Health, Cognition and Work Capacity Beyond the Age of 50

International Evidence on the Extensive and Intensive Margin of Work

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Abstract

Many recent reforms raise the age of retirement. But can all older individuals work longer? To answer that question this paper uses the European SHARE survey. Results are essentially fivefold. First, physical health and cognitive performance deteriorate with age. Second, the 50-54 employment rate is negatively impacted by ill health, less so by poor cognition. Third, ill health affects employment much more than hours. Fourth, there is no evidence of health justification bias (Bound, 1991). Finally, declining health & cognition explain at most 35% of the observed work reduction. This hints at a sizeable underused work capacity among elderly Europeans.

Keywords: Ageing, Health, Cognition, Work, Work Capacity **JEL Codes:** J22, I10, J26

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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 19^{th} century, advanced economies have been gaining roughly 2.4 years of longevity every decade (Oeppen et al., 2002). But this trend, in combination with lower fertility, translates into population ageing. And this has far-reaching economic and socio-political consequences. Ceteris paribus, population ageing will cause declining labour forces and rising old-age dependency. This may hurt economic growth and the overall quality of life if governments need to divert public spending from education or infrastructure investment to fund elderly-related obligations.

Different things could adjust to combat the contraction of the working-age population and the rise of old-age dependency and have been explored theoretically and empirically (Acemoglu et al., 2018; Acemoglu, 2010; Vandenberghe et al., 2013). They comprise higher female participation to the labour force (at least in the countries where it remains very low), slightly longer hours of work, less unemployment or even shorter initial education (Vandenberghe, 2020). But so far, the most common form of adjustment retained by policymakers consists of raising the age of effective retirement. Researchers at the OECD (Martins et al., 2005) have shown numerically that indexing retirement age on (rising) life expectancy could stabilise old-age dependency ratios around their current levels, preventing dramatic tax increases to finance pay-as-you-go pensions, or a general reduction of the level of pensions. And indeed stricter retirement policies implemented since the mid-1990s have proved effective at increasing employment rates (Atalay et al., 2015).

However, one concern often raised is whether such policies are fair, given that some individuals may be too unhealthy, or lack the cognitive skills, to continue working productively for any longer while waiting to 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 SHARE data used in this paper confirm the existence of [A] a negative relationship between age and health. Unsurprisingly, SHARE also indicates [B] that when people get older they tend, on average, to work much less. But the correspondence between [A] and [B] is not enough to draw conclusions as to the relationship between age and people's capacity/ability to work. This is because there are many other factors than health or cognition that determine paid work among elderly people. Just consider the role of pension. When growing older, workers become eligible for pension money, and thus tend to stop supplying labour beyond certain eligibility thresholds.[1] What we need to estimate is how much health/cognition affect individuals' work capacity — a capacity which may remain significantly larger than what elderly employment patterns suggest. By focusing here on health (and also cognition), our intention is not to diminish the importance of other factors influencing employment at older ages, nor to draw conclusions about how much people must supply labour — many individuals will prefer to retire, regardless of their health/cognitive performances, and many may not have the opportunity to word due to a lack of demand for old labour (Vandenberghe, 2013) —, but rather to suggest how much they could work given their health/cognition.

To estimate work capacity this paper capitalises on and improves an estimation strategy pioneered by Cutler et al. (2013a). That method involves two stages. The first one aims at estimating the relationship between employment and health (controlling for other attributes, such as education and gender) at ages 50 to 54. The choice of this age range is justified by the wish to capture the relationship between health and employment that exists in the absence of access to (early)retirement benefits i.e. before workers attain eligibility for social security and other replacement benefits. At stage two of the Cutler method, stage-one estimates are used to predict the capacity to work at older ages (55-70). The idea is to combines the estimated effect of health (and other characteristics) on employment for those aged 50-54 with the actual health of those aged 55-70. This approach assumes that the relationship between health and employment will be the same for the two groups, but should generate declining estimates of work capacity with age since health declines with age.

