Health, cognition and work capacity beyond the age of 50: International evidence on the extensive and intensive margins of work

Vincent VANDENBERGHE*

Abstract. *This article uses the Survey of Health, Ageing and Retirement in Europe (SHARE) to consider the soundness of recent reforms to raise the age of retirement. Findings indicate that physical health and cognitive performance deteriorate with age and have negative effects on the employment rate of the 50–54 age group. The impact of poor cognition is lower than that of ill health, and both have greater effects on employment than on hours. This being said, at most, health and cognitive decline explain 35 per cent of observed work reduction. This hints at a sizeable underused work capacity among elderly Europeans.*

Keywords: *ageing, health, cognition, work capacity, older worker, SHARE.*

1. Introduction

The increase in life expectancy is arguably the most remarkable by-product of economic growth and medical progress. Since the end of the nineteenth century, the populations of advanced economies have been gaining roughly 2.4 years of longevity every decade (Oeppen and Vaupel 2002). But this trend, in combination with lower fertility, translates into population ageing and has far-reaching economic and socio-political consequences. All other things being

* Institute of Economic and Social Research, Louvain Institute of Data Analysis and Modelling in Economics and Statistics (IRES-LIDAM), Université Catholique de Louvain (UCL), email: vincent.vandenberghe@uclouvain.be. The author would like to thank two anonymous reviewers for their thoughtful comments and efforts towards improving earlier versions of this article. This research received financial support from Action de Recherche Concertée (ARC) Research Project No. 18/23-088. The author also gratefully acknowledges the sources of funding for the collection of the Survey of Health, Ageing and Retirement in Europe (SHARE) data used in this article (for further details, see http://www.share-project.org/organisation/funding.html).

equal, population ageing will result in declining labour forces and rising old-age dependency. This may hurt economic growth and overall quality of life if it forces governments to divert public spending from education and infrastructure investment to fund obligations relating to the elderly.

In order to combat the contraction of the working-age population and the rise of old-age dependency, various factors could be adjusted and have been the subject of theoretical and empirical research (Acemoglu and Restrepo 2018; Acemoglu 2010; Vandenberghe, Waltenberg and Rigó 2013). These adjustments include increasing female participation in the labour force (at least in countries where it remains low), slightly increasing hours of work, bringing unemployment down and even reducing the length of initial education (Vandenberghe 2020). So far, however, the adjustment most commonly chosen by policymakers is that of raising the age of effective retirement. Researchers at the Organisation for Economic Co-operation and Development (OECD) have provided numerical evidence that indexing retirement age to (rising) life expectancy could stabilize old-age dependency ratios around their current levels, preventing dramatic tax increases in order to finance pay-as-you-go pensions or a general reduction of pension levels (Oliveira Martins et al. 2005). Indeed, stricter retirement policies implemented since the mid-1990s have proved effective in increasing employment rates (Atalay and Barrett 2015).

However, concerns are frequently raised over the fairness of such policies, given that some individuals may be too unhealthy or lack the cognitive skills to continue working productively for any longer until they can receive their pension. It is important, therefore, to investigate the extent to which ill health and/or poor cognition limit the ability of older people to work.

But estimating work capacity (or ability to work) and its evolution with age is not straightforward. The data from the Survey of Health, Ageing and Retirement in Europe (SHARE) used in this article confirm the existence of a negative relationship between age and health. Unsurprisingly, SHARE also indicates that when people get older they tend, on average, to work much less. But the correspondence between these two findings does not provide sufficient grounds to draw conclusions about the relationship between age and people's capacity to work. This is because paid work among elderly people is determined by many other factors other than health and cognition. One example is provided by pensions. When they grow older, workers become eligible for pension benefits and thus tend to stop supplying labour beyond certain eligibility thresholds.[1] Accordingly, this article seeks to estimate the extent to which health and/or cognition affect individuals' work capacity – a capacity that may remain significantly larger than suggested by elderly employment patterns. By focusing on health (and cognition), my intention is not to diminish the importance of other factors influencing employment at older ages, nor to draw conclusions about the extent to which people must supply labour – many individuals will prefer to retire, regardless of their health/cognitive performance, and many may not have the opportunity to work owing to a lack of demand for old-age labour (Vandenberghe

[1] Not so long ago, in many Member countries of the OECD, it was mandatory to retire at the age of 65 and sometimes even at the age of 60.

2013) – but rather to suggest how much work they could supply given their health and/or cognition conditions.

In order to estimate work capacity, this article builds on, and improves, an estimation strategy pioneered by Cutler, Meara and Richards-Shubik (2013). The “Cutler method”, as I will refer to it, comprises two stages. The first estimates the relationship between employment and health (controlling for other characteristics, such as education and sex) between the ages of 50 and 54. This age range is chosen in order to capture the relationship between health and employment in the absence of access to (early) retirement benefits; in other words, before workers become eligible for social security and other replacement benefits. In stage two, stage-one estimates are used to predict work capacity at older ages (55–70). The idea is to combine (i) the estimated effect of health (and other characteristics) on employment for those aged 50–54 with (ii) the actual health of those aged 55–70. This approach assumes that the relationship between health and employment will be the same for both groups but will generate declining estimates of work capacity with age, given that health declines with age.

The second stage in this method provides a counterfactual estimate, which is potentially very different to the actual work behaviour of elderly people. It considers the likely contribution of health to the evolution of individuals’ ability to work between the ages of 55 and 70. Contrary to most empirical work on ageing and on work at these ages, the priority here is not to come up with a list of regressors offering the most accurate description of the observed age/work profile. The latter is simply taken at face value in the raw data, providing a point of comparison to estimate the “unused” work capacity, indicated by the difference between the counterfactual estimate (the health-predicted work capacity) and the observed work of elderly individuals. The priority is to come up with the best possible description of people’s health in order to compute the most plausible counterfactual estimate. The reliability of results also depends heavily on the way in which the first stage of the method is conducted. Furthermore, the focus is not so much on maximizing the R^2 of the estimated model but rather on accounting for the various dimensions of health that are likely to impact employment and, what is more, minimize the risk of endogeneity. Coefficients estimated using ordinary least squares (OLS) regression can be biased if key variables (such as dimensions of health influencing employment) are omitted, if there are measurement errors and if a particular version of the selection problem, known as “justification” bias, is present (see Bound 1991). The latter is based on the idea that, in order to justify the fact that they do not work, non-working respondents exaggerate their degree of ill health compared to working respondents.

The rest of this article is organized as follows. The second section presents and discusses the existing literature on age and work capacity and the contributions made by this article. The third section presents the two-stage estimation of work capacity, the key identification problems and the way in which these are handled. The fourth section presents the SHARE microdata on work, health and cognition used in the article. The results are presented in detail in the fifth section and the sixth section summarizes the main findings and offers policy recommendations with a view to increasing elderly employment rates.

2. The relationship between age and work capacity

2.1. Literature review

This article is about work capacity and its evolution with age. It draws directly from Blundell et al. (2017) for its econometric methodology and from Wise (2017) for its international coverage. It contributes to the literature on ageing and work, in particular regarding the barriers to elderly employment, with a relative focus on the supply side of the labour market. I use the term "relative" because, when it comes to labour, my observations always concern the interaction of labour supply and demand. More precisely, the focus is on the role of declining health and/or cognition in limiting people's capacity to work. There are, of course, many other barriers to elderly employment but they will not be examined here, as they are not necessary in order to assess work capacity. Some such barriers originate on the demand side of the labour market – arising from some firms' reluctance to employ or recruit elderly workers, for instance – and have been studied by Hutchens (1986 and 2010), Dorn and Sousa-Poza (2010), Dostie (2011), Skirbekk (2004), van Ours and Stoeldraijer (2011), Vandenberghe, Waltenberg and Rigó (2013) and Delmez and Vandenberghe (2018). Other barriers concern the supply side of the labour market but should be distinguished from the health and cognition barriers studied here. Economists have documented the important role of (early) pension schemes and other welfare regimes in enticing individuals to leave the labour force early (Blöndal and Scarpetta 1999; Jousten et al. 2010). There is, for example, a large body of economic literature on joint retirement – that is, the propensity to coordinate retirement decisions – among dual-worker couples (see Michaud, Van Soest and Bissonnette 2020).

The general impression is that the work capacity of elderly people has improved over time. Using country-level data, Oeppen and Vaupel (2002) show that for 160 years "best-performance life expectancy"[2] has undergone a steady yearly increase of approximately three months. Other researchers, using the Global Burden of Disease Study,[3] show that disease rates[4] decreased over time and across all regions of the world between 1990 and 2017 (Chang et al. 2019). In the early 2010s, US economists Cutler, Ghosh and Landrum (2013) pointed to a compression of morbidity towards the end of life, which could explain why authors like Börsch-Supan (2014) challenge the claim that most workers' health is too poor to continue working until the age of 70. This article also seeks to test that claim by using individual-level international data to assess work capacity beyond the age of 50. In doing so, it adds to the existing literature on work capacity, which includes recent contributions by Jousten et al. (2010), Coile, Milligan and Wise (2016), Banks, Emmerson and Tetlow (2016) and, with a strong international dimension similar to that found here, the work coordinated by Wise (2017).

[2] The highest life expectancy observed in a given year.

[3] A worldwide observational epidemiological study led by the Institute for Health Metrics and Evaluation at the University of Washington. See https://www.thelancet.com/gbd.

[4] Age-standardized age-related rates.

In this article, as in the above-listed contributions, work capacity is defined as the expected level of work if ill health (and poor cognition) were the only determinants of older individuals' propensity to work. As stated above, I use Cutler's two-stage method in order to estimate work capacity. The alternative method (Milligan and Wise 2012; De Souza, Queiroz and Skirbekk 2019) was not chosen because it relies on a much less precise definition of health based on the mortality rate for people at a given age.

2.2. The contributions of this article to the literature on work capacity

Contrary to many existing studies using the Cutler method, this article has a strong international dimension, quantifying work capacity simultaneously for 20 countries. Also, compared to the aforementioned study by Wise (2017), it has the advantage of using SHARE data, which provide one single fully harmonized data set (Börsch-Supan et al. 2013).

The reliability of the Cutler method depends on the use of finely grained microdata, properly describing people's health and how it evolves with age. This is particularly important for the second stage of the method. In this regard, the SHARE data comprise a rich set of indicators of health and cognition that may have an impact on work capacity. This includes not only self-reported/subjective evaluations of respondents' physical health but also numerous and detailed doctor-diagnosed health conditions, such as diabetes, blood pressure problems and arthritis, and measurable conditions, such as difficulties with mobility and grip strength.

Another contribution of this article is that it considers not only physical health but also cognition, which is probably gaining ground through its role in enabling people to remain in paid employment, given the economy's reduced reliance on physical work. The SHARE data set is relatively rich in items like memory, mathematics and numeracy test scores, which can be used to compute a cognitive performance index. As far as I am aware, cognition has generally been absent from other academic contributions using the Cutler method and has received less attention in the broader economic literature on the determinants of elderly work. A notable exception is the work of Blundell et al. (2017) on the United Kingdom of Great Britain and Northern Ireland and the United States of America. Other authors have examined the relationship between cognition and earnings but not work (Anger and Heineck 2010). Cognition, as a dimension of ageing, has generated a large body of non-economic literature in the area of cognitive psychology (see Salthouse 2010) and related disciplines.

A further strength of this article is that it examines both the extensive (employment) and the intensive (duration of work) margins of work, whereas most of the existing literature considers only the decision to work and does not look at the relationship between ill health and/or poor cognition and the number of hours worked.[5]

[5] A relatively recent survey by the OECD and the EU (2016) only mentions Pelkowski and Berger (2004) and Moran, Farley Short and Hollenbeak (2011), both of which conclude that there is a negative impact on hours.

The Cutler method can be implemented relatively easily using simple econometrics. It has frequently been used in this way, including in international comparisons (Wise 2017), but its reliability depends heavily on the way in which its first stage is conducted. Most existing applications regress employment on self-reported health using OLS. This delivers a coefficient that then drives stage-two predictions for work capacity. However, Blundell et al. (2017) remind us that properly estimating the effect of health on work is a research programme in its own right. In particular, Bound (1991) raises the question of the magnitude of the "justification bias" relative to the traditional measurement error expected for self-reported health. To justify the fact that they do not work, non-working respondents may classify a given health problem as a more serious work limitation than would be reported by working respondents, creating an upward bias of the OLS-estimated coefficients. In this article, I try to address this problem by resorting to instrumental variables (IV) regression, using the more "objective" measures of health as instruments for subjective health.

3. Method

3.1. Overall presentation

The first stage of the Cutler method consists of estimating the relationship between health and/or cognition and the propensity to work. Existing papers define work as employment (*EMPL*), that is, the extensive margin of labour. This article also considers the intensive margin, or the number of hours worked (*HOURS*), plus what I call the "overall work" (*WORK*), which is the number of hours in the total target population, combining the extensive and intensive margins of labour.

Stage one involves only individuals who are still relatively young. I have opted for those between the ages of 50 and 54 for the reasons spelled out above (relatively high prevalence of health/cognition issues but limited risk of work decisions driven by the availability of (early) pension benefits). Algebraically, I regress – separately for each country i present in the SHARE data set – the various dimensions of work (*EMPL*, *HOURS* and *WORK*) on health and cognition.

$$Z_i^{50-54} = \beta_0^z + \beta_h^z HEALTH_i^{50-54} + \beta_c^z COGN_i^{50-54} + \gamma_i^z X_i^{50-54} + \varepsilon_i^z \quad (1)$$

where Z = *EMPL*, *HOURS*, *WORK*.

The econometric identification issues that are discussed in section 2.2 intervene at this stage. However, what matters for the moment is to note that the vector of coefficients $\widehat{\beta_0^z}$, $\widehat{\beta_h^z}$ and $\widehat{\beta_c^z}$ is retrieved from the estimation of equation (1). It should also be noted that the model contains controls X_i^{50-54} (that is, education, sex and time fixed effects delivering coefficient $\widehat{\gamma}$). At stage two, $\widehat{\beta_0^z}$, $\widehat{\beta_h^z}$ and $\widehat{\beta_c^z}$ are applied to the health, cognition and control variables characterizing individuals aged a = 50 ... , 70, tracking the evolution of health/cognition with age and indicating the respondents' expected work capacity.

$$\widehat{Z}_i^a = \widehat{\beta_0^z} + \widehat{\beta_h^z}\, HEALTH_i^a + \widehat{\beta_c^z}\, COGN_i^a \quad (2)$$

where Z = *EMPL*, *HOURS*, *WORK* and a = 50, ... , 55, … , 70.

The expected values in equation (2) can then be used to compute various synthetic indicators of work capacity decline in both absolute and relative terms.

I will focus on the cumulative impact over 20 years of age by comparing results for individuals aged 50 with those for individuals aged 70. To quantify the unused work capacity, I will compare the (average) predicted work capacity values with observed values. In the same vein, I will compute the percentage δ of the actual/observed work change between the ages of 50 and 70 that can be ascribed to work capacity (and thus health/cognition) decline.

$$\delta^{Z,\,50\text{–}70} = \frac{\hat{Z}^{70} - \hat{Z}^{50}}{Z^{70} - Z^{50}} \tag{3}$$

In this equation, δ can be computed as the ratio of two age-70 dummy coefficients (θ^{70}, π^{70}) calculated through the (respective) regression of predicted versus observed work on age dummies (50 being the reference age, corresponding to the intercepts).

$$\begin{aligned} \hat{Z}_i^a &= \theta^{50} + \theta^{51} AGE_i^{51} + \ldots + \theta^{70} AGE_i^{70} + \nu_i^z \\ Z_i^a &= \pi^{50} + \pi^{51} AGE_i^{51} + \ldots + \pi^{70} AGE_i^{70} + \mu_i^z \end{aligned} \tag{4}$$

where $AGE_i^{51} = 1$ if $a = 51$, 0 otherwise; $AGE_i^{70} = 1$ if $a = 70$, 0 otherwise; and $Z = EMPL, HOURS, WORK$.

$$\delta^{Z,\,50\text{–}70} = \frac{\hat{\theta}^{70}}{\hat{\pi}^{70}} \tag{5}$$

3.2. Properly identifying the health/cognition–work relationship

The estimation of the relationship between health/cognition and work among respondents aged 50–54 is of key importance in the above methodology. Blundell et al. (2017) provide an excellent review of possible biases. Here, I will focus on those affecting commonly used OLS estimates based on subjective health responses.

The broader literature on health and work (see Baker, Stabile and Deri 2004) interprets subjective measures as "noisy" measures of a latent (unobserved) health stock *H*.[6] If *HEALTH* in equation (1) represents the subjective health index constructed using the subjective/self-reported health items,[7] it can deviate from the actual health stock.

$$HEALTH_i = H_i + \tau_i \tag{6}$$

And the deviation term τ_i amounts to a (randomly distributed) reporting/measurement error causing attenuation bias. The term $VAR(\tau)$ in the denominator equation (7) captures the attenuation bias, with "noise" (in other words, larger $VAR(\tau)$) pushing the OLS-estimated β^Z towards zero.

$$\beta^Z = \frac{\tilde{\beta}^Z VAR(H)}{VAR(H) + VAR(\tau)} \tag{7}$$

But it is unlikely that τ_i amounts to just "noise". In that case, equation (7) becomes

$$\beta^Z = \frac{\tilde{\beta}^Z VAR(H) + COV(\varepsilon, \tau)}{VAR(H) + VAR(\tau)} \tag{8}$$

6 This stock can be considered as the "true" measure of the health influencing work.

7 See the last column of table 2.

and $COV(\varepsilon, \tau)$ on the numerator – where ε is the residual of the stage-one equation (1) – is different from zero. What is more, it is likely that $COV(\varepsilon, \tau) > 0$ is due to respondents' justification bias (Baker, Stabile and Deri 2004). This happens when they report values of *HEALTH* (and thus of τ) that are driven by their labour market status, whereby unemployed individuals report lower levels of health to justify their absence from employment. As equation (8) indicates, this potentially translates into an OLS-estimated β^Z that is larger than the coefficient of interest $\tilde{\beta}^Z$.

