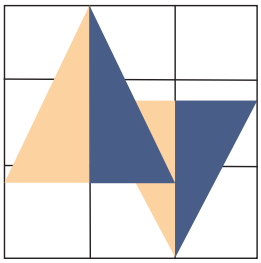

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Longitudinal Research with the Second Wave of SHARE: Representativeness of the Longitudinal Sample and the Mortality Follow-Up

Anne Schulz & Gabriele Doblhammer

Abstract:
With the second wave of SHARE there is the possibility to analyze the SHARE population in a longitudinal perspective with respect to health and mortality. This paper deals with the representativeness of the longitudinal sample as well as of the mortality follow-up. First, the risk of dying and of loss to follow-up between the two waves is analyzed to detect if there is some bias in the composition of the longitudinal sample. Second, death rates from SHARE are compared with HMD death rates and a meta-analysis is performed to assess the factors influencing mortality differences between SHARE and HMD. The results show that the longitudinal sample is positively selected with regard to education, physical and mental health. With respect to the mortality follow-up, the results confirm the expected underestimation of mortality in SHARE due to missing in deaths in the follow-up as well as due to the initial exclusion of the institutionalized population in the sample.

1 Introduction

In recent years, the Survey of Health, Ageing and Retirement in Europe (SHARE) has become an important data source for the analysis of the living conditions of the elderly. The survey was developed to assess the individual, as well as the societal ageing processes in Europe (www.share-project.org). It is a multidisciplinary and cross-national survey of older European people aged 50 and above. SHARE looks at the three central areas of living: household and family, socioeconomic conditions and health. Moreover, it covers the three phases of life of elderly people: the time before retirement, the time spent in retirement in good health and the time spent in deteriorating health (Börsch-Supan 2005).

With the second wave of SHARE, a country-specific follow-up has become available which lends itself to the analysis of several aspects of the ageing process in a longitudinal perspective. Especially for the analysis of health as a central point of optimal ageing, and of the determinants of good health, the SHARE survey seems to be an adequate data source. To answer the question of whether SHARE is indeed a suitable data source for the analysis of health and health transitions, the first part of this paper is dedicated to the representativeness of the longitudinal sample of the second wave with regard to demographic, socioeconomic and health-related characteristics. In most countries, the second wave also consists of a refreshment sample which is, however, not considered in this paper.

We expect that respondents who stay in the panel are subject to a positive health selection which might bias longitudinal health studies with SHARE. Therefore, we first compare key characteristics of those respondents who (1) participated in both waves and whom we call panel respondents, respondents who (2) are lost to follow-up, and respondents who (3) died between the two waves. Age, gender, partnership status and household size are considered as demographic features. Education and the gross equivalent income represent the socioeconomic characteristics. In addition, a block of health measures is implemented to assess the health status of the respondents at the time of the first wave. We perform a multinomial logistic regression to detect whether certain characteristics of the respondents are related to an increased risk of mortality or of loss to follow-up. The results are then used to help determine whether there is a bias in the composition of those respondents who participated in both waves of SHARE.

In the second part of the paper, the mortality follow-up is evaluated in more detail. There are two reasons why we might logically expect that a bias could arise in the mortality follow-up of SHARE that would result in an underestimation of mortality. First, the institutionalized population is missing in the first wave of SHARE. In addition, although respondents are followed into institutions in the second wave, the institutionalization rate in SHARE is too low to reflect reality. Thus, respondents entering institutions may be coded as cases lost to follow-up, rather than as deaths.

Second, the mortality follow-up is not based on registers (except for France), but on the so-called “end-of-life interview” with relatives living in the same household, or

with neighbors or friends. This procedure most probably leads to an underenumeration of deaths of respondents living alone.

Taking these two points into account, this part of our analysis is devoted to the question of how well the mortality follow-up between the first and second waves reflects mortality for all of the SHARE countries combined, when the Human Mortality Database (HMD) is used as the reference. The extent of the underestimation of mortality will vary from country to country depending on a number of factors. In this paper, we are particularly interested in the effect of factors that are related to the design of the surveys in the various countries. Therefore, we explore the effect of five indicators that should influence the country-specific mortality follow-up.

The first indicator is the institutionalization rate. The proportion of people living in an institution affects the representativeness of the first wave, as well as the probability of a transition into an institution between the two waves. The higher the institutionalization rates, the more selected the sample population will be in terms of good health. Thus, in countries with high institutionalization rates, the mortality estimate should be worse.

The second indicator is the percentage of people lost to follow-up between the first and second waves. On the one hand, panel attrition measures the quality of the longitudinal follow-up, with a high proportion of panel attrition causing problems not only for the mortality follow-up, but also for the representativeness of the second wave. Since the extent of loss to follow-up may be correlated with the poor health status of the respondent, a high percentage of people lost to follow-up results in an underestimation of the mortality estimate. Respondents moving shortly before death - e.g., those moving into an institution or living alone - might be lost and coded as attrition cases, rather than as deaths.

The third indicator is the non-response rate of wave one, with two possible opposite relationships to the mortality follow-up. On the one hand, non-response may occur when the designated sample person is unable to take part in the survey because of health problems. In countries with low institutionalization rates, where unhealthy people primarily live in private households, non-response may be higher than in countries with a large proportion of the elderly living in institutions. Thus, non-

response may be closely linked to institutionalization rates. A large non-response rate in the first wave may therefore be correlated with a low institutionalization rate, which may in turn lead to a better mortality estimate. On the other hand, non-response may be an indicator of the quality of the sample, and thus an increased non-response rate may lead to a worse mortality estimate.

The fourth indicator is the sample size of the first wave, with a smaller sample size introducing more sample variation, and thus leading to a worse mortality estimate.

As a control variable we introduce the proportion of observed deaths in SHARE relative to the expected number of deaths for each country calculated from HMD, which measures the quality of the mortality follow-up. The mortality estimates should be better in countries with a higher proportion of observed deaths.