Stage two is a counterfactual, and potentially very different than the actual work behaviour of elderly people. It is only about the likely contribution of health to the evolution of people' ability to work at ages 55 to 70. Contrary to most empirical work on age and work at these ages, the priority here is not to come out with a list of regressors delivering the best possible fit of the observed age/work profile. We just take the latter for what it is in the raw data, and we use it as a point of comparison to estimate the 'unused" work capacity i.e. the difference between the counterfactual (the health-predicted work capacity) and the observed work of elderly individuals. The priority is rather to come with the best possible description of people's health to compute the most plausible counterfactual. The reliability of results also depends heavily on the way stage one is conducted. At that level too, the priority is not so much to maximise the R^2 of the estimated model, but rather to *i)* account for the various dimensions of health that are likely to impact employment, and, what is more, *ii)* minimise

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

the risk of endogeneity. OLS-estimated coefficients can be biased if we omit key variables (i.e. dimensions of health influencing employment), if there are measurement errors, or in the presence of a particular version of the selection problem known as "justification" bias. This is the idea that to justify the fact that they don't work, non-working respondents exaggerate their degree of ill health, compare to working respondents.

The rest of the paper is organised as follows. In Section 1, we expose and discuss the existing literature on health and work capacity. Section 2 presents the two-stage estimation of work capacity, the key identification problems and the way we deal with them. Section 3 presents the SHARE microdata on work, health and cognition used in the paper. Results are presented in detail in Section 4, while Section 5 concludes.

2 The existing literature on age and work capacity and how we contribute to it

This paper is about "'work capacity" and its evolution with age. The two papers it relates directly to are Blundell et al. (2017) for the econometric methodology and that of Wise (2017) for the international coverage. It contributes to the literature on ageing and work, and more precisely the barriers to elderly employment. The relative focus is on the supply side of the labour market. We say "relative" because we all know that when it comes to labour, what we observe is always the result of the interaction of labour supply and labour 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. They will not be examined here, because that is not necessary to assess work capacity. Some of these barriers originate more on the demand side of the labour market (i.e. correspond to some firms' reluctance to employ or recruit elderly workers) and have been studied by Hutchens (1986), Hutchens (2010), Dorn et al. (2010), Dostie (2011), Skirbekk (2004), van Ours et al. (2011), Vandenberghe et al. (2013), or Delmez et al. (2018). Other barriers point at the supply side of the labour market, but should be distinguished from health/cognition barriers studied here. Economists have documented the important role of (early)pension schemes and other welfare regimes in enticing people to withdraw early from the labour force (Blöndal et al., 1999; Jousten et al., 2010). There is a large economic literature on joint retirement among dual-workers couples,...

The general impression about work capacity of elderly people is that it has improved over time. Using country-level data Oeppen et al. (2002) show that for 160 years, best-performance life expectancy has steadily increased by a quarter of a year per year. Other researchers, using the Global Burden of Diseases Study, show that the disease rates[2] have 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 et al. (2013b) pointed at a compression of morbidity towards the end of life. This barrage of good news could explain why authors like Börsch-Supan (2014) say that it is probably not true that most workers are too sick to continue working until the age of 70. The aim of this paper is to put the latter claim to the test, using individual-level international data to assess work capacity beyond the age of 50. In doing so we add to the existing literature on working capacity, with recent contributions by Jousten et al. (2010), Coile et al. (2016), Banks et al. (2016) and also, with a strong international dimension like in this paper, the work coordinated by Wise (2017).

Hereafter, like in the above-listed papers, 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, to estimate work capacity we use Cutler's two-stage method. There is an alternative method (Milligan et al., 2012; De Souza et al., 2019) but we do not implement it here as it relies on a much less precise definition of health i.e. the mortality rate for people of a given age.

What is our contribution to the literature on work capacity?