So far, the literature remains inconclusive about the relative importance of these two biases. O'Donnell, Van Doorslaer and Van Ourti (2015) suggest that the justification bias dominates, resulting in an upward-biased β^Z. However, Stern (1989) and Dwyer and Mitchell (1999) do not find that the justification bias prevails. My approach, hereafter, will be to use IV to deliver what will be my preferred econometric model. There are many potential instruments to choose from on the basis of the physical/dexterity tests implemented by the SHARE investigators (table 3).[8] It is straightforward to show that any subset of the "objective" health measures can be used to produce unbiased estimates of $\tilde{\beta}^Z$. The IV stage one consists of regressing the subjective health index (*HEALTH*) on the objective index (H^O) and is given by

$$\hat{\eta} = \frac{COV(HEALTH, H^O)}{VAR(H^O)} \tag{9}$$

where $HEALTH = H + \tau$.

If – as should be the case for any good instrument – $COV(H^O, \tau) = 0$, and assuming standardized variances, this stage-one coefficient is equivalent to

$$\hat{\eta} = \frac{COV(H, H^O)}{VAR(H)} \tag{10}$$

In stage two, labour market outcome Z is regressed on the value predicted by $\hat{\eta}H^O$.

$$\begin{aligned} \hat{\beta}^{Z,IV} &= \frac{COV(Z, \hat{\eta}H^O)}{\hat{\eta}^2 VAR(H^O)} \\ \hat{\beta}^{Z,IV} &= \tilde{\beta}^Z \frac{COV(H, H^O)}{\hat{\eta}\, VAR(H)} = \tilde{\beta}^Z \end{aligned} \tag{11}$$

4. Data

This article uses Waves 1, 2 and 4 to 7 of the SHARE survey,[9] providing a total of 303,985 observations (table 1). All SHARE respondents are 50 years old or older when interviewed for the first time. On account of various data limitations (miss-

8 All "objective" health measures have residual subjective or endogenous elements ("has a doctor ever told *you* that you had … diabetes?" (SHARE questionnaire); limitations are *not* measured by the interviewer but reported by the interviewee; grip strength is measured by the interviewer but requires the cooperation of the interviewee). In this light, using the measurements available in SHARE (table 3) should not be seen as the perfect way of addressing the problem of measurement error and justification bias.

9 Wave 3 contains life histories only, and is of no use here.

Table 1. Observations by country and wave

Country	Wave						Total
	1	2	4	5	6	7	
Austria	1 522	1 181	5 096	4 303	3 362	3 187	**18 651**
Belgium	3 637	3 147	5 194	5 546	5 716	4 853	**28 093**
Croatia	—	—	—	—	2 447	2 379	**4 826**
Czechia	—	2 669	5 392	5 541	4 801	4 192	**22 595**
Denmark	1 614	2 551	2 236	4 064	3 668	3 216	**17 349**
Estonia	—	—	6 757	5 699	5 559	5 070	**23 085**
France	2 965	2 900	5 666	4 432	3 887	3 298	**23 148**
Germany	2 926	2 585	1 610	5 616	4 354	3 797	**20 888**
Greece	2 666	3 236	—	—	4 821	3 039	**13 762**
Hungary	—	—	2 999	—	—	1 531	**4 530**
Ireland	—	1 007	—	—	—	—	**1 007**
Israel	2 296	2 389	—	2 567	2 015	2 122	**11 389**
Italy	2 505	2 929	3 507	4 664	5 219	4 529	**23 353**
Luxembourg	—	—	—	1 591	1 548	1 240	**4 379**
Poland	—	2 429	1 721	—	1 807	4 651	**10 608**
Portugal	—	—	1 962	—	1 665	487	**4 114**
Slovenia	—	—	2 708	2 924	4 197	3 681	**13 510**
Spain	2 276	2 375	3 663	6 579	5 569	4 676	**25 138**
Sweden	2 996	2 765	1 963	4 516	3 884	3 183	**19 307**
Switzerland	952	1 460	3 680	3 000	2 775	2 386	**14 253**
Total	**26 355**	**33 623**	**54 154**	**61 042**	**67 294**	**61 517**	**303 985**
N				303 985			

Notes: Observations indicated for waves 1 (2004), 2 (2007), 4 (2011), 5 (2013), 6 (2015) and 7 (2017). Wave 3 (2009) contains life histories only and is not used here.
Source: SHARE 2004–17.

ing values, absence of repeated observations where the country participated in only one wave), 20 of the 29 participating countries (Austria, Belgium, Croatia, Czechia, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Poland, Portugal, Slovenia, Spain, Sweden and Switzerland) are used in the analysis. SHARE contains a rich set of items describing not only people's work (employment status and hours of work if employed) but also their health status and their cognitive performance. I split health variables into two broad categories: "subjective" (table 2) and "objective" (table 3). As indicated in table 2, most items in the SHARE data set are self-reported or subjective but many also refer explicitly to conditions diagnosed by health professionals (heart attack, hypertension, cholesterol, stroke, diabetes, lung disease, cancer) or measured by the SHARE interviewers, such as mobility restrictions and the maximum grip strength of respondents (see last two columns of table 3). Items used to assess cognitive performance are reported in table 4. They consist of memory or numeracy/mathematics test scores.

Hereafter, I will make extensive use of subjective health and cognition indices. These are computed as the first principal components of items listed in

Table 2. Subjective physical health (all ages pooled)

Country	General ill health	Self-perceived ill health (US scale)	Long-term illness	Limited in activities	Number of limitations (daily living)	Number of limitations (instrumental)	Subjective health index
Austria	3.02	3.02	3.01	2.35	0.25	0.50	–0.09
Belgium	3.01	3.01	3.08	2.36	0.30	0.51	–0.10
Croatia	3.34	3.34	2.61	2.29	0.25	0.48	0.11
Czechia	3.36	3.36	2.78	2.25	0.26	0.47	0.12
Denmark	2.57	2.57	2.94	2.51	0.17	0.34	–0.39
Estonia	3.87	3.87	2.07	2.11	0.36	0.63	0.51
France	3.22	3.22	3.11	2.39	0.25	0.43	–0.03
Germany	3.26	3.26	2.53	2.29	0.24	0.35	0.06
Greece	2.99	2.99	3.57	2.64	0.17	0.46	–0.27
Hungary	3.67	3.67	2.28	2.25	0.28	0.63	0.33
Ireland	2.56	2.56	3.46	2.62	0.22	0.33	–0.47
Israel	3.21	3.21	2.78	2.39	0.45	0.98	0.11
Italy	3.27	3.27	3.35	2.44	0.28	0.50	–0.04
Luxembourg	3.08	3.08	3.05	2.36	0.22	0.40	–0.09
Poland	3.69	3.69	2.33	2.18	0.40	0.63	0.38
Portugal	3.73	3.73	2.85	2.24	0.44	0.63	0.34
Slovenia	3.34	3.34	2.99	2.33	0.25	0.49	0.06
Spain	3.38	3.38	2.96	2.51	0.39	0.73	0.09
Sweden	2.78	2.78	2.83	2.43	0.18	0.32	–0.25
Switzerland	2.71	2.71	3.58	2.58	0.10	0.19	–0.44

Notes: General ill health (European scale) = 1 (good)–5 (bad); self-perceived ill health (US scale) = 1 (good)–5 (bad); long-term illness = yes (1) no (0); limited in activities = 3 (no)–1 (severely); number of limitations with daily living activities = 0–6 scale; number of limitations with instrumental daily living activities = 0–9 scale. The subjective ill health index takes the first principal component of each variable (the higher it is, the worse the perceived health). Principal component analysis is conducted with all countries pooled. Displayed values correspond to the predicted score values divided by standard deviation.

Source: SHARE 2004–17.

tables 2 and 4, respectively. The IV estimation uses “objective” items listed in table 3 to instrument the subjective health index that appears in the last column of table 2.

5. Results

5.1. The evolution of ill health and poor cognition with age

Descriptive statistics drawn from the SHARE data set show that subjective physical health steadily deteriorates with age across all European countries (figure 1). The same holds for cognitive performance (figure 2). This is confirmed by a simple econometric analysis aimed at capturing the impact of an additional year of age on ill health and poor cognition, as seen in figure 3. The reported results are point estimates, calculated separately for each age band of five years for individuals aged 50 to 80. All countries are pooled, but the regression equations contain country and sex interacted with education fixed effects. A coefficient

Table 3. Objective health (all ages pooled): Doctor-diagnosed conditions or surveyor measurement

	Heart attack	Hyper-tension	Choles-terol	Stroke	Diabetes	Lung disease	Cancer	Ulcer	Parkinson	Cataract	Hip fracture	Other fractures	Alzheimer, senility	Arthritis	Mobility limitations	Max. strength grip
Austria	0.11	0.41	0.22	0.05	0.12	0.06	0.04	0.04	0.01	0.09	0.02	0.24	0.18	0.07	1.47	33.96
Belgium	0.10	0.34	0.31	0.03	0.11	0.06	0.05	0.06	0.01	0.07	0.02	0.21	0.15	0.05	1.50	34.48
Croatia	0.13	0.47	0.21	0.05	0.13	0.04	0.06	0.05	0.01	0.07	0.02	0.22	0.17	0.06	1.98	34.38
Czechia	0.13	0.50	0.25	0.05	0.18	0.07	0.05	0.05	0.01	0.10	0.02	0.18	0.17	0.07	1.56	33.99
Denmark	0.09	0.34	0.23	0.03	0.08	0.07	0.05	0.03	0.01	0.08	0.01	0.27	0.17	0.04	0.95	36.53
Estonia	0.19	0.49	0.20	0.05	0.13	0.07	0.05	0.08	0.01	0.10	0.02	0.19	0.15	0.08	2.02	33.00
France	0.13	0.32	0.24	0.03	0.11	0.06	0.05	0.03	0.01	0.07	0.02	0.23	0.13	0.04	1.42	32.70
Germany	0.11	0.43	0.20	0.04	0.13	0.07	0.07	0.03	0.01	0.09	0.02	0.21	0.18	0.07	1.34	35.83
Greece	0.11	0.41	0.30	0.02	0.12	0.05	0.02	0.07	0.01	0.07	0.02	0.26	0.11	0.02	1.65	32.21
Hungary	0.18	0.55	0.20	0.06	0.18	0.06	0.05	0.08	0.01	0.05	0.03	0.17	0.15	0.07	2.16	31.95
Ireland	0.08	0.30	0.28	0.04	0.09	0.03	0.04	0.07	0.01	0.04	0.03	0.28	0.08	0.02	1.20	33.63
Israel	0.15	0.43	0.37	0.04	0.23	0.04	0.05	0.05	0.01	0.12	0.02	0.25	0.15	0.05	1.45	29.19
Italy	0.09	0.41	0.23	0.02	0.12	0.05	0.03	0.03	0.00	0.06	0.01	0.27	0.13	0.03	1.40	32.37
Luxembourg	0.09	0.34	0.33	0.02	0.12	0.07	0.07	0.06	0.01	0.10	0.02	0.19	0.13	0.14	1.33	34.44
Poland	0.18	0.46	0.23	0.04	0.14	0.06	0.04	0.06	0.01	0.07	0.01	0.18	0.21	0.07	2.13	33.28
Portugal	0.11	0.46	0.41	0.04	0.19	0.06	0.06	0.08	0.01	0.09	0.02	0.15	0.17	0.06	2.10	29.61
Slovenia	0.12	0.46	0.25	0.04	0.13	0.05	0.05	0.06	0.00	0.08	0.02	0.23	0.15	0.07	1.78	34.02
Spain	0.10	0.39	0.28	0.02	0.16	0.06	0.04	0.03	0.01	0.08	0.02	0.21	0.20	0.05	1.61	28.98
Sweden	0.12	0.38	0.16	0.04	0.10	0.04	0.06	0.02	0.01	0.11	0.03	0.26	0.19	0.04	1.03	34.95
Switzerland	0.07	0.30	0.15	0.02	0.07	0.04	0.05	0.01	0.00	0.08	0.01	0.34	0.13	0.04	0.79	34.42

Notes: Mobility limitations = number of limitations (measured by interviewer). Max. strength grip = 0–100 (measured by interviewer).
Source: SHARE 2004–17.

Table 4. Cognition (all ages pooled)

Country	Orientation	Memory 1	Memory 2	Verbal fluency	Numeracy	Cognition index
Austria	3.80	5.44	4.11	22.47	3.69	–0.36
Belgium	3.77	5.20	3.70	20.25	3.36	–0.09
Croatia	3.84	5.29	3.60	19.08	3.30	–0.06
Czechia	3.76	5.27	3.56	21.24	3.47	–0.14
Denmark	3.79	5.62	4.36	22.92	3.60	–0.42
Estonia	3.77	5.23	3.66	21.67	3.23	–0.11
France	3.73	4.85	3.49	19.02	3.14	0.11
Germany	3.83	5.52	3.97	21.35	3.62	–0.31
Greece	3.83	4.96	3.44	14.04	3.35	0.19
Hungary	3.73	5.14	3.59	17.12	3.35	0.06
Ireland	3.76	5.30	4.14	15.86	3.39	–0.02
Israel	3.64	4.68	3.22	17.86	3.32	0.20
Italy	3.77	4.59	3.11	14.91	2.98	0.38
Luxembourg	3.79	5.33	4.29	18.06	3.42	–0.15
Poland	3.77	4.40	2.90	16.14	2.99	0.40
Portugal	3.75	4.35	3.11	14.35	2.72	0.51
Slovenia	3.79	4.94	3.22	21.43	3.16	0.02
Spain	3.55	3.97	2.62	15.17	2.53	0.72
Sweden	3.83	5.33	4.10	22.92	3.63	–0.35
Switzerland	3.88	5.57	4.33	20.56	3.81	–0.40

Notes: Orientation – score in time test (0 = bad; 4 = good); Memory 1 – score in first word list learning test (1–10 words); Memory 2 – score in second word list learning test (1–10 words); Verbal fluency – score in test (0–100); Numeracy – score in first test (0 = bad; 5 = good); Cognitive health index – first principal component of all previous cognition items (the higher the figure, the worse the cognitive performance). Principal component analysis is carried out with all countries pooled. Displayed values correspond to the predicted score values divided by standard deviation.

Source: SHARE 2004–17.

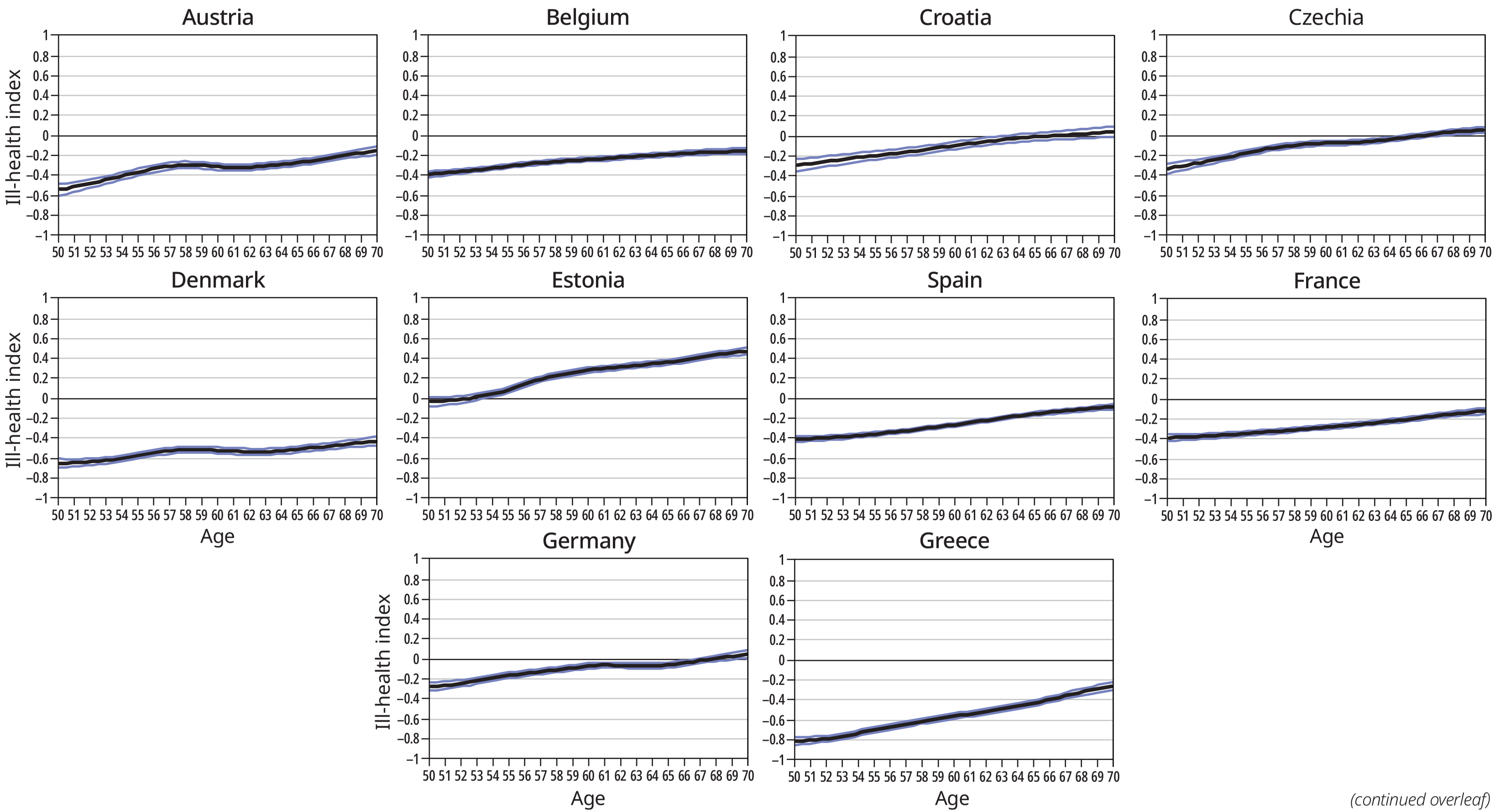
of 0.05 means that an additional year of age leads to a rise of 5 per cent of 1 standard deviation of the health and cognition indices. Figure 3 shows that the impact of an additional year is always synonymous with a decline in health. The 50–54 age band seems to experience a greater deterioration per additional year of age than the 60–64 age band but beyond 70, the deterioration accelerates unambiguously. As to cognition, there seems to be no impact of ageing on performance in the 50–54 age band but then a steady deterioration from 55 onward, clearly correlated with age.