We evaluate the mortality follow-up by comparing age-specific death rates for all SHARE countries, combined with age-specific death rates from the Human Mortality Database. To estimate the effect of the indicators on the country-specific mortality follow-up, we calculate partial life expectancy between ages 50 and 89 in the SHARE countries, and compare the results with the respective figures from the Human Mortality Database.

In the following, we describe our data, which is drawn from the SHARE survey and the Human Mortality Database; the method of the multinomial logistic regression; the calculation of the expected and observed mortality and the meta-regression used for identifying the association between the survey design indicators and the quality of the mortality estimate. We conclude this paper with a discussion of the impact of our findings on the representativeness of the longitudinal sample in the second wave and in the mortality analysis with SHARE.

2 Data

2.1 Survey of Health, Ageing and Retirement in Europe - SHARE

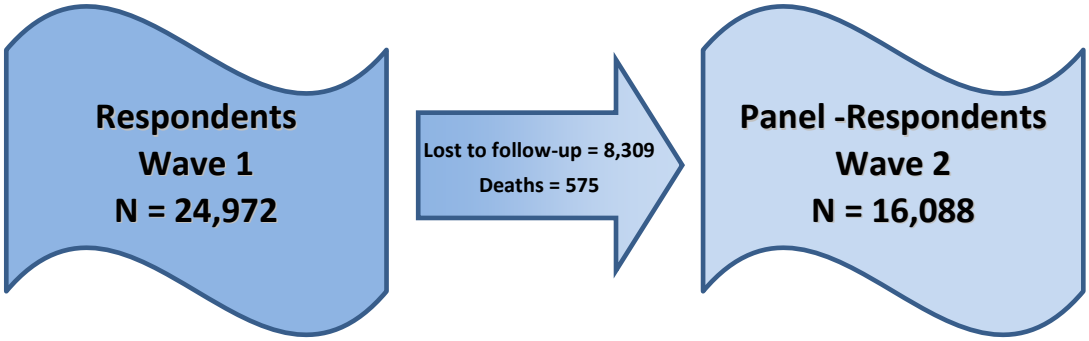
The first wave of SHARE was conducted in 2004 and 2005 in 11 countries that represent the main regions in Europe: Northern Europe (Sweden, Denmark), Central Europe (Austria, Germany, the Netherlands, France, Switzerland, Belgium) and the Mediterranean (Spain, Italy, Greece). Additionally, Israel participated in SHARE's first wave in 2005 and 2006. In total, 31,115 persons were interviewed. The second

wave, with 33,281 interviews, was conducted in most countries in 2006 and 2007. All countries of the first wave, with the exception of Israel, participated in the second wave. The Czech Republic, Poland and Ireland were also added to the SHARE program in the second wave.

The interview consists of several modules which cover the most important areas that affect the living conditions of elderly people, and particularly their health (SHARE 2009). Whether a respondent of the first wave was alive, dead or the vital status was unknown at the time of the second interview can be derived from the module "dead or alive." The date of death comes from the "end-of-life" interview. If a person who participated in the first wave of SHARE died between the first and the second wave, an end-of-life interview was sought. In this interview, relatives, friends or neighbors were asked about the last year of the decedent. This end-of-life module provides information about the date of death, as well as about the cause and the place of death. If no date of death is given in the "end-of-life" module, the information was derived from the coverscreen module for the households of the second wave. This module is the beginning of the interview, in which one household member answered questions about issues at the household level. The respondent was asked if anyone had died who was a member of the household at the time of the first interview. By comparing characteristics such as gender and the date of birth, it was possible to derive information about the date of death.

The following analysis relies on the two first waves of SHARE (Releases 2.3.1), and includes all countries that participated in both waves, with the exception of Greece. The analysis is based on 24,972 interviews conducted for the first wave of SHARE in Austria, Germany, Sweden, the Netherlands, Spain, Italy, France, Denmark, Switzerland and Belgium. Information about the date of death arises from the end-of-life module (471 cases). For 59 cases we identified the date of deaths by using the coverscreen module for the households. In 45 cases we know that the respondent died at some point between the first and the second interview, but the date of death is unknown.

Figure 1: Information on follow-up between the two waves of SHARE



Source: Own illustration

Out of all the respondents of the first wave, 16,088 individuals were interviewed a second time. 575 respondents were recorded as dead. The vital status at the time of the second interview is unknown for 7,261 respondents. 1,048 persons were alive but did not participate in the second interview. Those 8,309 respondents are therefore coded as cases lost to follow-up (Figure 1).

2.2 Human Mortality Database - HMD

We use the Human Mortality Database (www.mortality.org) to analyze the SHARE mortality follow-up. The HMD is an internet database that provides information on mortality for almost all European countries (except for Greece), as well as for the United States, Canada, Australia, Chile, Japan, New Zealand and Taiwan. The HMD is a joint project of the Department of Demography at the University of California, Berkeley (USA), and the Max Planck Institute for Demographic Research (MPIDR) in Rostock (Germany). In addition to providing annual population size and exposure-to-risk population data, the database is a potential source of information on annual births and deaths. For the following analysis, the number of deaths and the exposure-to-risk population of the years 2004 and 2005 are used.

3 Methods

3.1 Multinomial logistic regression

To identify characteristics that are related to an increased risk of loss to follow-up or mortality between the two waves of SHARE, we performed a multinomial logistic

regression (eq.[1]). The dependent variable is the status (panel respondent, lost to follow-up, deceased) at the time of the second wave. The panel respondents represent the reference category. We estimated the risk of loss to follow-up or death, dependent on several determinants x_k concerning the demographic, socioeconomic and health-related characteristics of the respondents in the first wave:

$$g_1 = \ln\left(\frac{p(lost\ to\ follow-up)}{p(panel)}\right) = \beta_{10} + \beta_{11}x_{11} + \cdots + \beta_{1k}x_{1k}$$

$$g_2 = \ln\left(\frac{p(deceased)}{p(panel)}\right) = \beta_{20} + \beta_{21}x_{21} + \cdots + \beta_{2k}x_{2k} \quad , \qquad [1]$$

(Hosmer and Lemeshow 2000).