A strong international dimension. Contrary to many existing papers using the Cutler method, this one quantifies work capacity simultaneously for 20 countries (AUT, BEL, CHE, CZE, DEU, DNK, ESP, EST, FRA, GRC, HUN, IRL, ISR, ITA, LUX, PRT, SVN, SWE). And compared to Wise (2017)) this one has the advantage that it uses only one fully-harmonised data set, i.e. the Survey of Health, Ageing and Retirement in Europe (SHARE).[3]

Not just subjective/self-reported health. The reliability of the Cutler method depends on the use of finely grained microdata, properly describing people's health and how the latter evolves with age. This is particularly important for stage two. We use SHARE which comprises a rich set of indicators of health/cognition that may impact on work capacity. This includes self-reported/subjective evaluation of respondents' physical health, but also numerous and detailed, doctor-diagnosed health conditions (diabetes, blood pressure

[2] Age-standardised age-related rates
[3] Börsch-Supan et al. (2013).

problems, arthritis. . .), difficulties with mobility, grip strength...

Health but also cognition. Another strength of the paper is that it considers physical health, but also cognition; whose contribution the people's capacity to remain in paid employment is probably gaining in importance, given the economy's reduced reliance on physical work. SHARE is relatively rich in items like memory, math or numeracy test scores, that can be used to compute a cognitive performance index. As far as we know, cognition is absent from papers using the Cutler method. And considering the broader economics literature on the determinants of elderly work, it has received less attention. A notable exception is Blundell et al. (2017) for the UK and the USA. Other authors have examined the relationship between cognition and earnings, but not work (Anger et al., 2010). This said cognition as a dimension of ageing has generated a huge non-economic literature, in cognitive psychology (Salthouse, 2010) and related disciplines.

Not just employment. This paper examines both the extensive (employment) and the intensive margin of work (duration of work): most existing papers only consider the decision to work, and do not look at the relationship between ill health and/or poor cognition and the number of hours worked.[4]

Sound econometrics. The Cutler method can be implemented relatively easily using simple econometrics. And it has already been used that way many times, including in international comparison (Wise, 2017). But its reliability depends heavily on the way stage one is conducted. Most existing applications regress employment on self-reported health using OLS. This delivers a coefficient $\hat{\beta}$ that then drives stage-two predictions for work capacity. But Blundell et al. (2017) reminds us that properly estimating the effect of health on work is a research programme of its own. There is, in particular, the question raised by Bound (1991) of the magnitude of the "justification bias" relative to the traditional measurement error that one expects with self-reported health. To justify the fact that they don't work, non-working respondents may classify a given health problem as a more serious work limitation than working respondents, creating an upward bias of the OLS-estimated coefficients. In this paper we try to address this problem by resorting to instrumental variable (IV) regression, using the more "objective" measures of health as instruments for subjective health.

[4] A relatively recent survey by OECD et al. (2016) only mentions Pelkowski et al. (2004) and Moran et al. (2011) who both conclude to a negative impact on hours.

3 Method

3.1 Overall presentation

Cutler's stage one consists of estimating the relationship between health and/or cognition and the propensity to work. Existing papers define work as employment ($EMPL$) i.e. the extensive margin of labour. We also consider the intensive margin i.e. the number of hours worked ($HOURS$), plus what we call the overall work ($WORK$) ie. the number hours in the total population, where the extensive ($EMPL$) and intensive ($HOURS$) margins are combined.

Stage one involves only individuals that are still relatively young. Here, we have opted for those aged 50-54 for the reasons spelt out above (i.e. relatively high prevalence of health/cognition issues, but limited risk of work decisions driven by the availability of (early)pension benefits). Algebraically, we regress — separately for each country i present in SHARE — different dimensions of work ($Z = EMPL, HOURS, WORK$) on health and/or cognition.

$$Z_i^{50-54} = \beta_0^Z + \beta_h^Z HEALTH_i^{50-54} + \beta_c^z COGN_i^{50-54} + \gamma^z X_i^{50-54} + \epsilon_i^Z \tag{1}$$

with $Z = EMPL, HOURS, WORK$

At stage one, there are many econometric identification issues that are discussed extensively hereafter in Section 2.2. What matters for the moment is to note that the vector of coefficients $\hat{\beta}_0^z$, $\hat{\beta}_h^z$, $\hat{\beta}_c^z$ is retrieved from the estimation of 1. Note also that the model contains controls X_i^{50-54} (i.e; education, gender and time fixed effects delivering $\hat{\gamma}$).