5.2. Assessing the impact of health/cognition on work beyond the age of 54

5.2.1. Stage-one results

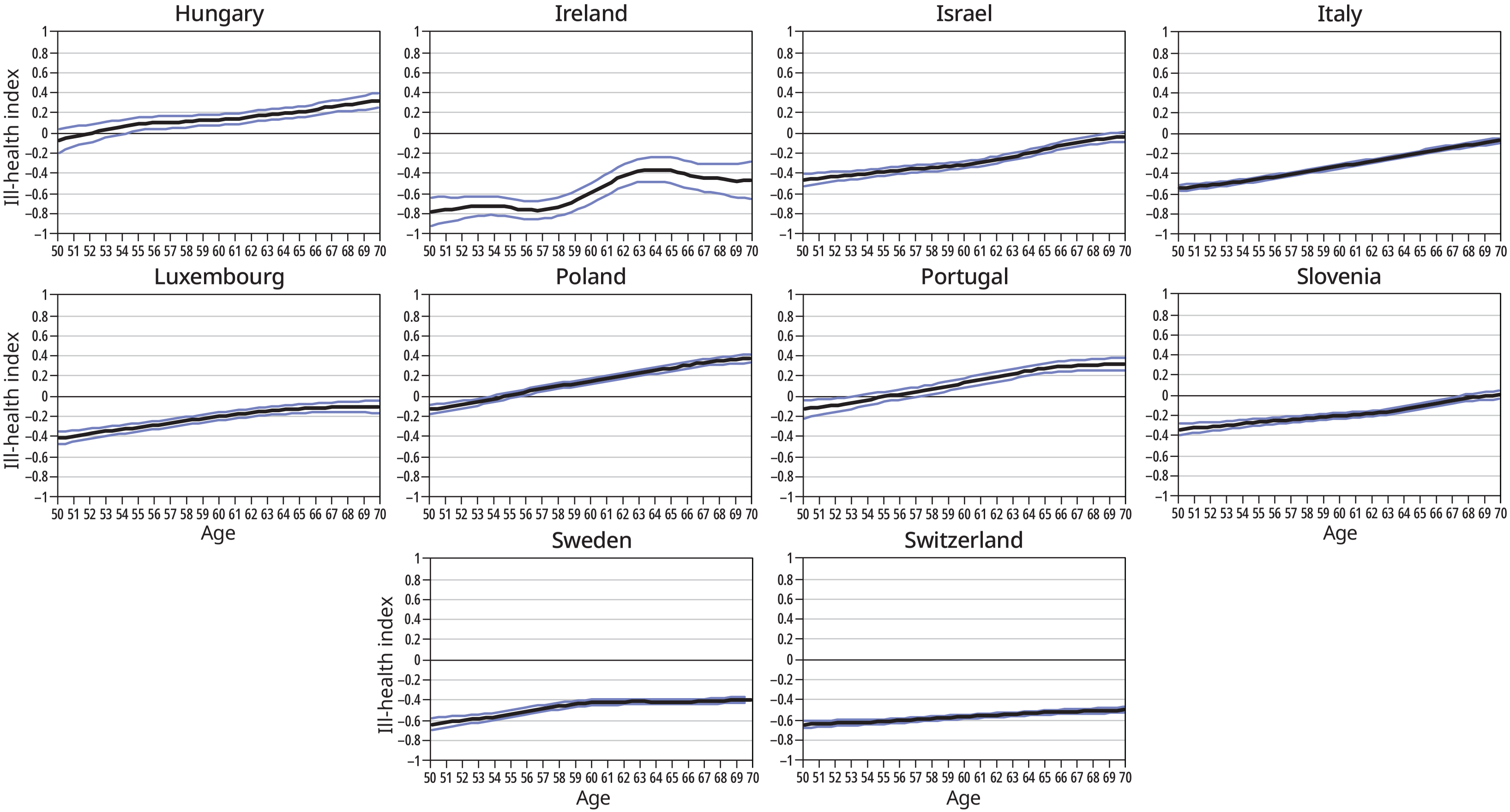
This section focuses on the likely impact of ill health and/or cognition on the work capacity of individuals aged 55–70, which is the central question addressed by this article. Table 5 contains stage-one results obtained using the preferred IV model, where subjective health is instrumented by "objective" health items

Figure 1. Age/ill-health index profiles for respondents aged 50–70



(continued overleaf)

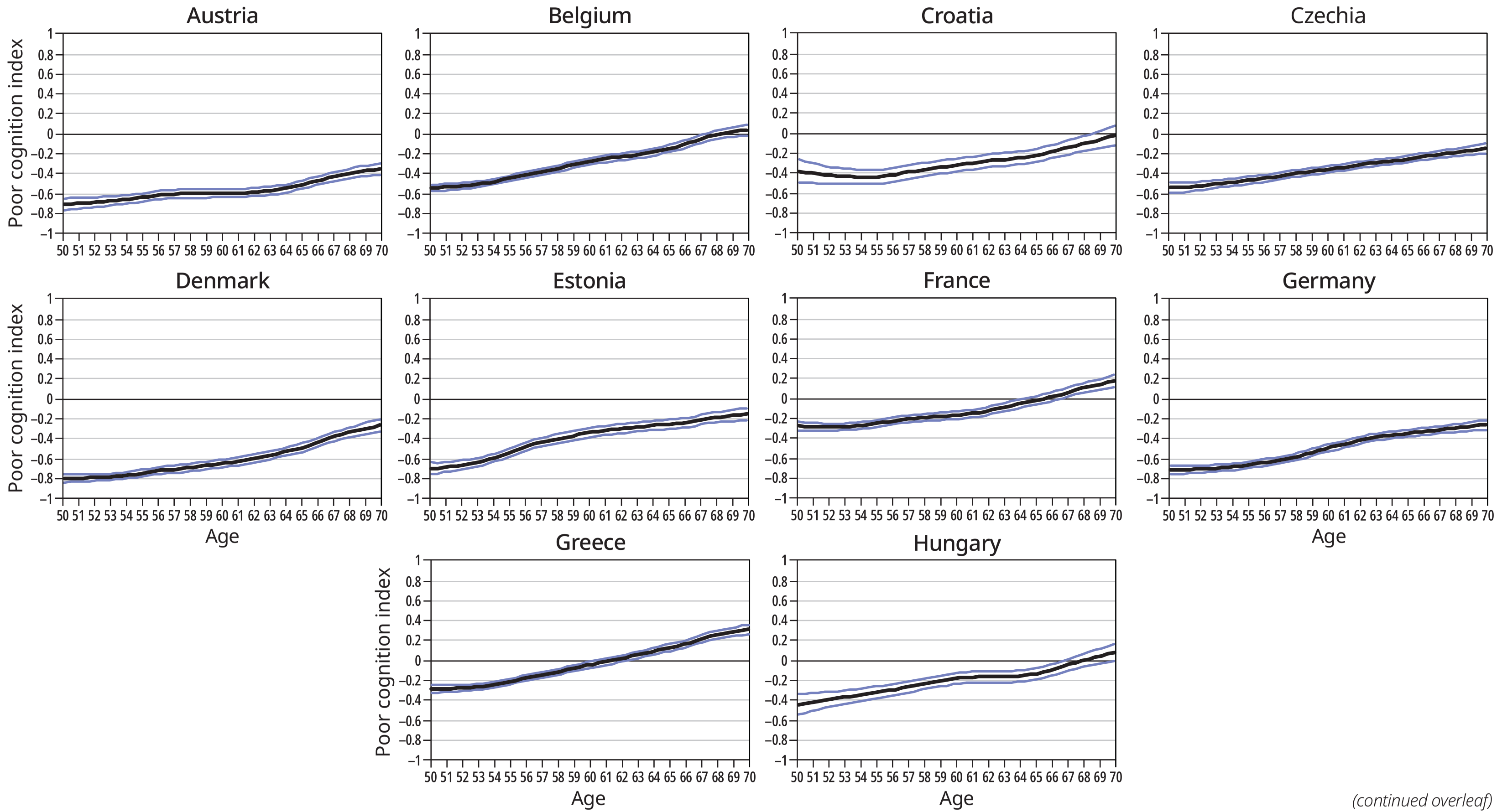
Figure 1. Age/ill-health index profiles for respondents aged 50–70 *(concl.)*



Note: The ill-health index displayed here is the first principal component from a list of subjective health variables described in table 2. Plotted values are the result of a kernel-weighted local polynomial regression of the health index on age.

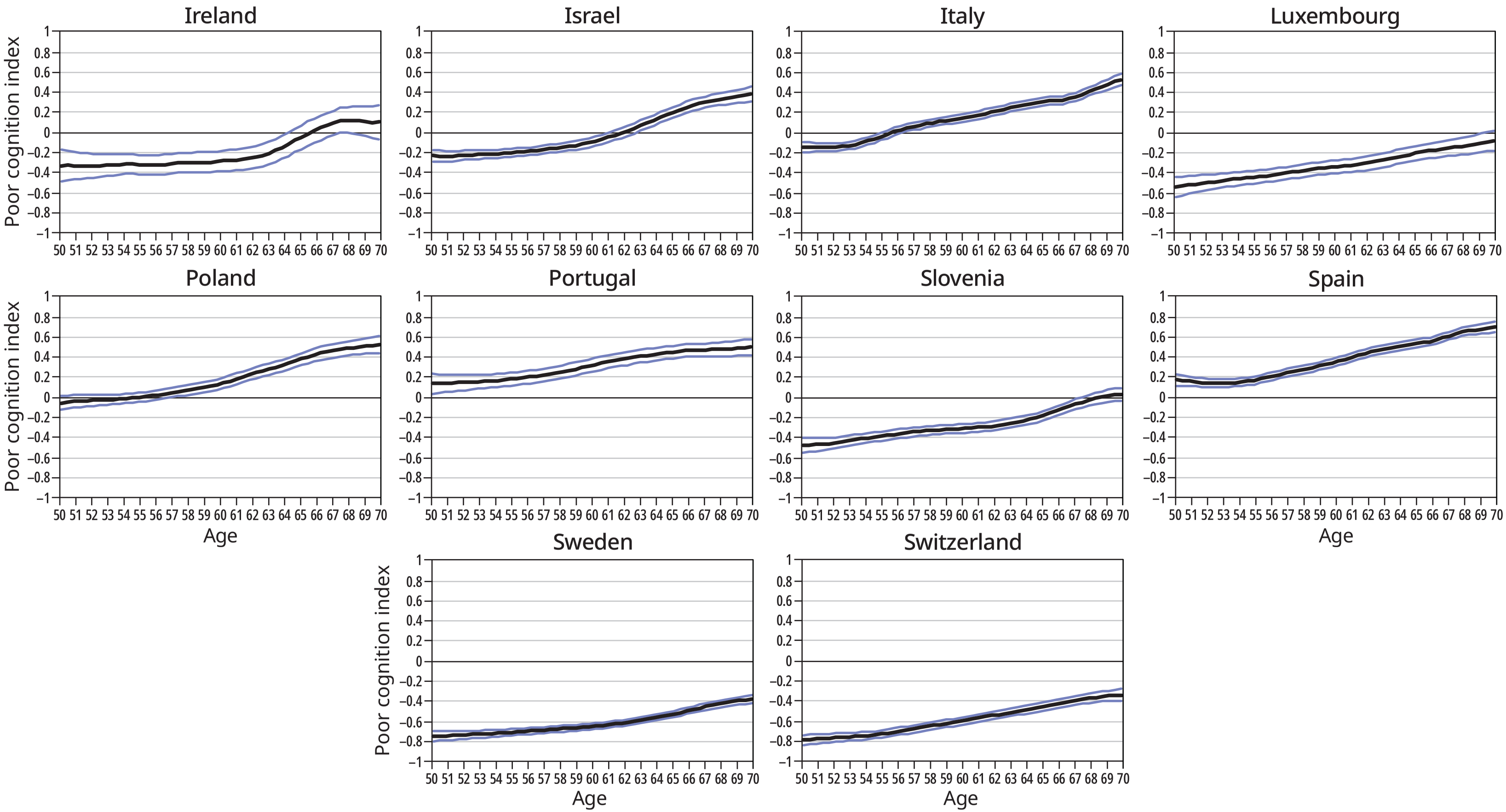
Source: SHARE 2004–17.

Figure 2. Age/poor cognition index profiles for respondents aged 50–70



(continued overleaf)

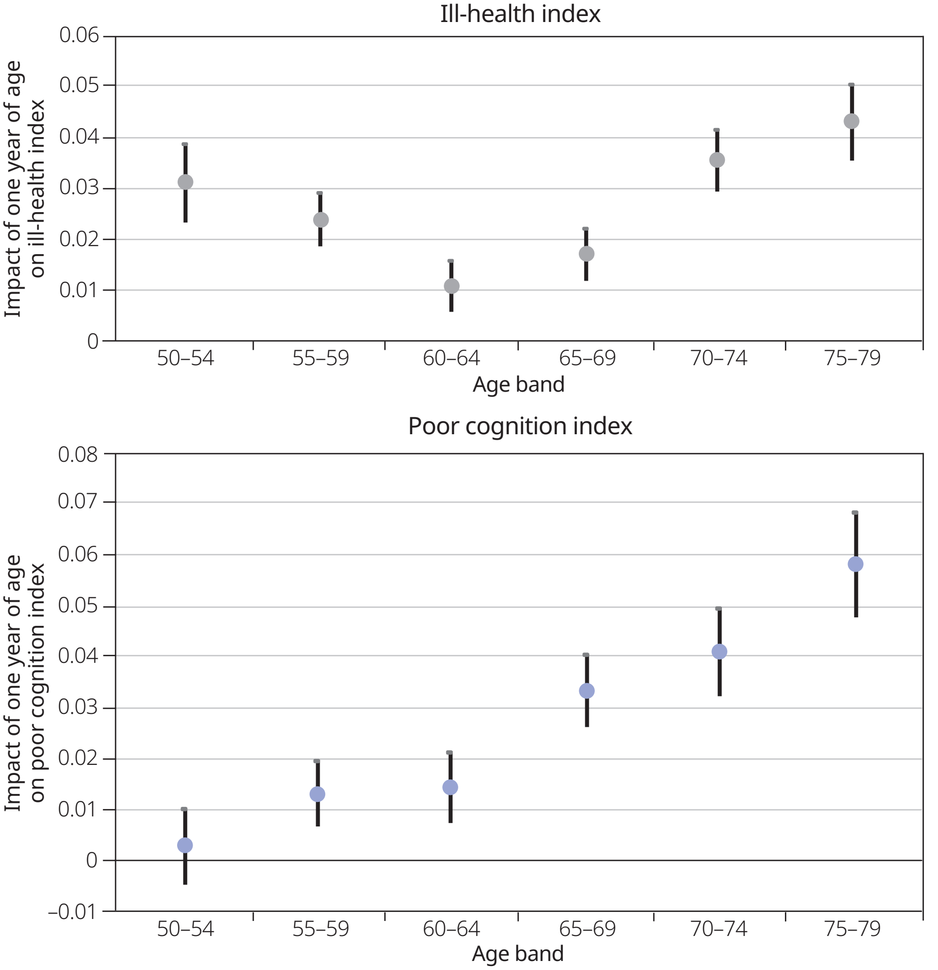
Figure 2. Age/poor cognition index profiles for respondents aged 50–70 *(concl.)*



Note: The poor cognition index displayed here is the first principal component from a list of cognitive performance items described in table 4. Plotted values are the result of a kernel-weighted local polynomial regression of the cognition index on age.

Source: SHARE 2004–17.

Figure 3. Marginal impact of ageing on ill health or poor cognition



Notes: The plotted dots are estimated coefficients. They capture the impact of one extra year of age (within each age band displayed on the x-axis) as a fraction of 1 standard deviation of the ill-health or poor cognition indices. Vertical bars represent 95 per cent confidence intervals. All countries are pooled but the regression equations contain educational attainment fixed effects interacted with sex and country.