As demographic determinants for the prediction of loss to follow-up or death, we included gender, age in groups (50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, 85+) at the time of the first interview, the household size (1, 2, 3+) and the partnership status with the possible answers "living with a spouse," "living with a partner," "living as single" and "other." All demographic predictors are taken from the coverscreen module of the first wave.

Education is classified by the ISCED-1997 code (SHARE 2010). It is differentiated into "low," "middle," "high" and "other." The gross equivalent income per month is adapted by the number of household members and consists of the values "less than 1000 €," "1000 € - 1700 €," "1700 € - 3000 €" and "more than 3000 €." Both socioeconomic indicators arise from the generated variables of SHARE.

Information on health is taken from the health modules of the generated variables. The number of chronic diseases is divided into "less than 2 chronic diseases" and "2 and more chronic diseases." Persons without any limitation in ADL and persons with at least one limitation in ADL are differentiated. The self-perceived health status is measured with the European scale ranging from "very good" to "very bad." The answers are combined to the groups "very good/good" and "less than good." SHARE also surveys mental health using the EURO-D scale. Respondents are divided into "depressed" if they answer at least three out of 12 items positively, and "not depressed" otherwise. The module "Cognitive Function" contains the five items "Orientation," "Numeracy," "Verbal fluency," "Recall 1" and "Recall 2;" which are

summarized on a scale with a maximum of 18 points. People with 14 or more points are not cognitively impaired. Respondents with 12 or 13 points have mild cognitive impairments. Scores from eight to 11 points refer to moderate cognitive impairments, and respondents with fewer than eight points are classified as having severe cognitive impairments (Christelis et al. 2006; Ziegler forthcoming).

3.2 Observed Mortality in SHARE

We defined each individual lifetime exactly to the month by the age at the first interview, and the age at death for cases in which a person had died. Age was measured in terms of age at last birthday, and was calculated for one-year age groups. The respondents who were still alive in the second wave and part of the sample were censored at the age at the second interview. People who were alive at the time of the second interview, but who refused to participate, were censored at the country-specific average time of the second interview. If there was no information about the survival status, or if the time of death was unknown, the cases were censored at half of the country-specific average time between the first and second interviews. The analysis was conducted with all the countries listed in the paragraph above combined. Observed age-specific death rates were calculated by estimating the person-years at risk E_x^{SHARE}, as well as by summing up the observed deaths D_x^o at every discrete age x. By dividing those two terms, the observed age-specific death rates m_x were calculated (eq. [2]).

$$m_x = \frac{D_x^o}{E_x^{SHARE}} \qquad [2]$$

3.3 Expected Mortality

The expected age-specific death rate was calculated on the basis of the HMD for the years 2004 and 2005. For every country *j,* the age-specific number of deaths was divided by the age-specific exposure-to-risk population. This leads to a country- and age-specific death rate M_{xj}^e. M_{xj}^e was then used to calculate the country-specific expected number of deaths D_{xj}^e by multiplying M_{xj}^e with the exposure-to-risk population E_{xj}^{SHARE} in SHARE (eq. [3]).

$$D_{xj}^e = E_{xj}^{SHARE} \cdot M_{xj}^e \qquad [3]$$

This gives the country-specific number of expected deaths in SHARE under the assumption that the mortality regime of the HMD also applies to the SHARE population. Summing up the expected deaths and the population at risk over all countries leads to the expected death rate M_x^e (eq. [4]).

$$M_x^e = \frac{\sum_{j=1}^{10} D_{xj}^e}{\sum_{j=1}^{10} E_{xj}^{SHARE}} = \frac{D_x^e}{E_x^{SHARE}} \qquad [4]$$

In addition, we calculated the 95% confidence interval of the expected age-specific death rate assuming that the number of deaths follows a Poisson distribution with mean λ. The lower and the upper confidence bounds [λ_1, λ_2] for each age were calculated such that

$$\Pr\{K \geq D_x^e \mid \lambda = \lambda_1\} = 0.025$$

and [5]

$$\Pr\{K \leq D_x^e \mid \lambda = \lambda_2\} = 0.025 \quad ,$$

where K is Poisson distributed and D_x^e is the number of total cases. Assuming that the exposure-to-risk population is deterministic rather than a random variable, the confidence interval of the death rate can be calculated as

$$\Pr\left\{\frac{\lambda_1}{E_x^{SHARE}} \leq M_x^e \leq \frac{\lambda_2}{E_x^{SHARE}}\right\} = 0.95 \quad . \qquad [6]$$

3.4 Meta-Analysis

We performed a meta-analysis to explore the factors that influence the differences in country-specific life expectancy between SHARE and the HMD. Since the sample population, as well as the number of deaths, becomes very small at the highest ages, we restricted this analysis to ages 50 to 89. Country-specific partial life expectancy and its standard errors on the basis of the HMD were calculated by using life table functions. For SHARE, age-specific death rates $h(x|Z)$ were estimated by applying hazard models introducing country as an explanatory variable. Several model

specifications were tested. First we estimated a continuous-time hazard model with the baseline function following a Gompertz function and the country dummies Z.

$$h(x \mid Z) = \theta \cdot \exp(ax) \cdot \exp(\sum_{j=1}^{9} \beta_j Z_j) \qquad [7]$$

Next, a discrete time proportional hazards models was estimated:

$$h(x \mid Z) = 1 - \exp\left(-\exp\left(\beta_0 + \beta' x + \sum_{j=1}^{9} \beta_j Z_j \right) \right) \quad , \qquad [8]$$

(Jenkins 2005). We introduced a linear as well as a second-order polynomial for the term $\beta' x$, and tested the fit of the model by applying the Akaike test criteria (AIC)[1]. Predicted hazards of the best-fitting model were then used to calculate country-specific partial life expectancy from ages 50 to 89, as well as the corresponding standard error of partial life expectancy.