At stage two, we apply $\hat{\beta}_0^Z$, $\hat{\beta}_h^Z$, $\hat{\beta}_c^Z$, to the health, cognition and control variables characterising individuals aged $a = 50..., 70$ — thus also those older than 50-54 — that inform about the evolution of health/cognition with age and deliver the respondents' expected work capacity.

$$\hat{Z}_i^a = \hat{\beta}_0^Z + \hat{\beta}_h^Z HEALTH_i^a + \hat{\beta}_c^Z COGN_i^a + \hat{\gamma}^z X_i^a \tag{2}$$

with $Z = EMPL, HOURS, WORK; a = 50, ..., 70$

The expected values in eq. 2 can then be used to compute various synthetic indicators of work capacity decline both in absolute and relative terms. We will focus on the cumulative impact over 20 years of age, by comparing results for individuals aged 50 to those for individuals aged 70. To quantify the unused work capacity, we will compare the [average] predicted work capacity values to those observed. In the same vein, we will compute the percentage δ of the actual/observed work change between the age of 50 and 70 that can be ascribed to work capacity (and thus health/cognition) decline.

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

The δs above can be computed as the ratio of two age-70 dummy coefficients (eq. 4) (θ^{70}, π^{70}) delivered by the regression of (respectively) predicted vs observed work on age dummies (50 being the reference age, corresponding to the intercepts).

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

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

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

3.2 Properly identifying the health/cognition-work relationship: the stage-one stake

Key in the above methodology is the estimation of the relationship between health/cognition and work among respondents aged 50-54. Blundell et al. (2017) contains an excellent review of possible biases. Hereafter, we will focus on those affecting OLS estimates that use subjective health responses. Note that these estimates are those commonly used by the existing papers on work capacity.

The broader literature on health and work (Baker et al., 2004 interpret subjective measures as "noisy" measures of a latent (unobserved) health stock H.[5] If $HEALTH$ in eq.1 represents the subjective health index constructed using the subjective/self-reported health items[6], 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 $VAR(\tau)$ on the denominator eq. 7 captures the attenuation bias; with noise (i.e. 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 just amounts to "noise". In that case, eq. 7 becomes

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

And $COV(\epsilon, \tau)$ on the numerator — where ϵ is the residual of the stage one eq. 1 — is different than zero. What is more, it is likely that $COV(\epsilon, \tau) > 0$ due to respondents' "justification bias" (Baker et al., 2004). This happens when they report values of health (and thus of τ_i) that are driven by their labour market status: with for instance unemployed individuals reporting lower level of health to justify their absence of employment. And as eq. 8 shows, 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 the two biases. O'Donnell et al. (2015) suggest that the justification bias dominates, resulting in an upward biased β^Z. However, Stern (1989) and Dwyer et al. (1999) do not find that the justification bias prevails. Our approach, hereafter will consist of using instrumental variables (IV)— to deliver what will be our preferred econometric model. We have many potential instruments to choose from. Following Blundell et al., 2017, we prioritise more "objective" health measures provided by SHARE i.e. doctor-diagnosed conditions, plus some results to physical/dexterity tests implemented by the SHARE investigators (Table 3).[7]

[5] This stock can be considered as the "true" measure of the health influencing work.

[6] e.g. see the last column of Table 2.