Source: SHARE 2004–17.

listed in table 3.[10] Those obtained using OLS are reported in table A1 in the Appendix. The upper part of table 5 (panel A) reports the impact of ill health on the work of individuals aged 50–54. The first line (β_h^{WORK}) shows the sizeable negative effect of ill health on overall work (*WORK*), that is, the total number of hours worked in the population aged 50–54. All countries display a statistically significant negative coefficient. In the case of Sweden, a value of –8.95 means that a 1 standard deviation rise in the ill-health index leads to a reduction of almost

[10] It should be noted that only health is instrumented. It is assumed that, since the cognition index assembles test scores administered by interviewers, it is much less exposed to endogeneity problems.

Table 5. Stage-one results [IV]: Impact of ill health and poor cognition on the work of respondents aged 50–54

	Austria	Belgium	Croatia	Czechia	Denmark	Estonia	France	Germany	Greece	Hungary
	A. Ill-health index									
β_h^{WORK}	–10.41***	–7.96***	–8.85***	–12.22***	–9.84***	–9.30***	–6.27***	–8.70***	–4.24**	–11.44***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.000)
β_h^{EMPL}	–0.28***	–0.20***	–0.22***	–0.29***	–0.23***	–0.23***	–0.18***	–0.21***	–0.10***	–0.30***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
β_h^{HOURS}	–0.02	–1.81*	–2.42**	–1.02	–2.02	–0.83	–0.80	–0.58	–0.84	–0.90
	(0.995)	(0.024)	(0.003)	(0.680)	(0.050)	(0.285)	(0.205)	(0.507)	(0.621)	(0.286)
	B. Poor cognition index									
β_c^{WORK}	–3.34*	–1.57**	1.53	0.03	–1.00	–1.82	–3.07***	–0.07	0.39	–1.15
	(0.014)	(0.002)	(0.128)	(0.984)	(0.408)	(0.125)	(0.000)	(0.917)	(0.722)	(0.600)
β_c^{EMPL}	–0.05	–0.06***	0.06*	–0.00	–0.05	–0.03	–0.04**	–0.04***	–0.01	–0.05***
	(0.174)	(0.000)	(0.014)	(0.873)	(0.053)	(0.223)	(0.002)	(0.000)	(0.811)	(0.000)
β_c^{HOURS}	–2.54**	0.40	–0.25	–0.19	–0.70	–0.04	–2.15*	1.25*	0.65	1.65
	(0.008)	(0.271)	(0.776)	(0.850)	(0.209)	(0.909)	(0.015)	(0.037)	(0.631)	(0.334)
N	18373	27750	4822	22209	17206	22369	22644	20680	13710	4523

	Ireland	Israel	Italy	Luxembourg	Poland	Portugal	Slovenia	Spain	Sweden	Switzerland
	A. Ill-health index									
β_h^{WORK}	–6.76**	–9.00***	–5.47***	–6.26	–11.72***	–6.23***	–8.95***	–8.83***	–8.95***	–4.46***
	(0.003)	(0.000)	(0.000)	(0.065)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h^{EMPL}	–0.19*	–0.23***	–0.12***	–0.12	–0.24***	–0.23***	–0.17***	–0.18***	–0.18***	–0.14**
	(0.028)	(0.000)	(0.000)	(0.190)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
β_h^{HOURS}	–7.55	0.71	–2.91***	–2.22	0.23	–3.23	–3.53**	–3.24	–2.15*	1.20
	(0.093)	(0.581)	(0.000)	(0.435)	(0.934)	(0.585)	(0.009)	(0.106)	(0.012)	(0.425)
	B. Poor cognition index									
β_c^{WORK}	–2.57	–1.26	–3.99***	0.65	–0.75	0.24	–1.56	–4.15***	0.50	–2.10***
	(0.398)	(0.556)	(0.000)	(0.630)	(0.478)	(0.904)	(0.239)	(0.000)	(0.105)	(0.001)
β_c^{EMPL}	0.08	–0.03	–0.09***	0.01	–0.04	0.02	–0.03	–0.10***	0.02	–0.03
	(0.175)	(0.455)	(0.000)	(0.799)	(0.103)	(0.810)	(0.150)	(0.000)	(0.242)	(0.161)
β_c^{HOURS}	–6.87**	–1.59	–2.37**	0.85	0.65	2.03	–0.23	–0.84*	0.04	–0.33
	(0.001)	(0.491)	(0.006)	(0.582)	(0.397)	(0.611)	(0.822)	(0.039)	(0.950)	(0.653)
N	1003	10880	23137	4372	10265	4010	13478	24474	18772	13966

*, ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels, respectively.

Notes: Results are point estimates β_h^Z and β_c^Z of the effect of a 1 standard deviation increment of the index on work, employment and hours. *p*-values are indicated between parentheses. Underlying standard errors have been bootstrapped (100 iterations). Physical/subjective health index instrumented by objective variables in table 3. Overall work (*WORK*) is understood as the combination of hours (*HOURS*) and employment (*EMPL*).

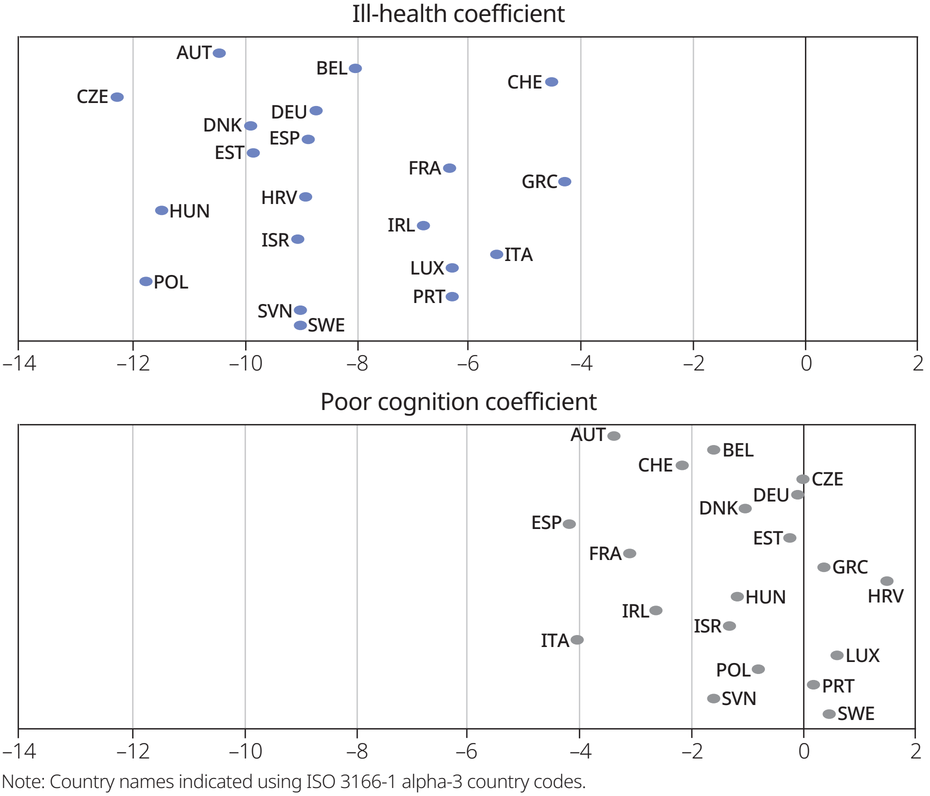
Source: Author's calculations based on SHARE (2004–17) data.

9 hours in the average number of hours worked in the population aged 50–54. The next line (β_h^{EMPL}) captures the impact of a 1 standard deviation rise on the employment rate (*EMPL*). All coefficients are negative, statistically significant and large in magnitude. Again, in the case of Sweden, a 1 standard deviation rise in the value of the ill-health index is associated with a fall of 18 percentage points in the employment rate. The last line (β_h^{HOURS}) reports the results for the

intensive margin. They are all negative but most of them are not statistically significant. This contrasts with the results obtained for *EMPL* and suggests that the extensive margin (that is, the move out of employment) is the main adjustment variable used when it comes to dealing with ill health.

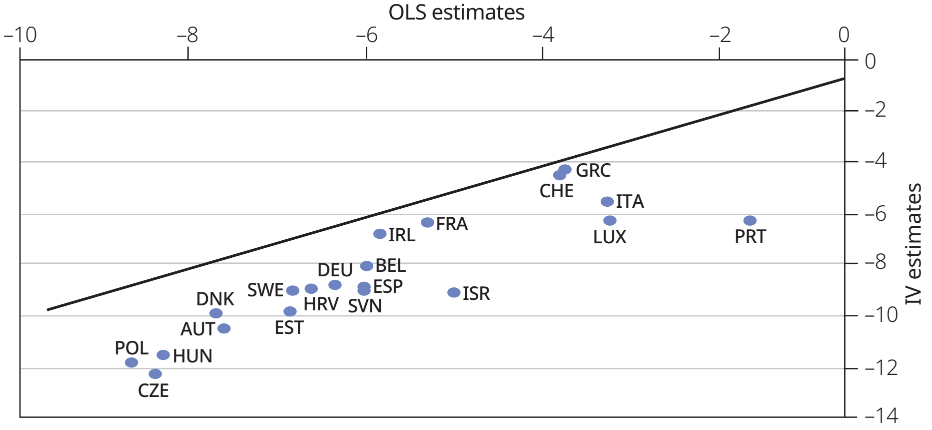
The lower part of table 5 (panel B) presents the results for cognition. It is clear to see that the association between poor cognition and work among individuals aged 50–54 is weaker, whatever the dimension of work considered. This is even more visible in figure 4, which plots ill health and poor cognition estimates (β_h^{WORK}) and (β_c^{WORK}). In many countries, the effect of poor cognition on overall work at the age of 50–54 is not statistically significant, and this contrasts with the effects of ill health. The tentative conclusion is that ill health plays a much greater role in determining individuals' participation in work than poor cognition. A nuance, however, is that SHARE is perhaps weaker at measuring cognition than health, or at least the components of cognition that matter for employment at the ages of 50–54. It could be argued that the items listed in table 4 point to problems emerging only at a relatively advanced age. At the same time, figure 3 shows that SHARE cognition items capture performance changes that intervene much earlier. Already for the 55–59 age band, the marginal impact of ageing on the cognition index is positive and statistically significant.

Figure 4. Comparison of the impacts of ill health (β_h^{WORK}) and poor cognition (β_c^{WORK}) on overall work for respondents aged 50–54



Note: Country names indicated using ISO 3166-1 alpha-3 country codes.
Source: Author's calculations based on SHARE (2004–17) data.

Figure 5. Comparison of the IV- and OLS-estimated impact of ill health on overall work (β^{WORK}) for respondents aged 50–54



Note: Country names indicated using ISO 3166-1 alpha-3 country codes.
Source: Author's calculations based on SHARE (2004–17) data.

Before turning to the stage-two results, it is worth stressing that the stage-one correction for endogeneity seems to matter. A comparison of IV and OLS estimates for ill health (figure 5) suggests that OLS leads to an underestimation of the negative impact of ill health on work among those aged 50–54. In the case of Sweden, there is a reduction of overall work (*WORK*) of 8.95 hours when using IV. That reduction is of only 6.78 hours when using OLS. The other countries display similar differences when comparing the two estimation methods. This tentatively suggests the absence of a strong justification bias. The above results are supportive of measurement-error problems inherent in the absence of a proper measure of the overall "stock" of health that is synonymous with attenuation bias. Table A2 in the Appendix reports the detailed outcome of the comparison of the predicted decline in overall work (*WORK*) using OLS and IV. Table A3 presents the results of the tests for weak instruments or under-identification. For all countries, I reject the null or no statistically significant relationship between the subjective health index and the objective health measures. This demonstrates that the "objective" health measures are strong predictors of the subjective health index. Lastly, table A4 in the Appendix presents the results of the comparison between two specifications of the IV model: one with ill health only, and one with ill health and poor cognition. This finds no strong evidence in support of the richer specification including cognition. In the richer model, the coefficients for the health index barely deviate from the coefficients in the simpler model.

5.2.2. Stage-two results

Table 6 displays the stage-two results. They are based on stage-one coefficients obtained with IV (table 5). They consist mostly of predictions of what work capacity among individuals aged 70 should be were health and cognition the only determinants. They are calculated in deviation from the work capacity of individuals aged 50. Panel A indicates that, in the case of Sweden, the employment rate

Table 6. Stage-two results: Work reduction among 70-year-olds (ref. 50-year-olds) explained by ill health and/or poor cognition

	Austria	Belgium	Croatia	Czechia	Denmark	Estonia	France	Germany	Greece	Hungary
	A. Level of reduction predicted by health and/or cognition decline (0 = 50–54 level)									
WORK	–3.068***	4.224***	–3.875**	6.785***	3.887***	6.201***	–4.112***	–2.660***	–0.460	6.566***
	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.660)	(0.000)
EMPL	–0.0778***	–0.122***	–0.0865**	–0.155***	–0.101***	–0.140***	–0.0980***	–0.107***	–0.0288	–0.176***
	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.196)	(0.000)
HOURS	–0.372	–0.128	–0.457	–1.185*	–0.0539	–0.855	–1.297***	1.471**	0.296	0.561
	(0.487)	(0.746)	(0.402)	(0.032)	(0.901)	(0.080)	(0.001)	(0.001)	(0.778)	(0.641)
	B. Percentage of reduction predicted by health and/or cognition decline (1 = 50–54 level)									
WORK	–0.111***	0.151***	–0.160**	0.204***	0.120***	0.195***	–0.136***	0.0951***	0.0201	–0.246***
	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.659)	(0.000)
EMPL	–0.109***	–0.162***	–0.152**	–0.192***	–0.119***	–0.178***	–0.121***	–0.141***	–0.0492	–0.269***
	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.192)	(0.000)
HOURS	–0.00195	0.0126	–0.00897	–0.0152	–0.00119	–0.0214	–0.0164	0.0531***	0.0306	0.0326
	(0.890)	(0.338)	(0.557)	(0.302)	(0.930)	(0.113)	(0.130)	(0.000)	(0.291)	(0.380)
	C. Share of observed work reduction explained by health and/or cognition decline (1 = 100%), $\delta^{Z,50\text{–}70}$									
WORK	0.117***	0.174***	0.255**	0.223***	0.140***	0.256***	0.149***	0.102***	0.0229	0.272***
	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.661)	(0.000)
EMPL	0.109***	0.165***	0.150**	0.197***	0.125***	0.207***	0.124***	0.142***	0.0499	0.269***
	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.193)	(0.000)
HOURS	0.0245	0.0150	-0.0377	0.129	0.00547	0.101	-2.949	-0.225	0.0999	-0.108
	(0.551)	(0.947)	(0.615)	(0.937)	(0.914)	(0.097)	(0.880)	(0.950)	(0.933)	(0.863)
N	18 373	2 775	4 822	22 209	17 206	22 369	22 644	20 680	13 710	4 523

	Ireland	Israel	Italy	Luxembourg	Poland	Portugal	Slovenia	Spain	Sweden	Switzerland
	A. Level of reduction predicted by health and/or cognition decline (0 = 50–54 level)									
WORK	–5.307	5.735***	4.192***	0.510	8.107***	0.942	5.368***	5.347***	–2.193***	–0.623
	(0.092)	(0.000)	(0.000)	(0.735)	(0.000)	(0.455)	(0.000)	(0.000)	(0.000)	(0.468)
EMPL	–0.0812	–0.174***	–0.112***	–0.0233	–0.240***	–0.0965*	–0.120***	–0.131***	–0.0408***	–0.0605***
	(0.112)	(0.000)	(0.000)	(0.403)	(0.000)	(0.011)	(0.000)	(0.000)	(0.001)	(0.000)
HOURS	–4.743	0.0482	–0.913	1.266	2.664*	4.054*	–1.234	–1.701*	–0.488	1.680*
	(0.124)	(0.976)	(0.123)	(0.206)	(0.014)	(0.017)	(0.052)	(0.023)	(0.345)	(0.022)
	B. Percentage of reduction predicted by health and/or cognition decline (1 = 50–54 level)									
WORK	–0.186	0.234***	0.164***	0.0179	0.311***	0.0893	0.181***	0.213***	0.0611***	–0.0210
	(0.074)	(0.000)	(0.000)	(0.737)	(0.000)	(0.457)	(0.000)	(0.000)	(0.000)	(0.467)
EMPL	–0.115	–0.264***	–0.159***	–0.0303	–0.383***	–0.153**	–0.161***	–0.199***	–0.0458***	–0.0722***
	(0.106)	(0.000)	(0.000)	(0.400)	(0.000)	(0.009)	(0.000)	(0.000)	(0.001)	(0.000)
HOURS	–0.0805	0.0413	–0.00603	0.0497	0.117**	0.287*	–0.0248	–0.0171	–0.0160	0.0553*
	(0.286)	(0.384)	(0.703)	(0.130)	(0.002)	(0.023)	(0.119)	(0.399)	(0.260)	(0.013)
	C. Share of observed work reduction explained by health and/or cognition decline (1 = 100%), $\delta^{Z,50\text{–}70}$									
WORK	0.200	0.263***	0.193***	–0.0205	0.638***	–0.0791	0.205***	0.229***	0.0661***	0.0238
	(0.071)	(0.000)	(0.000)	(0.738)	(0.000)	(0.458)	(0.000)	(0.000)	(0.000)	(0.468)
EMPL	0.124	0.313***	0.167***	0.0306	0.355***	0.157**	0.163***	0.203***	0.0476***	0.0781***
	(0.107)	(0.000)	(0.000)	(0.402)	(0.000)	(0.009)	(0.000)	(0.000)	(0.001)	(0.000)
HOURS	1.167	–0.00232	0.175	–0.135	–0.145*	1.275	0.0599	0.206	0.0248	–0.128*
	(0.733)	(0.975)	(0.938)	(0.830)	(0.015)	(0.870)	(0.338)	(0.926)	(0.370)	(0.036)
N	1 003	10 880	23 137	4 372	10 265	4 010	13 478	24 474	18 772	13 966

*, ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels, respectively.