Subsequently, a meta-regression was carried out to explain differences in life expectancy between SHARE and HMD using the indicators described above. For the first indicator, institutionalization rate, we use two alternative operationalizations: the "percentage of people at age 65 and above living in institutions," and the "number of beds in institutions per 10,000 inhabitants." The first indicator is taken from the European Commission (2007), with the exception of Switzerland, where it is calculated using data from the Swiss Federal Statistical Office (www.statistik.admin.ch) and the HMD. The second indicator is retrieved from the European Health for All Database. For Austria, this number was generated by using information from Hofmarcher and Rack (2006) and the HMD. The reason for choosing two operationalizations is the lack of harmonization in the definition of institutionalized population between the countries. The third indicator, "proportion lost to follow-up," between the two waves was calculated with SHARE data of the first and second waves, and the final two indicators were "non-response rate of the first wave" and "sample size of the first wave." All information is taken from the SHARE homepage. The control variable is defined as the percentage of observed

[1] AIC=-2Log$L$ + kp, where L is likelihood function, k is 2 and p is the number of regression parameters (Klein and Moeschberger 2005)

deaths in SHARE relative to the expected number of deaths that would have been observed if the SHARE population had followed the mortality conditions of the HMD.

The dependent variable of the meta-regression is the difference in partial life expectancy for ages 50 to 89 between SHARE and the HMD in years. The first model only contains the control variable "proportion of observed to expected number of deaths." Because we only observed 10 countries, the other five indicators were introduced separately into five separate models, with the "proportion of observed to expected number of deaths" as a control variable. The models were weighted by the precision of the estimate of the partial life expectancy in SHARE. The precision was defined as one divided by the standard error of the difference in partial life expectancy between SHARE and HMD. The standard error of the life expectancy difference is analogue to the standard error of partial life expectancy in SHARE, since the partial life expectancy of HMD data is assumed to be deterministic.

4 Results

This section is divided into two parts. The first part presents an analysis of the representativeness of the longitudinal sample of the second wave. The second part provides an evaluation of the mortality follow-up of SHARE.

Table 1 summarizes the demographic, socioeconomic and health-related characteristics of the longitudinal sample, the respondents lost to follow-up and the deceased respondents. Relative to the panel respondents, the deceased are much older, live in smaller households, have lower incomes, and have less education. Their physical and mental health levels are worse than those of the panel respondents and of the people lost to follow-up. The deceased differ significantly from the panel respondents in all measures. Those lost to follow-up closely resemble the panel respondents. Significant differences between the panel respondents and those lost to follow-up can be seen for the following characteristics: mean age, mean number of chronic diseases, proportion with 1+ ADL limitations, proportion with at least good health and proportion cognitively impaired.

Table 1: Comparison of selected characteristics from Wave 1 of the longitudinal sample, respondents lost to follow-up and deceased respondents between the two waves of SHARE

	Panel	*Lost to follow-up*	*Deceased*
Proportion men	45.1%	45.1%	57.7% ***
Mean age	64.0	64.6 **	75.5 ***
Mean household size	2.2	2.1	2.0 ***
Proportion living as single	25.3%	25.5%	41.6% ***
Mean gross equivalent income	2,717 €	2,596 €	2,080 € ***
Proportion with low education	44.9%	46.1%	53.7% ***
Mean number chronic diseases	1.52	1.46 *	2.38 ***
Proportion with 1+ ADL limitations	9.0%	10.3% **	38.9% ***
Proportion with at least good health	64.5%	59.3% ***	28.0% ***
Proportion depressed	24.2%	24.4%	44.1% ***
Proportion cognitively impaired	31.9%	41.7% ***	67.0% ***

***p≤0.01; **p≤0.05; *p≤0.1
Source: SHARE, Wave 1 Release 2.3.1, Wave 2 Release 2.3.1

The multinomial regression model shows the relative risk of loss to follow-up and mortality (Table 2). The first model includes demographic factors like gender, age, household size and partnership status. The second model is extended by introducing the socioeconomic factors education and gross equivalent income. The third model also covers important health measures. All models are controlled by country dummies.

Predictors of loss to follow-up

While the household size does not affect the risk of getting lost to follow-up, the partnership status does. Living with a partner rather than with a spouse is correlated with a higher risk of leaving the panel. This effect remains stable when socioeconomic and health characteristics are taken into account. Non-married partners may have a higher probability of dissolving the partnership. Such changes may lead to refusing further participation in the panel survey. Having higher education correlates with a lower risk getting lost to follow-up. It can be assumed that the awareness of the importance of such a Europe-wide survey is higher among more educated people, and thus the probability that they will refuse to participate in further waves of SHARE is lower. As expected, respondents who describe their health as less than good have an increased risk of leaving the panel. An unexpected result is the effect of chronic

diseases. Persons with two or more chronic diseases have a lower risk of getting lost to follow-up than respondents reporting fewer than two chronic diseases. A strong predictor for loss to follow-up is the presence of cognitive impairments. The more severe the cognitive impairments are, the higher the risk of getting lost to follow-up is. It can be assumed that people with severe cognitive impairments may have moved into an institution between the two waves of SHARE, and therefore could not be followed up. Controlling for socioeconomic and health-related features leaves an u-shaped age effect. The youngest (ages 50-54) and the oldest respondents (ages 80+) are more likely to leave the panel, whereas people ages 55 to 79 have the highest chances of going on to participate in the second wave.

Predictors of mortality

As expected, the risk of mortality increases with age, and men have a higher risk of dying than women. Socioeconomic factors and health variables explain part of the age effect. Respondents living in households with two or more persons have a higher risk of mortality than persons living in a single household. In fact, it is more likely that those persons have a higher risk of being identified as dead because the household does not necessarily dissolve with the death of the respondent, and the surviving household members are able to report the death. By contrast, a single household will not continue exist after the person dies. Thus, identifying the death will be more complicated. In addition to the effect of household size, we observe a separate effect of living with a partner. The risk of dying is highest for people without a partner. With respect to the health measures, we see that the risk of dying is increased when people report limitations in physical and/or mental health. Respondents who report having at least one limitation in ADL and less than good health are more likely to die. In addition, the deceased are more often affected by depression and cognitive impairments.

