	0.030	0.024	0.031	0.026
Belgium	0.020	0.034	0.030	0.032	0.032	0.030
Bulgaria	0.297	0.155	0.156	0.197	0.004	0.162
Croatia	0.106	0.084	0.065	0.090	0.027	0.074
Cyprus Rep.	0.034	0.055	0.078	0.036	0.040	0.049
Cyprus TCC	-0.013	0.034	0.020	0.005	0.007	0.011
Czech Rep.	0.039	0.052	0.047	0.041	0.007	0.037
Denmark	0.004	0.003	0.007	0.002	0.026	0.008
Estonia	0.065	0.035	0.038	0.047	0.005	0.038
Finland	0.016	0.020	0.010	0.018	0.072	0.027
France	0.026	0.031	0.019	0.025	0.027	0.026
Germany East	0.031	0.054	0.058	0.005	0.112	0.052
Germany West	0.016	0.024	0.030	0.022	0.027	0.024
Great Britain	0.016	0.031	0.015	0.024	0.012	0.020
Greece	0.093	0.064	0.083	0.078	0.001	0.064
Hungary	0.118	0.140	0.086	0.139	0.026	0.102
Ireland	0.032	0.022	0.033	0.012	0.025	0.025
Italy	0.048	0.023	0.048	0.048	0.028	0.039
Latvia	0.121	0.063	0.054	0.066	0.025	0.066
Lithuania	0.170	0.100	0.054	0.099	0.089	0.102
Luxembourg	0.000	0.010	0.013	0.016	0.061	0.020
Malta	0.015	0.024	0.017	0.024	0.057	0.027
Netherlands	0.007	0.010	0.013	0.011	0.026	0.013
North Ireland	0.005	0.019	0.012	0.012	0.058	0.021
Poland	0.092	0.071	0.070	0.075	0.055	0.073
Portugal	0.057	0.088	0.083	0.087	0.029	0.069
Romania	0.139	0.123	0.130	0.108	0.143	0.129
Slovakia	0.077	0.072	0.058	0.041	0.093	0.068
Slovenia	0.044	0.038	0.040	0.041	0.067	0.046
Spain	0.034	0.020	0.038	0.015	0.072	0.036
Sweden	0.003	0.004	0.008	0.008	0.042	0.013
Turkey	0.087	0.063	0.051	0.038	0.005	0.049
Average	**0.057**	**0.050**	**0.047**	**0.046**	**0.042**	**0.048**