Notes: Estimates based on stage-one IV-estimated health/cognition-to-work relationship, see table 5. *p*-values are indicated between parentheses. Underlying standard errors have been bootstrapped (100 iterations). C – corresponding to equations (3) to (5) in section 3. Overall work (*WORK*) is the combination of hours (*HOURS*) and employment (*EMPL*).

Source: Author's calculations based on SHARE (2004–17) data.

would drop by 4.08 percentage points, while overall work would decline by 2.193 hours. Panel B reports the same calculations but in relative terms. Perhaps more interestingly, panel C presents the estimates of $\delta^{Z,50\text{–}70}$ (equations (3) to (5) in section 3): the share of the observed work decline between the ages of 50 and 70 that can be ascribed to the health/cognition-driven deterioration of work capacity. For Sweden, health/cognition deterioration only accounts for 2.48 percentage points of the observed decline of weekly hours. Bootstrapped standard errors suggest that this share is not statistically different from zero. As to employment, health/cognition explain 4.76 percentage points of the observed decline; a share that is statistically significant. And overall work indicates a health/cognition-related share of about 6.61 percentage points. Turning to the other countries, the shares explained by health/cognition decline are always statistically significant for the employment rate, rising to up to 35.5 per cent in the case of Poland. Luxembourg is the only country with a share that is not statistically different from zero.

Figure 6 provides a visual representation of, and extends, the results of table 6, displaying the predicted work capacity for all possible ages between 50 and 70. The pattern that emerges – and more so, it seems, in relatively rich countries like Austria, Denmark, Germany, Sweden and Switzerland – is that of a relatively limited and smooth decline between the ages of 50 and 70. Across all countries, a very small reduction of the hours worked (*HOURS*) is predicted. This is a direct consequence of the very small – if any – impact of ill health and poor cognition on hours among individuals aged 50–54, estimated at stage one. Furthermore, and still in line with stage-one results, predictions are mostly of a reduction in employment. And, logically, the prediction of the decline of the overall labour supply almost perfectly parallels the extensive margin.

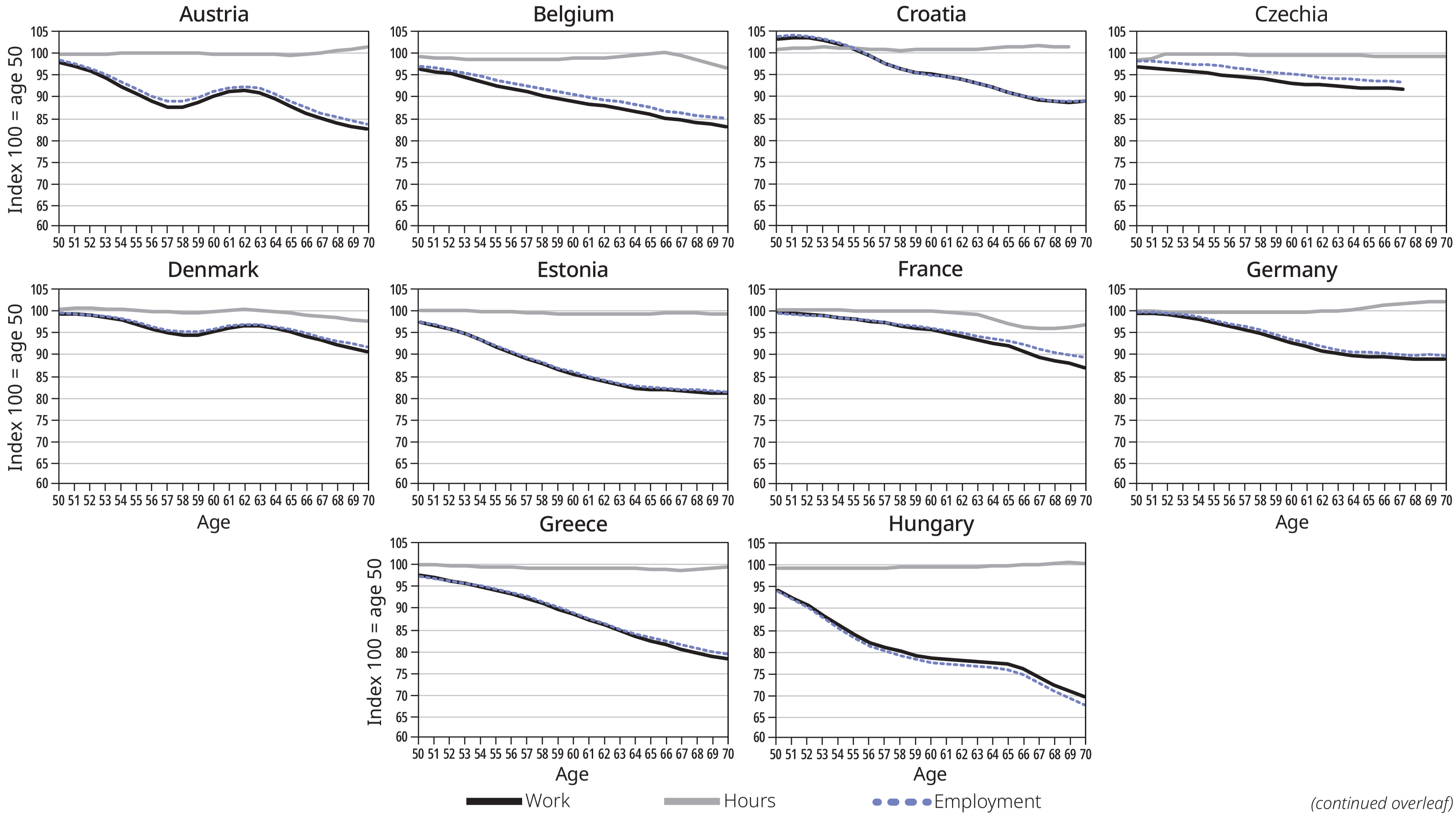
Figures 7, 8 and 9 are the graphical extensions of table 6, panel C. They compare the work capacity predictions to the actual work observed among individuals over the age of 50. They invariably illustrate, country by country, the existence of an important gap between work capacity (as predicted by the evolution of health/cognition) and the actual level of work. In Sweden, overall work (*WORK*) is predicted to fall from 37.8 to 34 hours between the ages of 50 and 70 (figure 7). By contrast, actual work at the age of 70 is close to zero. The gap is less dramatic for individuals aged 65 or 60, but it is still considerable. This suggests that even at those ages there is a significant unused work capacity. It is only under the age of 60 that there is some (visual) alignment between the health/cognition-driven prediction and the observed level of work. Figure 7 also reveals heterogeneity across European countries regarding the point at which a significant gap opens up between estimated work capacity and actual work. Sweden is, in fact, the country where it opens up the latest; reflecting the country's well-publicized performance when it comes to maintaining its older citizens in employment (Martin 2018).

A final consideration is that of the relationship between the work capacity predictions for 70-year-olds and the economic wealth of the different countries examined here.[11] Although these are all European countries,[12] and are

[11] For this, I draw on data from the Penn World Table version 9.1 (2020). https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.1. See Feenstra, Inklaar and Timmer (2015).

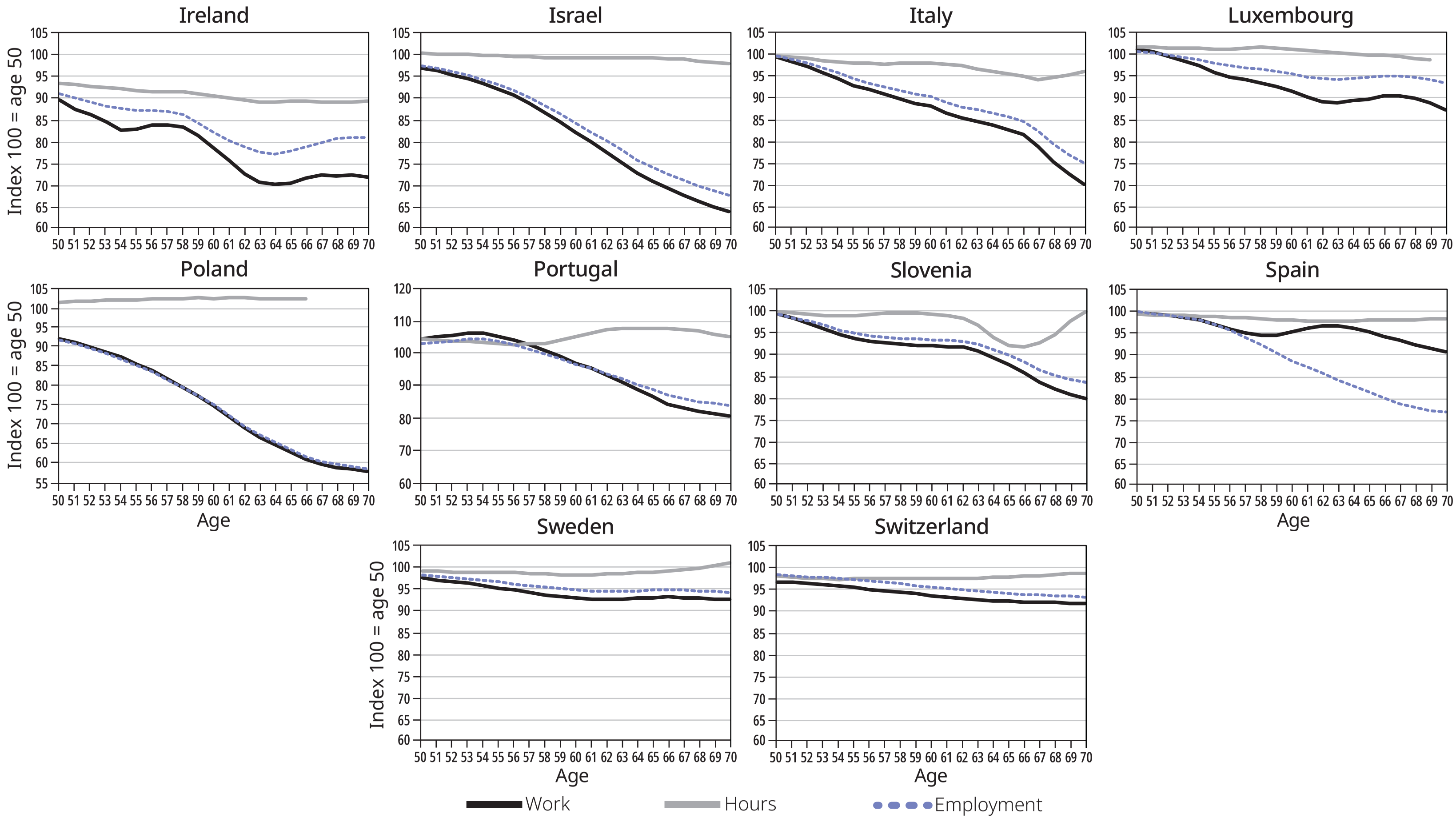
[12] Except Israel.

Figure 6. Predicted working hours (*HOURS*), employment rate (*EMPL*) and overall work (*WORK*) for respondents aged 50–70



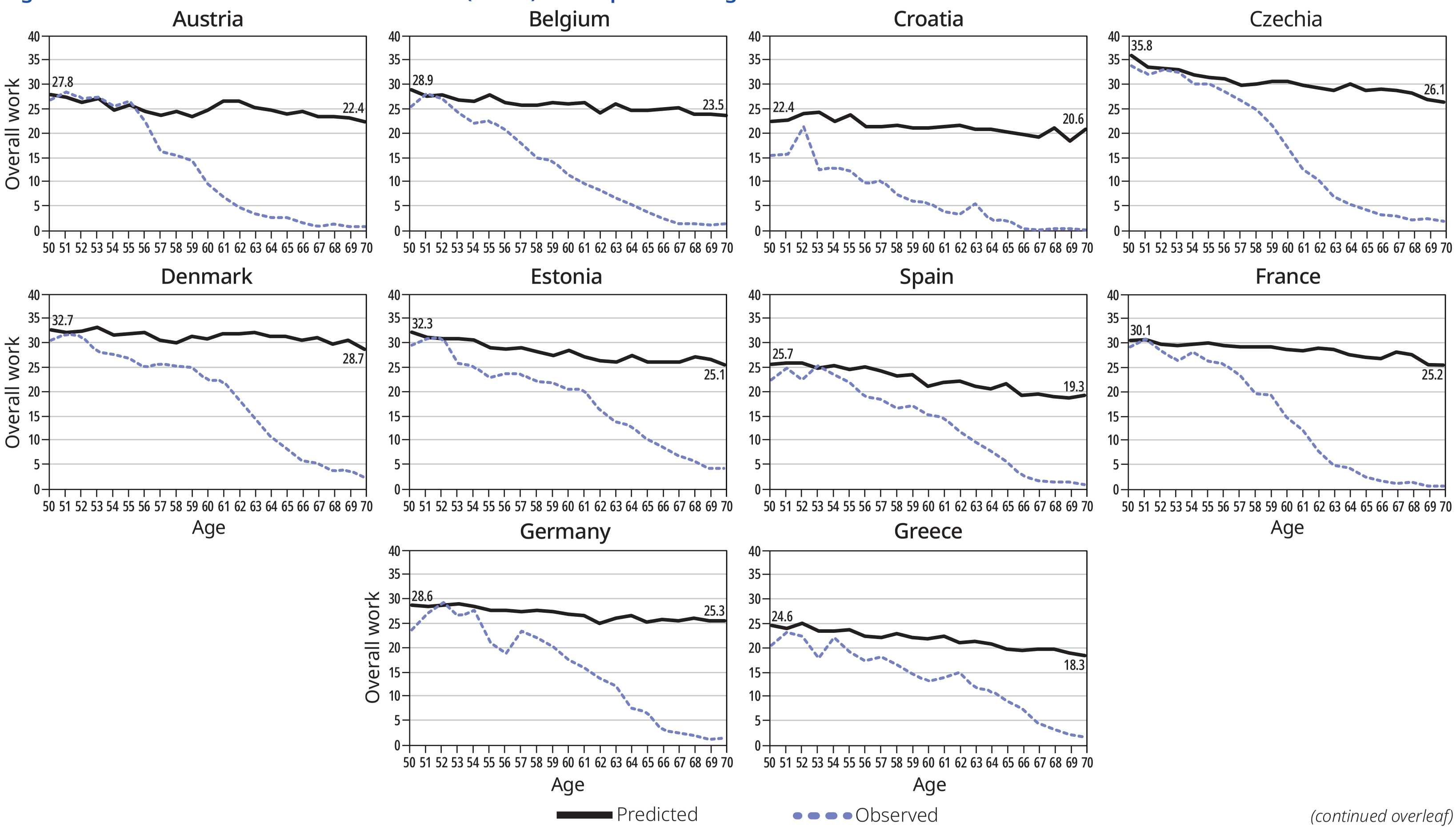
(continued overleaf)

Figure 6. Predicted working hours (*HOURS*), employment rate (*EMPL*) and overall work (*WORK*) for respondents aged 50–70 *(concl.)*



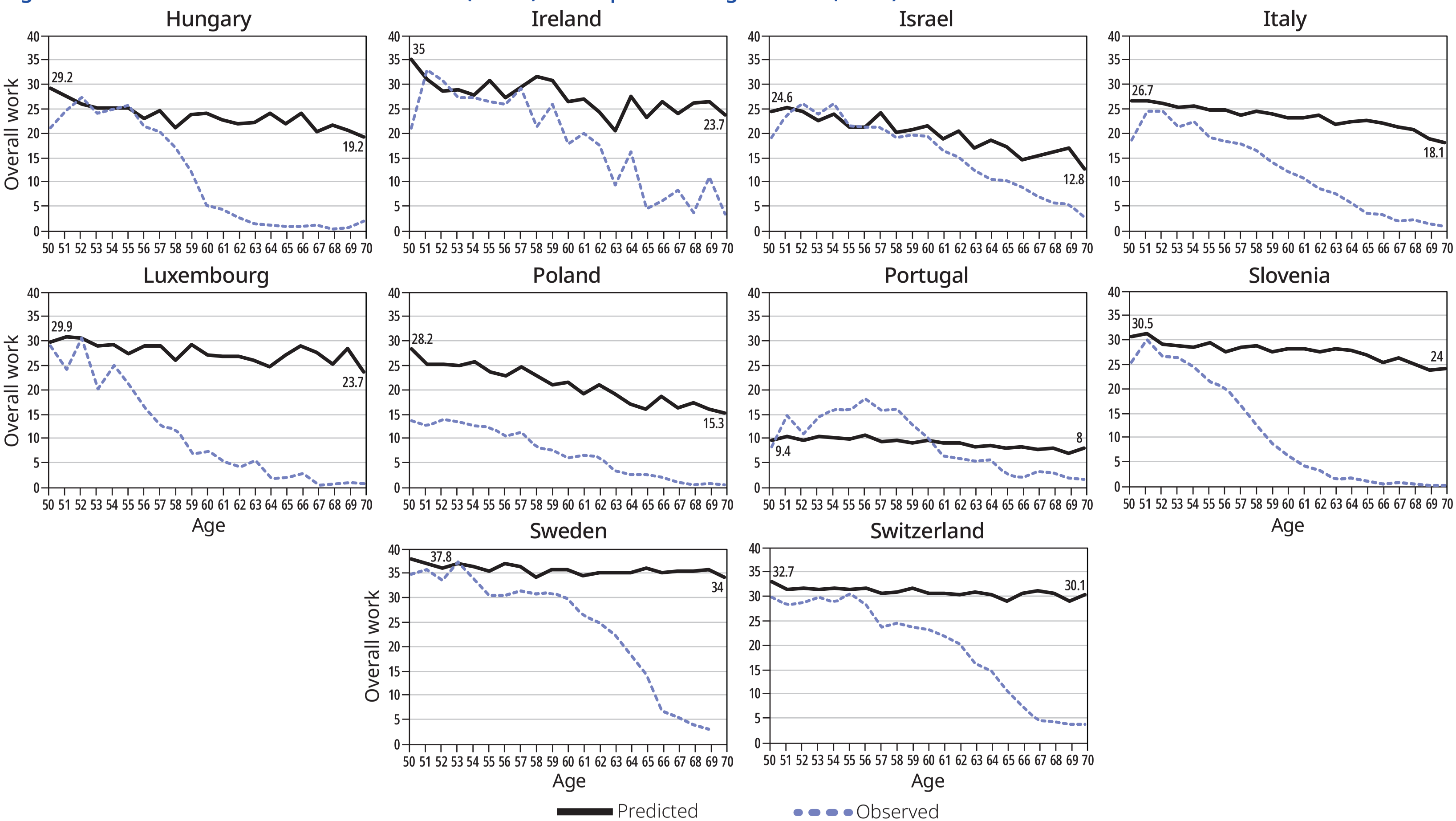
Source: Author's calculations based on SHARE (2004–17) data.