The results lead to the conclusion that panel respondents are profoundly different from respondents who are lost to follow-up and those who died between the two waves of SHARE. Those lost to follow-up tend to be rather young or very old, to live in instable partnerships, to have low levels of education, and to suffer from poor physical health and cognitive impairments. The deceased are more likely than other respondents to be male, old, single, and limited in ADL; and to be in poor physical

and mental health. Therefore, the panel respondents are positively selected. The regression results allow us to state that the longitudinal follow-up consists of more females and highly educated people. They are mostly married and are in relatively good physical and mental health, apart from the number of chronic diseases.

Table 2: Odds ratios of loss to follow-up and of mortality

	Model 1		*Model 2*		*Model 3*	
	Lost	Deceased	Lost	Deceased	Lost	Deceased
Gender						
Men	1	1	1	1	1	1
Women	0.994	0.459 ***	0.976	0.440 ***	0.995	0.400 ***
Age						
50-54	1	1	1	1	1	1
55-59	0.908 **	1.391	0.903 **	1.366	0.891 **	1.129 *
60-64	0.834 ***	2.268 ***	0.818 ***	2.155 ***	0.801 ***	1.903 **
65-69	0.850 ***	3.745 ***	0.823 ***	3.458 ***	0.801 ***	2.968 ***
70-74	1.037	5.121 ***	0.996	4.628 ***	0.930	3.292 ***
75-79	0.957	10.077 ***	0.914	9.021 ***	0.811 ***	5.666 ***
80-84	1.160 **	14.929 ***	1.103	13.312 ***	0.888	6.134 ***
85+	1.645 ***	43.576 ***	1.566 ***	38.651 ***	1.163	13.859 ***
Household size						
1	1	1	1	1	1	1
2	1.076	1.569 **	1.073	1.549 **	1.025	1.388 *
3+	1.008	1.859 ***	1.003	1.804 ***	0.947	1.481 **
Partnership status						
Living with spouse	1	1	1	1	1	1
Living with partner	1.206 ***	1.159	1.208 ***	1.162	1.189 **	1.164
Living as single	1.032	1.812 ***	1.024	1.767 ***	0.973	1.504 **
Other	1.493	3.293	1.492	3.365	1.322	1.516
Gross equivalent income						
Less than 1000€			1	1	1	1
1000€ - 1700€			0.963	0.983	0.994	1.060
1700€ - 3000€			0.979	1.004	1.046	1.139
More than 3000€			0.948	0.941	1.000	0.977
Education						
Low			1	1	1	1
Middle			0.923 **	0.839	0.985	1.085
High			0.795 ***	0.658 ***	0.875 ***	0.952
Other			0.975	1.308 *	0.865 **	0.983
Chronic diseases						
Less than 2 chronic diseases					1	1
2 and more chronic diseases					0.852 ***	1.096
Activities of daily living						
No limitations					1	1
1 and more limitations					0.986	1.885 ***
Self-perceived health						
Very good / good					1	1
Less than good					1.160 ***	2.116 ***
Depression						
Not depressed					1	1
Depressed					0.930	1.297 **
Cognitive function						
Not impaired					1	1
Mild cogn. impairments					1.351 ***	1.261
Moderate cogn. impairments					1.404 ***	1.388 **
Severe cogn. impairments					2.001 ***	2.452 ***
Missing					1.622 ***	2.472 ***

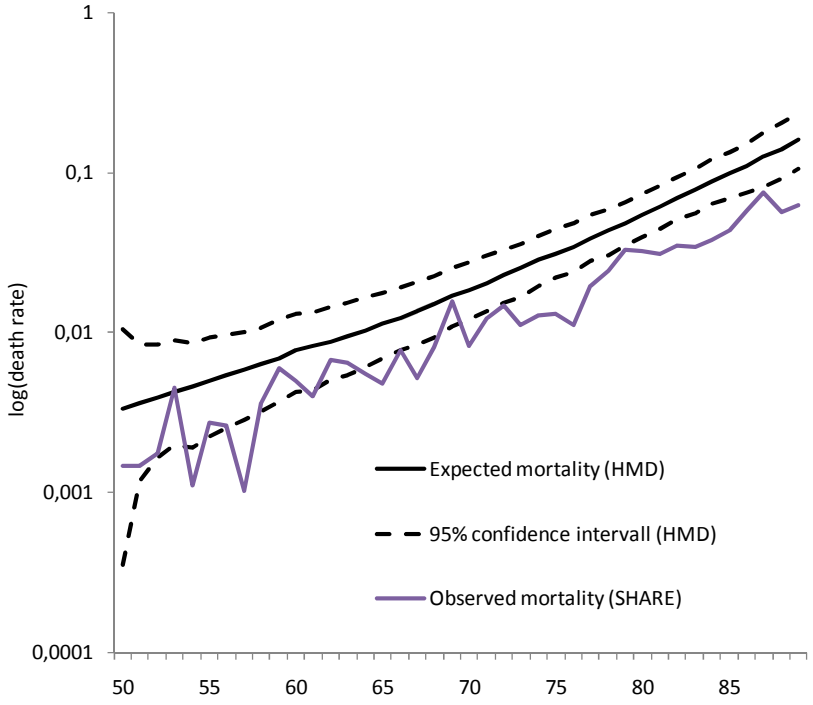
Controlled for Countries

***p≤0.01; **p≤0.05; *p≤0.1

Source: SHARE, Wave 1 Release 2.3.1, Wave 2 Release 2.3.1

In the second part of our study, we analyze the mortality follow-up in SHARE in more detail. Figure 2 shows the trajectories of the observed and expected age-specific death rates, as well as the 95% confidence interval of the expected death rates on a logarithmic scale. If the values of the observed death rates stay within the borders of the confidence interval, it can be assumed that the mortality measured in SHARE is a random realization of the real mortality conditions. The empirical death rates are characterized by a discontinuous form. This is because we did not use any theoretical distribution for smoothing. The empirical death rates mostly lie within the confidence interval up to age 65 (blue line), albeit close to the lower bound. From age 65 onwards, the rates are predominantly located below the lower bound of the confidence interval. Here we can see that SHARE systematically underestimates expected mortality.