Figure 7. Predicted vs observed overall work (*WORK*) for respondents aged 50–70



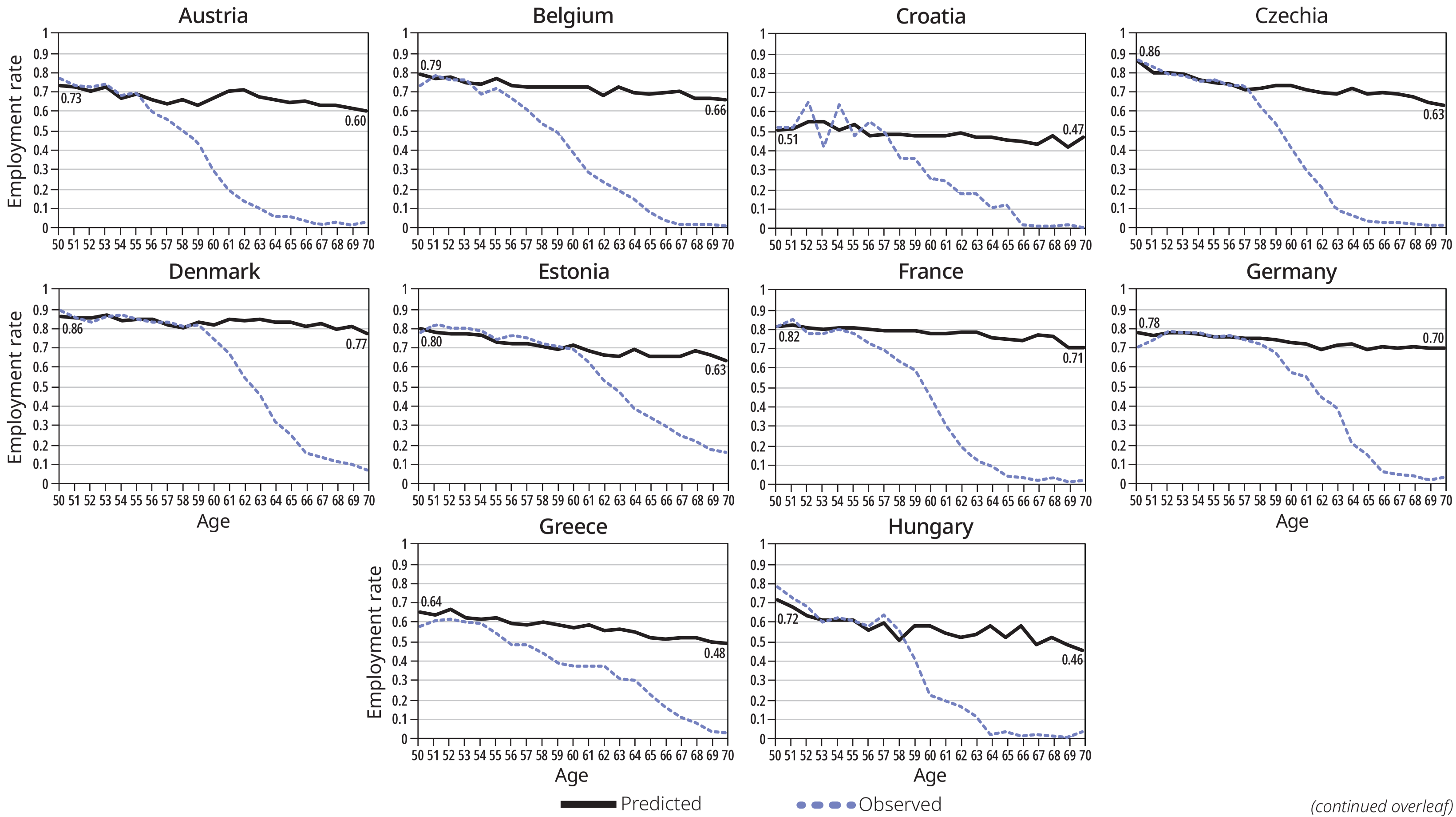
(continued overleaf)

Figure 7. Predicted vs observed overall work (*WORK*) for respondents aged 50–70 *(concl.)*



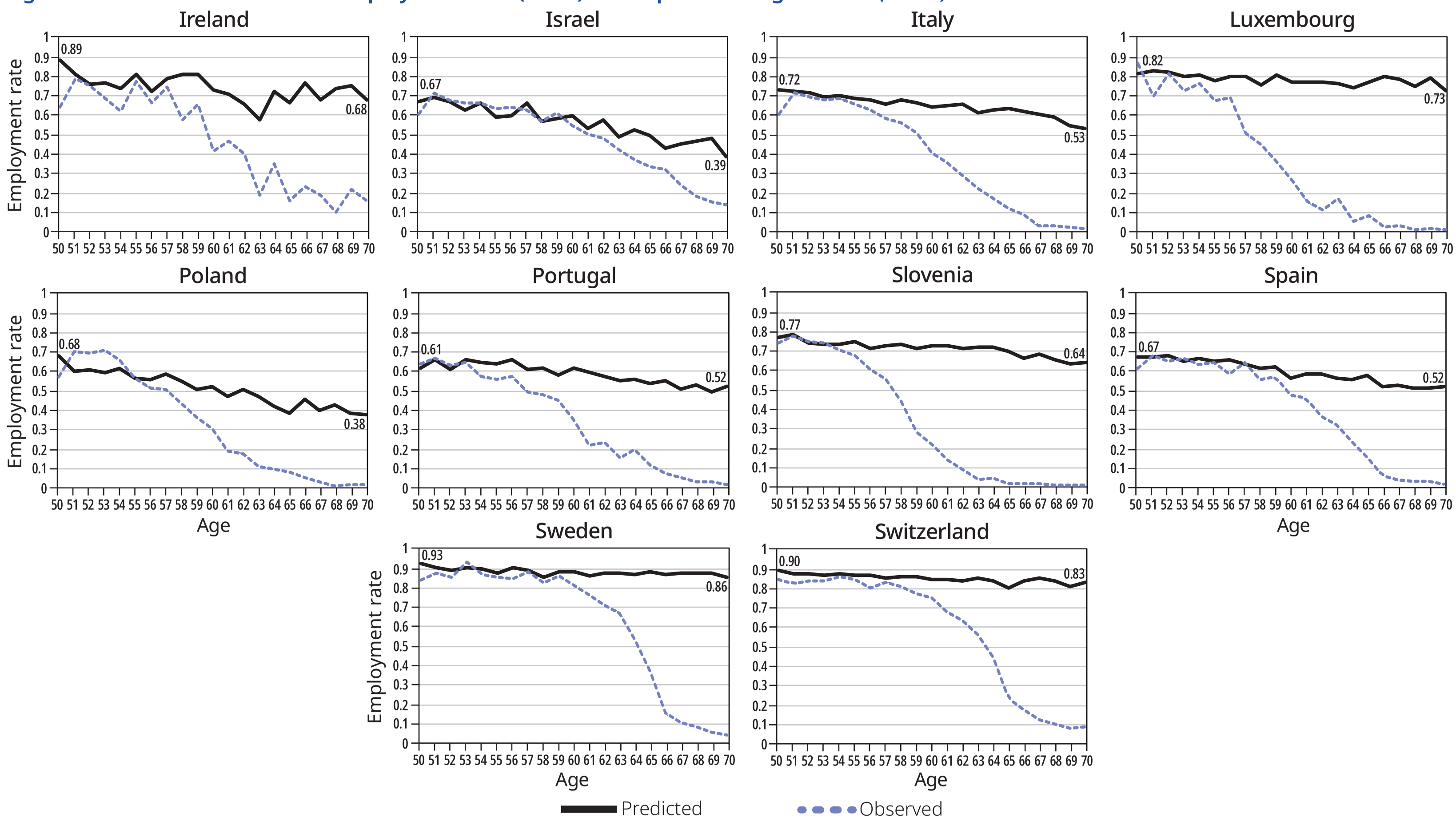
Source: Author's calculations based on SHARE (2004–17) data.

Figure 8. Predicted vs observed employment rate (*EMPL*) for respondents aged 50–70



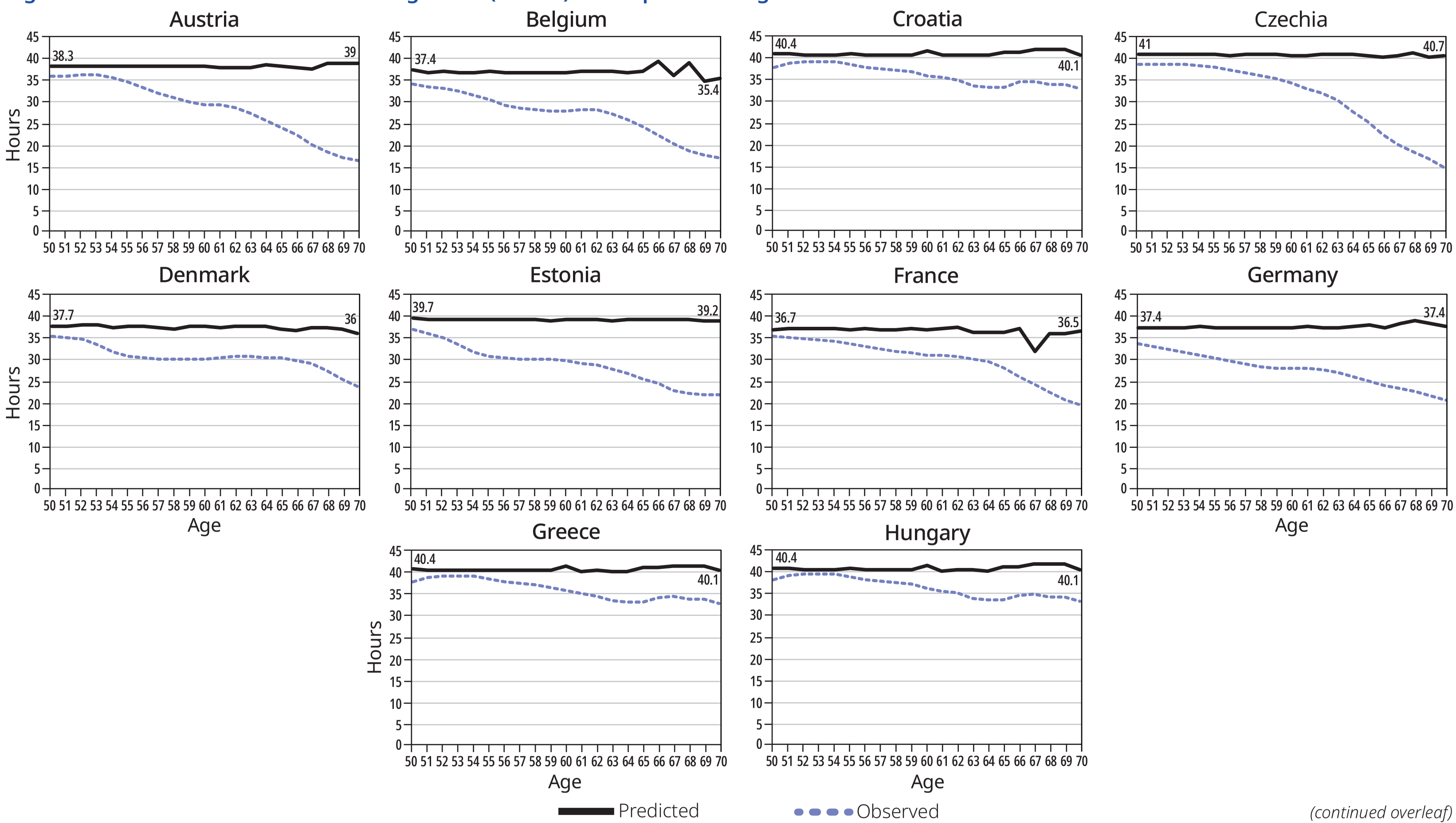
(continued overleaf)

Figure 8. Predicted vs observed employment rate (*EMPL*) for respondents aged 50–70 *(concl.)*



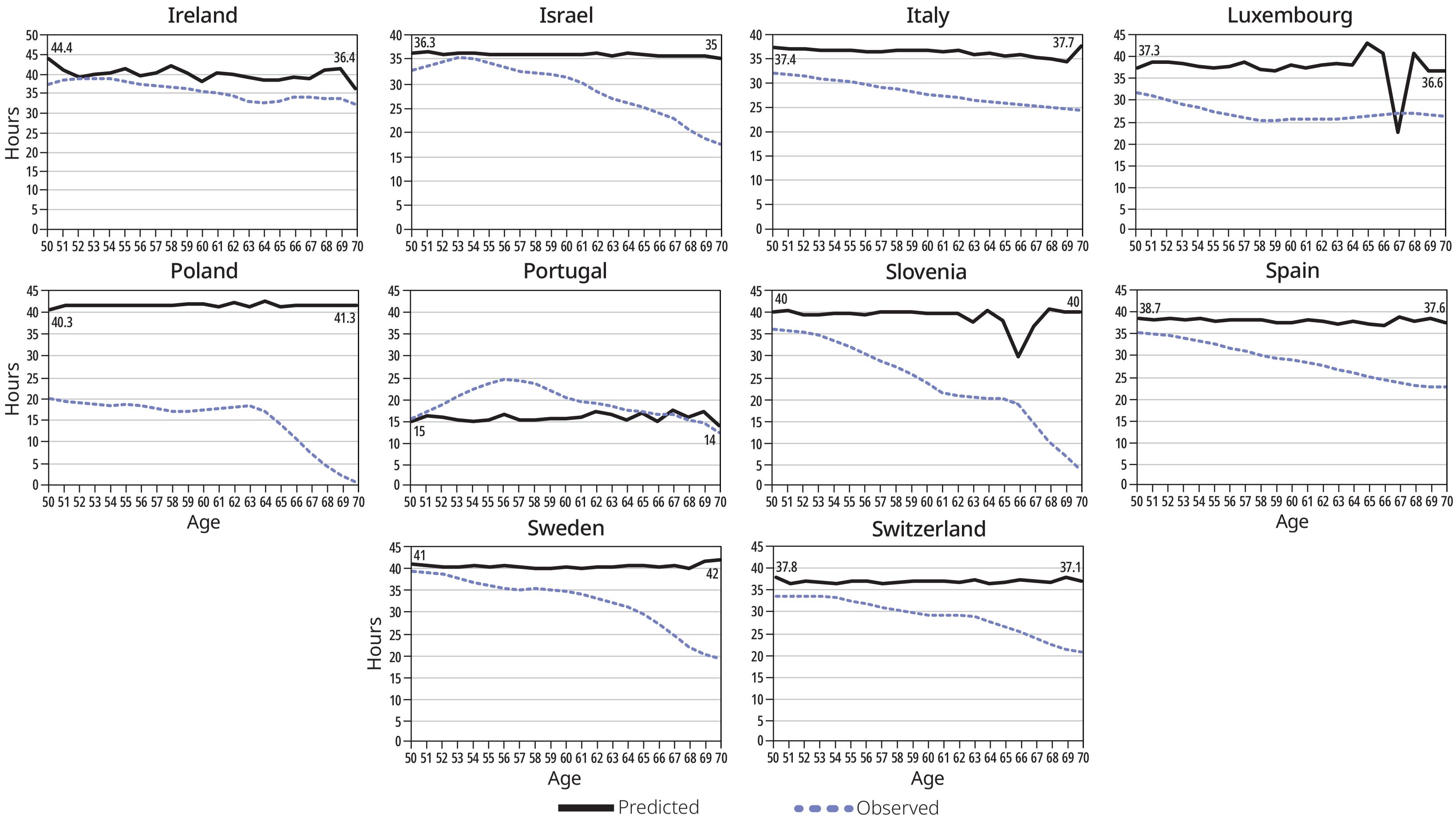
Source: Author's calculations based on SHARE (2004–17) data.