Figure 2: Expected and observed death rates in SHARE and HMD

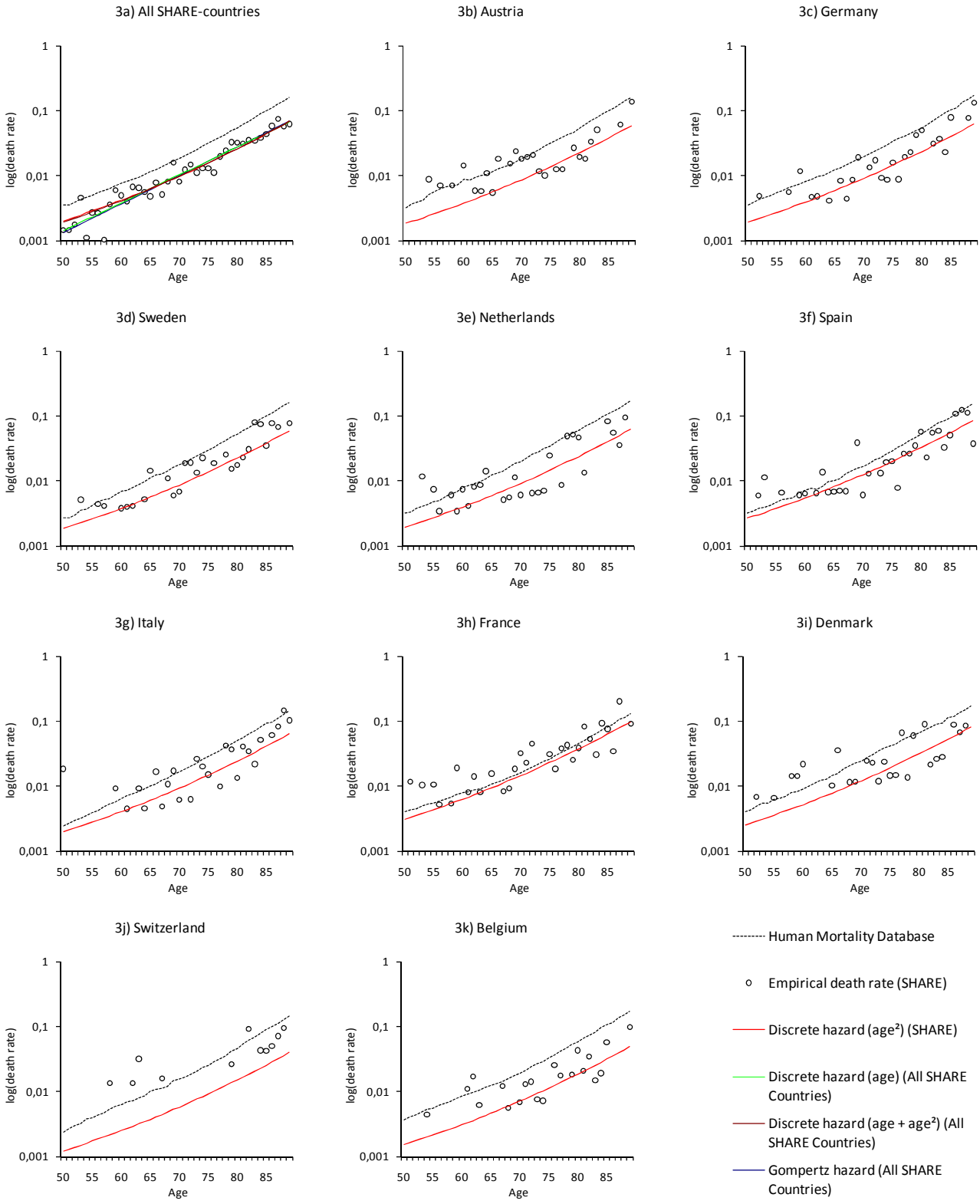


Source: SHARE, Wave 1 Release 2.3.1, Wave 2 Release 2.3.1, and HMD

In the following, we explore the factors that underlie the underestimation of mortality at the country level. First, we model the age-specific trajectories of mortality in SHARE by using a Gompertz specification of the hazard, as well as a discrete time

transformation. Countries are introduced into the model in the form of indicator variables.

Figure 3: Model results and empirical death rates based on SHARE and HMD



Source: SHARE, Wave 1 Release 2.3.1, Wave 2 Release 2.3.1, and HMD

Figure 3 shows the expected death rates based on the HMD (dashed line), and the death rates estimated by the hazard models with SHARE data for all SHARE countries together (3a), as well as for each country separately (3b to 3k). For comparison, the empirical death rates in SHARE computed according to equation [2] are plotted (dots). Both the death rates estimated by the Gompertz model (blue line) and the discrete time model with age introduced as a linear term (green line) follow a relatively similar trajectory. The Akaike information criterion (AIC) - computed for the models that include age as a (1) linear, vs. a (2) quadratic, vs. a (3) second order polynomial term - shows that the model that best fits the data is the one with the quadratic term, followed by the one with a linear term. Thus, a model with a quadratic term only is chosen to predict country-specific hazards, which are then used to compute partial life expectancy.

Table 3 contains the country-specific partial life expectancy from ages 50 to 89 for the SHARE data and the HMD data, as well as the difference between the two sets of data and the number of recorded deaths between the two waves of SHARE. In addition, the indicators “sample size of Wave 1,” “percentage lost to follow-up between the two waves,” “non-response rate of the first wave,” the two operationalizations of the “institutionalization rate” and the control variable “proportion of observed to expected number of deaths” are presented.