Figure 9. Predicted vs observed working hours (*HOURS*) for respondents aged 50–70



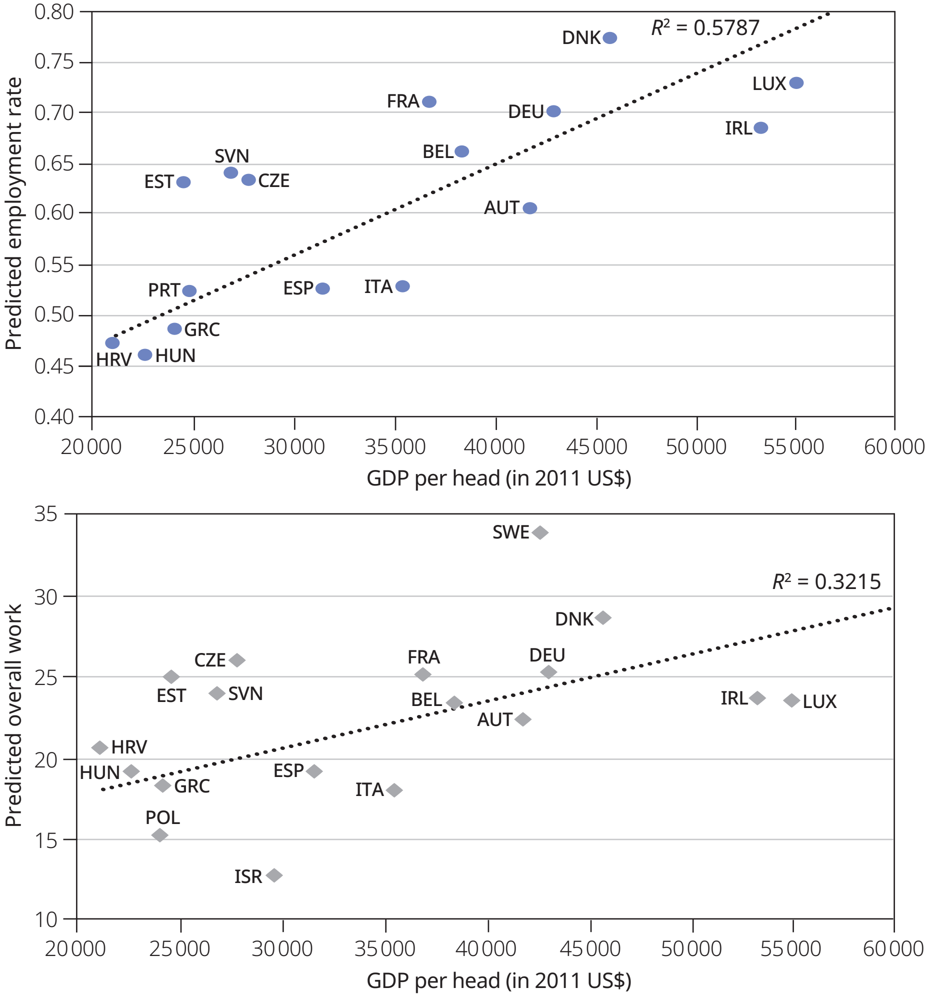
(continued overleaf)

Figure 9. Predicted vs observed working hours (*HOURS*) for respondents aged 50–70 *(concl.)*



Source: Author's calculations based on SHARE (2004–17) data.

Figure 10. Predicted work capacity at the age of 70 and GDP per capita (predicted employment rate (*EMPL*) and overall work (*WORK*))



Notes: Real GDP at constant 2011 national prices. Country names indicated using ISO 3166-1 alpha-3 country codes.

Source: Author's calculations based on SHARE (2004–17) and Penn World Table version 9.1 (countries not present in both data sets are not included).

thus relatively similar at the global level, they diverge significantly in terms of relative living conditions. For instance, Switzerland's global domestic product (GDP) per capita is more than double that of Poland, and significantly larger than that of Belgium. Do these differences matter for work capacity beyond the age of 50? A simple plot (figure 10) suggests that the answer might be "yes". Particularly in the case of work capacity defined as the predicted employment rate (*EMPL*), there is a positive correlation between GDP per capita and the predicted level at the age of 70. This is a simple correlation that must not be interpreted as causation but it hints at the existence of a relatively strong link between GDP per capita and the average health of a population, and how the latter declines with age.

6. Concluding remarks

The rise of old-age dependency in Europe and elsewhere explains the proliferation of reforms aimed at lifting the effective age of retirement. A recurrent question, however, is whether older individuals have the health and cognitive capacity to work longer. This article has explored this question by asking how much older individuals (on average) could work were they subject to the same health/cognition-to-work relationship as individuals aged 50–54. The method assumes that any impacts of health/cognition on work capacity do not vary by age: the negative impact of ill health/poor cognition observed among individuals aged 50–54 is assumed to be a valid predictor of what would be the impact of the same degree of ill health/poor cognition on individuals aged 55, 56 … to 70. What is more, it is also assumed that work itself (and its accumulation) does not affect health/cognition. This is a potentially important concern, investigated by some economists – see Bassanini and Caroli (2015) for a review of the (rather mixed) evidence.[13] The results presented in this article should be interpreted with these limitations in mind.

However, this article makes a number of contributions. Using comparable fully harmonized microdata from the SHARE survey, it brings a strong international dimension by quantifying work capacity simultaneously for 20 countries that tend to differ in many respects (GDP per capita, welfare and labour market institutions). It measures not only physical health but also cognition; and health is not just considered in subjective terms, encompassing many "objective" items, including doctor-diagnosed and measurable conditions. For its part, work is examined both in its extensive and intensive margins (employment and hours, respectively). Another clear strength of this article is its use of econometrics to address a certain number of biases, in particular when it comes to properly estimating the relationship between health and work among individuals between the ages of 50 and 54. It shows that the OLS method, as used in Wise (2017), underestimates the negative impact of ill health on people's capacity to work.

The results gathered in this article lead to five main findings. First, there is solid evidence that people aged 50–54 who are suffering from health problems significantly reduce their participation in employment (the extensive margin of work). This result is relatively unsurprising and is aligned with the findings published by other economists using the Cutler method (Wise 2017; Coile, Milligan and Wise 2016; Banks, Emmerson and Tetlow 2016; Cutler, Meara and Richards-Shubik 2013).

[13] Some studies find that work, in particular long hours or night shifts, accelerates health decline; while others suggest exactly the opposite. There is abundant literature asking whether retirement is good for health. A sizeable body of literature also discusses whether retirement is good or harmful for cognition (Mazzonna and Peracchi 2012; Bonsang, Adam and Perelman 2012).

Second, evidence indicates that the impact of declining health on hours worked is also negative, but that it is of a much smaller magnitude and is generally not statistically significant. This suggests, at least in Europe, that elderly workers suffering from ill health rarely adjust work at the intensive margin but rather stop working altogether.

Third, in contrast with ill health, poor cognition is found to have no impact on work among individuals aged 50–54. Consequently, cognition and its decline with age add little explanatory power to predicting work capacity.[14] This result is in line with the recent findings of Blundell et al. (2017) for the United Kingdom and the United States.

Fourth, there appears to be no evidence of a health “justification bias” in the self-reporting of health-related limitations to work, as conjectured by Bound (1991). Rather, I have found the opposite when self-reported health is instrumented (using the IV method) by objective health measures provided by SHARE, including doctor-diagnosed conditions and results from physical/dexterity tests carried out by SHARE researchers. I argue that this is supportive of a rather more potent measurement-error problem known to create a downward bias.

Fifth, declines in health/cognition are found to explain, at most, 35 per cent of the observed work reduction between the ages of 50 and 70 – and smaller percentages if slightly younger categories of older workers are considered. The results support the idea that many older individuals, across a relatively large and diverse set of European countries, have the capacity to work up to the age of 70. This is in line with the findings of Wise (2017), although I add an interesting extension by identifying a positive correlation between GDP per capita and work capacity at the age of 70.

If health/cognition-driven work capacity remains intrinsically high, then policymakers wanting to increase elderly employment rates should probably focus on the other determinants of employment among older workers. These comprise supply-side determinants, such as a preference for leisure, the fact that spouses’ retirement decisions tend to be correlated, caretaking obligations and – despite many pension reforms aimed at addressing the problem – financial disincentives to postpone retirement. Determinants on the demand side (in other words, on the side of firms and employers in general) include the fact that older individuals’ capacity to work may be seriously hampered by rampant age discrimination (Neumark, Burn and Button 2017), and an employability handicap driven by a low productivity-to-labour cost ratio compared to prime-age or young workers (Dostie 2011; Vandenberghe 2011 and 2013; van Ours and Stoeldraijer 2011).

It is also important to stress that these conclusions are not to suggest that all those whose health/cognition levels allow them to work should necessarily do so. Some individuals may well prefer to retire early and receive a smaller pension, and some countries may be able to afford, or would be willing to pay for, retirement before a marked work capacity decline. After all, most old-age

[14] However, it could be argued that this result suggests that SHARE data are worse at measuring cognition than physical health, at least when it comes to the dimensions that matter for work.

pension schemes in Europe were not primarily (or are no longer) designed as invalidity schemes.[15]

Lastly, it is worth considering that the methods and results presented in this article address the work capacity of the population overall. Even if, as amply shown in this article, the health and cognition of most individuals are sufficiently good to allow them to work up to the age of 70, there are many individuals whose health is too poor for them to work. Bad health already prevents some younger individuals aged 50–54 from working.[16] Thus, as already stated by Coile, Milligan and Wise (2016) and Wise (2017), it is crucial that decision-makers consider the needs of such individuals and, for instance, provide well-designed disability insurance and active labour market programmes that can reliably assess limited, or absent, work capacity.

References

Acemoglu, Daron. 2010. "When Does Labor Scarcity Encourage Innovation?" *Journal of Political Economy* 118 (6): 1037–1078.

Acemoglu, Daron, and Pascual Restrepo. 2018. "Demographics and Automation", NBER Working Paper No. 24421. Cambridge, MA: National Bureau of Economic Research.

Anger, Silke, and Guido Heineck. 2010. "Cognitive Abilities and Earnings: First Evidence for Germany". *Applied Economics Letters* 17 (7): 699–702.

Atalay, Kadir, and Garry F. Barrett. 2015. "The Impact of Age Pension Eligibility Age on Retirement and Program Dependence: Evidence from an Australian Experiment". *Review of Economics and Statistics* 97 (1): 71–87.

Baker, Michael, Mark Stabile, and Catherine Deri. 2004. "What Do Self-Reported, Objective, Measures of Health Measure?" *Journal of Human Resources* 39 (4): 1067–1093.

Banks, James, Carl Emmerson, and Gemma Tetlow. 2016. "Health Capacity to Work at Older Ages: Evidence from the United Kingdom", NBER Working Paper No. 21980. Cambridge, MA: National Bureau of Economic Research.

Bassanini, Andrea, and Eve Caroli. 2015. "Is Work Bad for Health? The Role of Constraint versus Choice". *Annals of Economics and Statistics*, No. 119/120: 13–37.

Blöndal, Sveinbjörn, and Stefano Scarpetta. 1999. "The Retirement Decision in OECD Countries", OECD Economics Department Working Papers, No. 202. Paris: OECD.

Blundell, Richard, Jack Britton, Monica Costa Dias and Eric French. 2017. "The Impact of Health on Labour Supply near Retirement", IFS Working Paper W17/18. London: Institute for Fiscal Studies.

Bonsang, Eric, Stéphane Adam, and Sergio Perelman. 2012. "Does Retirement Affect Cognitive Functioning?" *Journal of Health Economics* 31 (3): 490–501.

Börsch-Supan, Axel. 2014. "Aging Societies: Individual and Societal Plasticity", MEA Discussion Paper No. 201422. Munich: Munich Center for the Economics of Aging.

Börsch-Supan, Axel, Martina Brandt, Christian Hunkler, Thorsten Kneip, Julie Korbmacher, Frederic Malter, Barbara Schaan, Stephanie Stuck, and Sabrina Zuber. 2013. "Data Resource Profile: The Survey of Health, Ageing and Retirement in Europe (SHARE)". *International Journal of Epidemiology* 42 (4): 992–1001.

Bound, John. 1991. "Self-Reported versus Objective Measures of Health in Retirement Models". *Journal of Human Resources* 26 (1): 106–138.

[15] For an in-depth analysis of the long-term evolution of the role of pension schemes in the United States, see Costa (1998, 6–31).

[16] Otherwise, it would not be possible to estimate the relationship between health and work, and compute estimates of work capacity.

Chang, Angela Y., Vegard F. Skirbekk, Stefanos Tyrovolas, Nicholas J. Kassebaum, and Joseph L. Dieleman. 2019. "Measuring Population Ageing: An Analysis of the Global Burden of Disease Study 2017". *Lancet Public Health* 4 (3): E159–E167.

Coile, Courtney, Kevin S. Milligan, and David A. Wise. 2016. "Health Capacity to Work at Older Ages: Evidence from the U.S.", NBER Working Paper No. 21940. Cambridge, MA: National Bureau of Economic Research.

Costa, Dora L. 1998. *The Evolution of Retirement: An American Economic History, 1880–1990*. Chicago, IL: University of Chicago Press.

Cutler, David M., Kaushik Ghosh, and Mary Beth Landrum. 2013. "Evidence for Significant Compression of Morbidity in the Elderly U.S. Population", NBER Working Paper No. 19268. Cambridge, MA: National Bureau of Economic Research.

Cutler, David M., Ellen Meara, and Seth Richards-Shubik. 2013. "Health and Work Capacity of Older Adults: Estimates and Implications for Social Security Policy", SSRN Working Paper. https://dx.doi.org/10.2139/ssrn.2577858.

De Souza, Laeticia R., Bernardo L. Queiroz, and Vegard F. Skirbekk. 2019. "Trends in Health and Retirement in Latin America: Are Older Workers Healthy Enough to Extend their Working Lives?". *Journal of the Economics of Ageing* 13 (May): 72–83.

Delmez, Françoise, and Vincent Vandenberghe. 2018. "Long Working Hours Make Us Less Productive but Also Less Costly". *Labour* 32 (4): 259–287.

Dorn, David, and Alfonso Sousa-Poza. 2010. "'Voluntary' and 'Involuntary' Early Retirement: An International Analysis". *Applied Economics* 42 (4): 427–438.

Dostie, Benoit. 2011. "Wages, Productivity and Aging". *De Economist* 159 (2): 139–158.

Dwyer, Debra Sabatini, and Olivia S. Mitchell. 1999. "Health Problems as Determinants of Retirement: Are Self-Rated Measures Endogenous?" *Journal of Health Economics* 18 (2): 173–193.

Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer. 2015. "The Next Generation of the Penn World Table". *American Economic Review* 105 (10): 3150–3182.

Hutchens, Robert. 1986. "Delayed Payment Contracts and a Firm's Propensity to Hire Older Workers". *Journal of Labor Economics* 4 (4): 439–457.

———. 2010. "Worker Characteristics, Job Characteristics, and Opportunities for Phased Retirement". *Labour Economics* 17 (6): 1010–1021.

Jousten, Alain, Mathieu Lefèbvre, Sergio Perelman, and Pierre Pestieau. 2010. "The Effects of Early Retirement on Youth Unemployment: The Case of Belgium". In *Social Security Programs and Retirement around the World: The Relationship to Youth Employment*, edited by Jonathan Gruber and David A. Wise, 47–76. Chicago, IL: University of Chicago Press.

Martin, John P. 2018. *Live Longer, Work Longer: The Changing Nature of the Labour Market for Older Workers in OECD Countries*. IZA Discussion Paper No. 11510. Bonn: Institute of Labor Economics.

Mazzonna, Fabrizio, and Franco Peracchi. 2012. "Ageing, Cognitive Abilities and Retirement". *European Economic Review* 56 (4): 691–710.

Michaud, Pierre-Carl, Arthur Van Soest, and Luc Bissonnette. 2020. "Understanding Joint Retirement". *Journal of Economic Behavior & Organization* 173 (May): 386–401.

Milligan, Kevin S., and David A. Wise. 2012. "Health and Work at Older Ages: Using Mortality to Assess the Capacity to Work across Countries", NBER Working Paper No. 18229. Cambridge, MA: National Bureau of Economic Research.

Moran, John R., Pamela Farley Short, and Christopher S. Hollenbeak. 2011. "Long-Term Employment Effects of Surviving Cancer". *Journal of Health Economics* 30 (3): 505– 514.

Neumark, David, Ian Burn, and Patrick Button. 2017. "Is It Harder for Older Workers to Find Jobs? New and Improved Evidence from a Field Experiment", NBER Working Paper No. 21669 (Revised). Cambridge, MA: National Bureau of Economic Research.

O’Donnell, Owen, Eddy Van Doorslaer, and Tom Van Ourti. 2015. “Health and Inequality”. In *Handbook of Income Distribution*, edited by Anthony B. Atkinson and François Bourguignon, Vol. 2B, 1419–1533. Amsterdam: North Holland.

OECD (Organisation for Economic Co-operation and Development) and European Union. 2016. *Health at a Glance: Europe 2016 – State of Health in the EU Cycle*. Paris.

Oeppen, Jim, and James W. Vaupel. 2002. “Broken Limits to Life Expectancy”. *Science* 296 (5570): 1029–1031.

Oliveira Martins, Joaquim, Frédéric Gonand, Pablo Antolín, Christine de la Maisonneuve, and Kwang-Yeol Yoo. 2005. “The Impact of Ageing on Demand, Factor Markets and Growth”, OECD Economics Department Working Papers, No. 420. Paris: OECD.

Pelkowski, Jodi Messer, and Mark C. Berger. 2004. “The Impact of Health on Employment, Wages, and Hours Worked over the Life Cycle”. *Quarterly Review of Economics and Finance* 44 (1): 102–121.

Salthouse, Timothy A. 2010. “Selective Review of Cognitive Aging”. *Journal of the International Neuropsychological Society* 16 (5): 754–760.

Skirbekk, Vegard. 2004. “Age and Individual Productivity: A Literature Survey”. *Vienna Yearbook of Population Research* 2: 133–154.

Stern, Steven. 1989. “Measuring the Effect of Disability on Labor Force Participation”. *Journal of Human Resources* 24 (3): 361–395.

van Ours, Jan C., and Lenny Stoeldraijer. 2011. “Age, Wage and Productivity in Dutch Manufacturing”. *De Economist* 159 (2): 113–137.

Vandenberghe, Vincent. 2011. “Boosting the Employment Rate of Older Men and Women”. *De Economist* 159 (2): 159–191.

———. 2013. “Are Firms Willing to Employ a Greying and Feminizing Workforce?” *Labour Economics* 22 (June): 30–46.

———. 2020. “Ageing Calls for Shorter Full-Time Tertiary Education and Increased Continuing Education”, Discussion Paper 2020/01. Louvain-la-Neuve: IRES-LIDAM.

Vandenberghe, Vincent, Fábio Waltenberg, and Mariann Rigó. 2013. “Ageing and Employability: Evidence from Belgian Firm-Level Data”. *Journal of Productivity Analysis* 40 (1): 111–136.

Wise, David A., ed. 2017. *Social Security Programs and Retirement around the World: The Capacity to Work at Older Ages*. Chicago, IL: University of Chicago Press.

Appendix

Table A1. Stage-one results (OLS): Impact of ill health and poor cognition on the work of respondents aged 50–54

	Austria	Belgium	Croatia	Czechia	Denmark	Estonia	France	Germany	Greece	Hungary
	A. Ill-health index									
β_h^{WORK}	−7.56***	−5.95***	−6.56***	−8.32***	−7.66***	−6.80***	−5.24***	−6.30***	−3.70***	−8.23***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h^{EMPL}	−0.19***	−0.15***	−0.15***	−0.21***	−0.19***	−0.17***	−0.15***	−0.16***	−0.07***	−0.20***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h^{HOURS}	−0.35	−0.76	−1.15	−1.03	−1.45*	−0.21	−0.27	−0.62	−1.86	−1.78**
	(0.784)	(0.134)	(0.144)	(0.165)	(0.030)	(0.655)	(0.469)	(0.190)	(0.082)	(0.007)
	B. Poor cognition index									
β_c^{WORK}	−0.67	−2.49***	1.15	−2.49***	−1.68**	−1.90***	−3.04***	−0.64	0.39	−1.25
	(0.364)	(0.000)	(0.307)	(0.000)	(0.007)	(0.000)	(0.000)	(0.276)	(0.728)	(0.499)
β_c^{EMPL}	−0.02	−0.07***	0.04	−0.04**	−0.03*	−0.02	−0.04***	−0.04***	−0.01	−0.05***
	(0.245)	(0.000)	(0.103)	(0.004)	(0.045)	(0.123)	(0.000)	(0.001)	(0.653)	(0.000)
β_c^{HOURS}	−0.38	0.18	0.32	−1.22	−0.39	−0.93*	−2.06**	0.93	1.04	2.26
	(0.599)	(0.686)	(0.572)	(0.129)	(0.380)	(0.010)	(0.003)	(0.166)	(0.339)	(0.310)
N	18 373	27 750	4 822	22 209	17 206	22 369	22 644	20 680	13 710	4 523

	Ireland	Israel	Italy	Luxembourg	Poland	Portugal	Slovenia	Spain	Sweden	Switzerland
	A. Ill-health index									
β_h^{WORK}	−5.80***	−4.96***	−3.22***	−3.20	−8.60***	−1.60	−5.97***	−5.99***	−6.78***	−3.75***
	(0.001)	(0.000)	(0.000)	(0.075)	(0.000)	(0.142)	(0.000)	(0.000)	(0.000)	(0.000)
β_h^{EMPL}	−0.14**	−0.12***	−0.07***	−0.08	−0.20***	−0.16***	−0.12***	−0.14***	−0.15***	−0.11***
	(0.002)	(0.000)	(0.000)	(0.101)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h^{HOURS}	−5.43	−0.46	−1.23*	−1.75	−0.25	2.83	−2.01*	−2.13	−1.98***	−0.35
	(0.087)	(0.648)	(0.049)	(0.175)	(0.728)	(0.253)	(0.011)	(0.105)	(0.001)	(0.461)
	B. Poor cognition index									
β_c^{WORK}	−3.44	−2.09	−3.96***	−0.35	−0.66	0.10	−2.77*	−4.35***	−0.73	−2.41**
	(0.186)	(0.250)	(0.000)	(0.709)	(0.339)	(0.961)	(0.039)	(0.000)	(0.074)	(0.002)
β_c^{EMPL}	0.02	−0.05	−0.08***	−0.01	−0.04*	−0.03	−0.06*	−0.09***	0.00	−0.05**
	(0.776)	(0.112)	(0.000)	(0.711)	(0.029)	(0.597)	(0.019)	(0.000)	(0.957)	(0.002)
β_c^{HOURS}	−5.32**	−0.70	−2.15**	0.78	1.14	1.58	−0.58	−1.85***	0.07	−0.33
	(0.006)	(0.764)	(0.002)	(0.408)	(0.063)	(0.602)	(0.567)	(0.000)	(0.839)	(0.709)
N	1 003	10 880	23 137	4 372	10 265	4 010	13 478	24 474	18 772	13 966

*, ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels, respectively.

Notes: Results are point estimates β_h^Z and β_c^Z of the effect of a 1 standard deviation increment of the index on work, employment and hours. *p*-values are indicated between parentheses. Underlying standard errors have been bootstrapped (100 iterations). Physical/subjective health index instrumented by objective variables in table 3. Overall work (*WORK*) is the combination of hours (*HOURS*) and employment (*EMPL*).

Source: Author's calculations based on SHARE (2004–17) data.

Table A2. Stage-one results: Impact of physical health and cognition on the overall work (*WORK*) of respondents aged 50–54 and comparison of OLS and IV

	Austria	Belgium	Croatia	Czechia	Denmark	Estonia	France	Germany	Greece	Hungary
	Model 1: OLS ill-health index and poor cognition index									
β_h^{WORK} *OLS*	−7.56***	−5.95***	−6.56***	−8.32***	−7.66***	−6.80***	−5.24***	−6.30***	−3.70***	−8.23***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_c^{WORK} *OLS*	−0.67	−2.49***	1.15	−2.49**	−1.68**	−1.90**	−3.04***	−0.64	0.39	−1.25
	(0.366)	(0.000)	(0.503)	(0.001)	(0.003)	(0.004)	(0.000)	(0.350)	(0.685)	(0.442)
	Model 2: IV ill-health index and poor cognition index									
β_h^{WORK} *IV*	−10.41***	−7.96***	−8.85***	−12.22***	−9.84***	−9.80***	−6.27***	−8.70***	−4.24**	−11.44***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)
β_c^{WORK} *IV*	−3.34	−1.57*	1.53	0.03	−1.00	−0.19	−3.07***	−0.07	0.39	−1.15
	(0.067)	(0.013)	(0.454)	(0.984)	(0.528)	(0.867)	(0.000)	(0.933)	(0.705)	(0.568)
	Comparison models 1 and 2									
β_h^{WORK} *IV–OLS*	−2.85**	−2.02***	−2.29	−3.89***	−2.18**	−2.99**	−1.03	−2.39***	−0.54	−3.20*
	(0.007)	(0.000)	(0.150)	(0.000)	(0.007)	(0.002)	(0.170)	(0.001)	(0.642)	(0.011)
β_c^{WORK} *IV–OLS*	−2.66	0.92**	0.38	2.52	0.68	1.72*	−0.03	0.58	−0.00	0.10
	(0.109)	(0.007)	(0.680)	(0.056)	(0.639)	(0.048)	(0.935)	(0.120)	(0.997)	(0.917)
N	6364	10327	2387	8134	5925	7177	8154	8472	7038	2966

	Ireland	Israel	Italy	Luxembourg	Poland	Portugal	Slovenia	Spain	Sweden	Switzerland
	Model 1: OLS ill-health index and poor cognition index									
β_h^{WORK} *OLS*	−5.80**	−4.96***	−3.22***	−3.20*	−8.60***	−1.60	−5.97***	−5.99***	−6.78***	−3.75***
	(0.002)	(0.000)	(0.000)	(0.015)	(0.000)	(0.246)	(0.000)	(0.000)	(0.000)	(0.000)
β_c^{WORK} *OLS*	−3.44	−2.09	−3.96***	−0.35	−0.66	0.10	−2.77**	−4.35***	−0.73	−2.41**
	(0.138)	(0.079)	(0.000)	(0.784)	(0.549)	(0.951)	(0.005)	(0.000)	(0.396)	(0.007)
	Model 2: IV ill-health index and poor cognition index									
β_h^{WORK} *IV*	−6.76*	−9.00***	−5.47***	−6.26*	−11.72***	−6.23***	−8.95***	−8.83***	−8.95***	−4.46**
	(0.019)	(0.000)	(0.000)	(0.026)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
β_c^{WORK} *IV*	−2.57	−1.26	−3.99***	0.65	−0.75	0.24	−1.56	−4.15***	0.50	−2.10*
	(0.319)	(0.414)	(0.000)	(0.715)	(0.548)	(0.912)	(0.241)	(0.000)	(0.605)	(0.020)
	Comparison models 1 and 2									
β_h^{WORK} *IV–OLS*	−0.97	−4.04***	−2.25*	−3.06	−3.13**	−4.63**	−2.98**	−2.85*	−2.17*	−0.71
	(0.646)	(0.001)	(0.040)	(0.171)	(0.006)	(0.005)	(0.007)	(0.011)	(0.041)	(0.498)
β_c^{WORK} *IV–OLS*	0.87	0.82	−0.03	1.00	−0.09	0.14	1.20	0.20	1.22*	0.31
	(0.670)	(0.352)	(0.950)	(0.389)	(0.883)	(0.919)	(0.174)	(0.830)	(0.040)	(0.379)
N	991	3845	8563	2004	2905	2023	5100	8614	6866	4558

*, ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels, respectively.

Notes: *p*-values in parentheses. Underlying standard errors have been bootstrapped (100 iterations). Overall work (*WORK*) is the combination of hours (*HOURS*) and employment (*EMPL*). Physical/subjective health index instrumented by objective variables listed in table 3. Level of reduction predicted by health and/or cognition decline (0 = 50–54 level).

Source: Author's calculations based on SHARE (2004–17) data.

Table A3. Validity of objective health items as instruments of subjective health index

	Cragg-Donald Wald F-statistic	Kleibergen-Paap rk Wald F-statistic	Cragg-Donald Wald LM-statistic	Cragg-Donald Wald LM-statistic (*p*-value)
Austria	58.24	65.4328	213.50	0.0000
Belgium	168.70	161.9989	483.90	0.0000
Croatia	30.00	70.2251	128.47	0.0000
Czechia	69.22	186.2675	300.69	0.0000
Denmark	99.80	97.2003	328.62	0.0000
Estonia	89.56	189.0850	340.82	0.0000
France	113.21	103.6121	401.69	0.0000
Germany	97.95	93.0086	414.24	0.0000
Greece	82.54	70.1884	325.32	0.0000
Hungary	28.63	51.4255	103.54	0.0000
Ireland	18.43	102.7409	35.75	0.0011
Israel	43.39	57.4291	163.60	0.0000
Italy	72.38	64.7244	344.10	0.0000
Luxembourg	13.03	40.7144	64.67	0.0000
Poland	49.46	123.2353	198.35	0.0000
Portugal	17.07	19.0707	72.35	0.0000
Slovenia	40.00	40.8839	147.94	0.0000
Spain	93.70	81.0782	370.97	0.0000
Sweden	38.31	41.0943	147.58	0.0000
Switzerland	49.99	51.7269	165.68	0.0000

Notes: The Cragg-Donald/Kleibergen-Paap Wald tests are weak identification tests. They are in essence an F-test (testing the significance of all stage-one regressors to be jointly equal to zero) accounting for the presence of heteroscedasticity. The under-identification test (Cragg-Donald Wald LM) is a Lagrange multiplier (LM) test of whether the equation is identified, that is, that the excluded instruments are "relevant", meaning correlated with the endogenous regressors. The test is essentially the test of the rank of a matrix: under the null hypothesis that the equation is underidentified, the matrix of reduced form coefficients on the L1 excluded instruments has rank = K1–1 where K1 = number of endogenous regressors. Under the null hypothesis, the statistic is distributed as chi-squared with degrees of freedom = (L1–K1 + 1). A rejection of the null hypothesis indicates that the matrix is full column rank, that is, that the model is identified.

Source: Author's calculations based on SHARE (2004–2017) data.

Table A4. Stage-one and stage-two results: Impact of ill health/ poor cognition on the overall work (*WORK*) of respondents aged 50–54 and comparison of IV ill health only vs ill health and poor cognition

	Austria	Belgium	Croatia	Czechia	Denmark	Estonia	France	Germany	Greece	Hungary
	A. Model 1: IV ill-health index only									
β_h^{WORK}	–8.97***	–7.95***	–5.49**	–10.22***	–8.80***	–7.87***	–6.58***	–8.16***	–3.83*	–10.78***
	(0.000)	(0.000)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)
Reduction [A]	–6.56	–6.11***	–7.67***	–12.59	–6.91	–7.03***	–6.76***	–3.89***	–5.28***	–18.13***
	(0.089)	(0.000)	(0.000)	(0.110)	(0.110)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	B. Model 2: IV ill–health index and poor cognition index									
β_h^{WORK}	–7.62***	–6.85***	–7.37***	–9.14***	–8.27***	–7.23***	–5.90***	–6.59***	–5.63***	–9.18***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_c^{WORK}	–0.92	–3.35***	–0.41	–3.18***	–2.20***	–2.61***	–3.99***	–1.99**	–1.15	–3.01*
	(0.262)	(0.000)	(0.809)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.253)	(0.022)
Reduction [B]	–2.86***	–4.30***	–4.12***	–7.08***	–3.93***	–5.78***	–4.24***	–4.03***	–4.23***	–7.56***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	C. Comparison models 1 and 2									
Reduction [A]–[B]	3.71	1.81**	3.55*	5.51	2.98	1.25	2.52*	–0.14	1.05	10.56***
	(0.337)	(0.002)	(0.012)	(0.485)	(0.489)	(0.113)	(0.037)	(0.891)	(0.376)	(0.000)
N	6 364	10 327	2 387	8 134	5 925	7 177	8 154	8 472	7 038	2 966

	Ireland	Israel	Italy	Luxembourg	Poland	Portugal	Slovenia	Spain	Sweden	Switzerland
	A. Model 1: IV ill–health index only									
β_h^{WORK}	–7.18*	–9.44***	–4.84***	–4.87	–6.25***	–5.34**	–8.11***	–8.90***	–8.75***	–4.70***
	(0.011)	(0.000)	(0.000)	(0.081)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.001)
Reduction [A]	–4.12	–12.08***	–6.10*	–6.40*	–6.07*	3.85	–9.05***	–8.62***	–10.88***	–3.61
	(0.137)	(0.000)	(0.040)	(0.012)	(0.014)	(0.177)	(0.000)	(0.000)	(0.000)	(0.552)
	B. Model 2: IV ill–health index and poor cognition index									
β_h^{WORK}	–6.99***	–5.45***	–4.03***	–5.88***	–8.92***	–2.15	–6.97***	–6.52***	–7.92***	–5.34***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.116)	(0.000)	(0.000)	(0.000)	(0.000)
β_c^{WORK}	–2.04	–4.42***	–6.06***	–0.31	–0.85	–0.86	–4.87***	–5.76***	–1.47	–1.51
	(0.396)	(0.000)	(0.000)	(0.803)	(0.415)	(0.511)	(0.000)	(0.000)	(0.081)	(0.090)
Reduction [B]	–3.97*	–8.52***	–6.24***	–2.90**	–7.76***	–1.49*	–6.62***	–7.32***	–2.62***	–2.07***
	(0.010)	(0.000)	(0.000)	(0.004)	(0.000)	(0.040)	(0.000)	(0.000)	(0.000)	(0.000)
	C. Comparison models 1 and 2									
Reduction [A]–[B]	0.15	3.55	–0.14	3.50	–1.69	–5.34	2.43*	1.30	2.43*	1.54
	(0.955)	(0.127)	(0.962)	(0.137)	(0.476)	(0.059)	(0.044)	(0.583)	(0.044)	(0.799)
N	991	3 845	8 563	2 004	2 905	2 023	5 100	8 614	5 100	4 558

*, ** and *** indicate statistical significance at the 10, 5 and 1 per cent levels, respectively.

Notes: *p*-values in parentheses. Underlying standard errors have been bootstrapped (100 iterations). Overall work (*WORK*) is the combination of hours (*HOURS*) and employment (*EMPL*). Physical/subjective health index instrumented by objective variables listed in table 3. Level of reduction predicted by health and/or cognition decline (0 = 50–54 level).

Source: Author's calculations based on SHARE (2004–17) data.