Table 3: Variables used in the statistical meta-analysis

SHARE-Country	*e(50-89) SHARE years*	*e(50-89) HMD years*	*Difference (SHARE-HMD) years*	*Sample size wave 1*	*Recorded deaths between wave 1 & wave 2*	*% Observed to expected deaths*	*% People aged 65+ living in institutions*	*Beds in institutions per 10,000 inhabitants*	*% Lost to follow-up*	*% Non-response rate wave 1*
Austria	35.0	30.6	**4.5**	1893	41	58.5	4.9[a]	83.4[d]	32.4	12.5
Germany	34.8	30.3	**4.5**	3008	55	41.0	6.8[a]	86.4[c]	46.4	13.8
Sweden	35.0	31.1	**3.9**	3053	66	45.4	8.7[a]	2.8[c]	31.9	15.4
Netherlands	34.8	30.3	**4.5**	2979	63	56.9	8.8[a]	104.7[c]	37.7	12.2
Spain	33.3	31.2	**2.1**	2396	92	72.5	2.9[a]	3.3[c]	38.8	26.3
Italy	34.7	31.5	**3.2**	2559	56	50.1	3.9[a]	29.6[c]	28.9	20.3
France	32.4	31.3	**1.1**	3193	85	95.8	6.5[a]	13.2[c]	34.6	6.7
Denmark	33.5	29.1	**4.3**	1707	55	62.5	7.4[a]	44.2[c]	23.4	7.0
Switzerland	36.5	31.9	**4.7**	1004	15	41.8	7.0[b]	116.1[c]	28.4	13.1
Belgium	35.8	30.2	**5.6**	3827	47	33.1	6.4[a]	119.3[c]	25.0	9.5

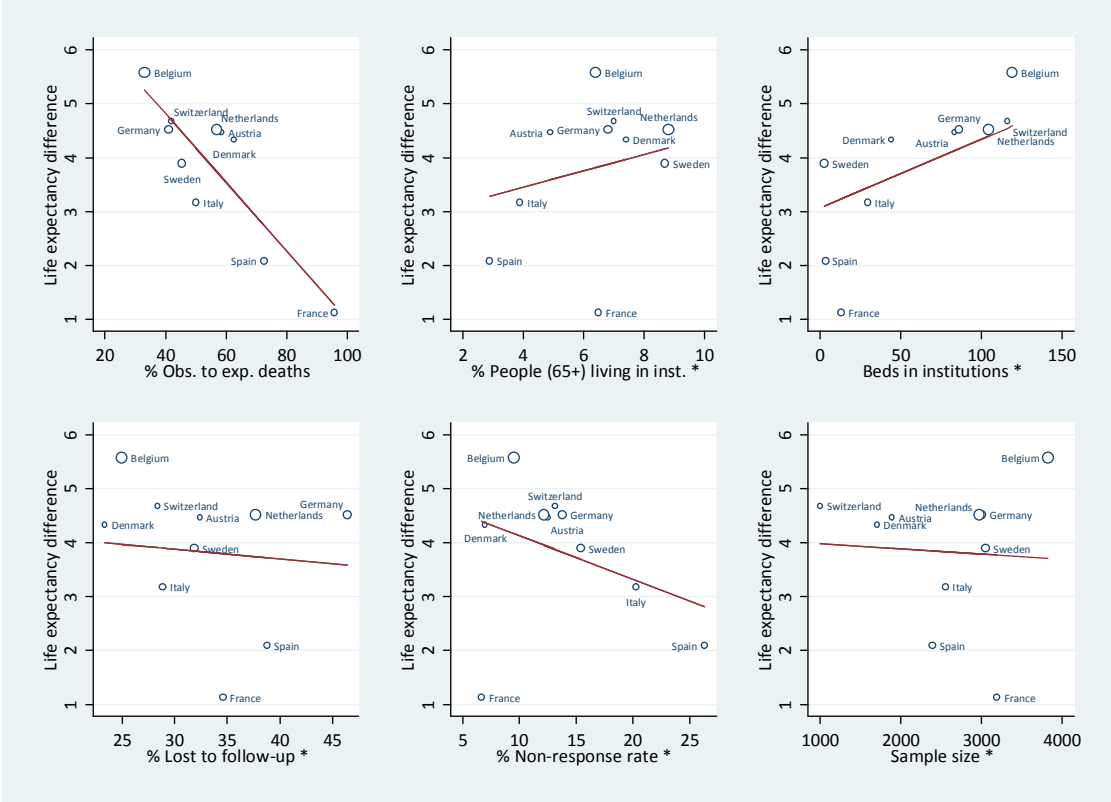
[a] European Commission (2007); [b] Bundesamt für Statistik, Statistik der sozialmedizinischen Institutionen, Schweiz and HMD

[c] European Health for All Database (HFA-DB); [d] Hofmarcher and Rack (2006) and HMD

Source: SHARE, Wave 1 Release 2.3.1, Wave 2 Release 2.3.1, and HMD

As expected, SHARE overestimates partial life expectancy in all countries. The difference between SHARE and HMD ranges from 1.1 years for France to 5.6 years for Belgium. In France, the difference is the smallest since the "proportion of observed to expected number of deaths" is the highest, at about 96% of all deaths recorded. This is due to fact that the Survey Agency in France used the French death register to identify the vital status of the respondents of the first wave (personal communication). Therefore, all meta-regressions are controlled for the "proportion of observed to expected number of deaths" to detect whether the difference is also influenced by further indicators. The difference in life expectancy is used as the dependent variable in the meta-regression. Figure 4 shows the correlation between the difference and each indicator by plotting the country-specific values where the size of the marker for each country stands for the precision of the estimate. The larger the marker, the smaller the standard error of the partial life expectancy in SHARE, and the higher the precision of the estimate. The red lines represent the fitted values of the meta-regressions.

Figure 4: Meta-regression of the difference in life expectancy on six indicators



* controlled for "Proportion of observed to expected deaths"

Source: SHARE, Wave 1 Release 2.3.1, Wave 2 Release 2.3.1, and HMD

The standardized beta values of the meta-regression suggest that the indicators "beds in institutions" and "non-response rate" have the greatest effect on the dependent variable (Table 4).

If only the control variable is taken into account, we observe a strong negative relationship (beta=-0.063, p=0.002) between the "proportion of observed to expected number of deaths" and the life expectancy difference (Figure 4). An increase of 10 percentage points in the proportion of observed deaths reduces the difference between SHARE and HMD by more than half a year (0.63 years).

Table 4: Results of the meta-regression

Meta-Variable	**β-*Coefficient***	***stand.* β**	***p-value***
% People aged 65+ living in institutions	0.15089	0.29016	0.268
Beds in institutions per 10,000 inhabitants	0.01279	0.59913	0.072
% Lost to follow-up	-0.01789	-0.12407	0.652
% Non-response rate wave 1	-0.08055	-0.48091	0.099
Sample size	-0.00010	-0.02413	0.784

controlled for "Proportion observed to expected deaths"

Source: SHARE, Wave 1 Release 2.3.1, Wave 2 Release 2.3.1, and HMD

Despite controlling for the "proportion of observed to expected number of deaths," the "number of beds in institutions per 10,000 inhabitants" shows a strong positive correlation with the life expectancy difference (Figure 4 and Table 4). Except for France, countries like Spain and Italy, which have low institutionalization rates, are shown to have the smallest differences in life expectancy; while for the Netherlands, where a high percentage of people live in institutions, SHARE underestimates mortality to a higher degree. The effect is large, with an increase of only 50 beds in institutions per 10,000 inhabitants, resulting in an increase of 0.64 years in the difference of life expectancy (beta=0.0128, p=0.072). Even though it shows the same trend, the alternative indicator for measuring the institutionalization rate of the population, "percentage of people at age 65 and above living in institutions," has no significant effect on life expectancy difference.

The non-response rate in the first wave of SHARE is negatively correlated with the difference in life expectancy, which is decreasing by about half a year, with the non-response rate increasing by five percentage points (beta=-0.081, p=0.099). No correlation with the difference in life expectancy exists for the two indicators "sample size" and "percentage lost to follow-up."

5 Discussion

The results of the first part of the paper show that the three examined groups (panel respondents participating in both waves, people who are lost to follow-up between the two waves and people who died between the two waves) were profoundly different in their characteristics at the time of the first wave.

Our results support the conclusion that the longitudinal sample is particularly biased with regard to important characteristics like gender, age, partnership status, education and physical and mental health. The risk of loss to follow-up is high among people of working ages (50-54), decreases around retirement age (55-69), and increases again among the oldest old. Health studies are therefore constrained by the limited follow-up into institutions at old age. The panel respondents are positively biased in terms of physical and mental health. It is interesting to note, however, that respondents with a high number of chronic diseases have a greater chance of staying in the panel. One explanation could be that it is not the number, but the severity of the diseases that affects loss to follow-up. Another explanation is that multimorbidity is the standard at old age (van den Akker et al. 1998; Marengoni et al. 2008), and it is therefore not related to frailty and the risk of dropping out of the sample.

All in all, the longitudinal sample is dominated by married, highly educated and relatively healthy persons. Hence, when analyzing health transitions in a longitudinal perspective, we should be aware that the results may be biased due to the strong positive health selection of the longitudinal sample. Given that one-third of sample is lost to follow-up, the biased composition of the panel respondents may lead to a severe underestimation of the effect of health predictors.

The second part of the paper uses the Human Mortality Database to check the mortality follow-up in SHARE. We find that SHARE, for all countries combined, tends to underestimate the mortality regime up to age 65, and to systematically underestimate mortality from age 65 onwards. At the younger ages, this is the result

of the underenumeration of deaths; while at the older ages, this effect is amplified by the missing institutionalized population.

We use country-specific indicators related to the national survey designs and the survey qualities of SHARE to explore the causes of the bias in mortality. With the exception of the indicators "percentage of people at age 65 and above living in institutions," "sample size" and "percentage lost to follow-up," the indicators are statistically significant in explaining at least some of the difference in partial life expectancy between ages 50 and 89 seen in the SHARE and the HMD data. The relationship between the indicators, as well as the gap itself, are generally in line with our expectations.

The institutionalization rate of a specific country is able to explain an important part of the difference between SHARE and HMD. Since SHARE is restricted to private households in the first wave, and the follow-up in institutions is insufficient, it is unlikely that this source of bias will diminish over future waves (except in France). This also explains why there is a general underestimation in the mortality of all SHARE countries combined. We find that the two variables "proportion of observed to expected number of deaths" and the "institutionalization rate" are highly correlated. This correlation may be interpreted as tending to confirm our initial hypothesis that the mortality follow-up is particularly prone to underreporting in cases of changes in the last residential address due to institutionalization.

With regard to the indicator "non-response rate in wave one," we have put forward two opposing hypotheses. Our results support the hypothesis that a high non-response rate is closely linked to a low institutionalization rate. Thus, the non-response rate tends to measure the inability of the designated survey participants to join the sample due to health reasons, rather than capture the general quality of the survey.

The major limitation of the meta-analysis is the limited set of indicators. Even more significant is the problem that the small number of countries restricts this analysis to regression models which consider in each case only the effect of one indicator controlled for the "proportion of observed to expected number of deaths." This does not permit us to explore confounding effects between the indicators.

Finally, we wish to offer some reflections concerning the implications of our analysis for the study of mortality based on SHARE. First, our analysis suggests that the

mortality follow-up in SHARE can be used for all countries combined. Nevertheless, a certain bias will always remain, since the country-specific institutionalization rates will continue to be an important factor influencing the mortality follow-up. Since people living in institutions are excluded from the first wave of SHARE, and the follow-up in institutions is far from complete, the underestimation of mortality will continue to be an issue in future waves. To alleviate this problem, at least in part, we recommend that the SHARE administrators use register data, where available, to complete the mortality follow-up. Using register data would not only solve the problem of underenumeration of deaths; it would also make it possible to include the deaths of the respondents who have moved into an institution. Over the long term, this would help to overcome the initial exclusion of the institutional population.

At present, SHARE cannot be used to study mortality at the country level, and it is questionable whether this will change in future. The country-specific number of observed deaths is too small to permit any meaningful analysis. When mortality is studied for all the SHARE countries combined, structural indicators capturing the study design in each country should be included in the analysis. Alternatively, the minimum requirement would be to include dummy variables indicating the respective country.

6 Acknowledgements

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