[7] All "objective" health measures have residual subjective or endogenous elements (has the doctor ever

Finally, it is straightforward to show that any subset of the "objective" health measures can be used to deliver unbiased estimates of $\tilde{\beta}^Z$. IV stage one consists of regressing subjective health index ($HEALTH$) on objective index (H^O) and delivers

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

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

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

At stage two, labour market outcome Z is regressed on the value predicted by $\hat{\eta}H^O$. Recalling that H is a combination of all objective health conditions H^0, and thus that $VAR(H) = VAR(H^0)$, we have that

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

4 Data

This paper uses waves 1,2 and 4 to 7 of the SHARE survey[8]; a total of 303,985 individuals X waves (Table 1). All individuals in SHARE are 50 or older when interviewed for the first time. Data limitations of different sorts (missing values, absence of repeated observations as the country participated only in one wave) explain that we retain 20 out of the 29 participating countries (AUT, BEL, CHE, CZE, DEU, DNK, ESP, EST, FRA, GRC, HUN, IRL, ISR, ITA, LUX, PRT, SVN, SWE) in the analysis.

told YOU about diabetes...; limitations are NOT measured by interviewer but reported by interviewee; grip strength is measure by the interviewer but requires the cooperation of the interviewee). So using those available in SHARE (Table 3) should no be seen as the perfect way to address the problem of measurement error and justification bias.

[8]Wave 3 contains life histories only, and is of no use here.

SHARE contains a rich set of items describing people's work (employment status and hours of work if employed) but also their health status and their cognitive performance. We split health variables in two broad categories, "subjective" (Table 2) and "objective" (Table 3). Most items in SHARE are self-reported/subjective (Table 2) but many also explicitly refer to conditions diagnosed by health professionals (heart attack, hypertension, cholesterol, stroke, diabetes, lung disease, cancer) or measured by the SHARE interviewers like 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/math test scores.

Hereafter, we will make extensive use of subjective health and cognition indexes. These are computed as the first principal components of items listed in (respectively) Table 2 and Table 4. When resorting to IV estimation, we use "objective" items listed in 3 to instrument the subjective health index that appears in the last column of Table 2.

Table 1: SHARE data. Observation[a] by country (lines) and wave[b] (col.)

	(Waves)						
	1	2	4	5	6	7	Total
AUT	1,522	1,181	5,096	4,303	3,362	3,187	18,651
BEL	3,637	3,147	5,194	5,546	5,716	4,853	28,093
CHE	952	1,460	3,680	3,000	2,775	2,386	14,253
CZE	.	2,669	5,392	5,541	4,801	4,192	22,595
DEU	2,926	2,585	1,610	5,616	4,354	3,797	20,888
DNK	1,614	2,551	2,236	4,064	3,668	3,216	17,349
ESP	2,276	2,375	3,663	6,579	5,569	4,676	25,138
EST	.	.	6,757	5,699	5,559	5,070	23,085
FRA	2,965	2,900	5,666	4,432	3,887	3,298	23,148
GRC	2,666	3,236	.	.	4,821	3,039	13,762
HRV	.	.	.	.	2,447	2,379	4,826
HUN	.	.	2,999	.	.	1,531	4,530
IRL	.	1,007	.	.	.	.	1,007
ISR	2,296	2,389	.	2,567	2,015	2,122	11,389
ITA	2,505	2,929	3,507	4,664	5,219	4,529	23,353
LUX	.	.	.	1,591	1,548	1,240	4,379
POL	.	2,429	1,721	.	1,807	4,651	10,608
PRT	.	.	1,962	.	1,665	487	4,114
SVN	.	.	2,708	2,924	4,197	3,681	13,510
SWE	2,996	2,765	1,963	4,516	3,884	3,183	19,307
Total	26,355	33,623	54,154	61,042	67,294	61,517	303,985
N	303,985						

Source: SHARE 2004-2017
[a]: year$X$respondents
[b]: wave 1 [2004], wave 2 [2007], wave 4 [2011], wave 5 [2013], wave 6 [2015], wave 7 [2017]. Wave 3 [2009] contains life histories only and is not used here.

Table 2: Subjective physical health [all ages pooled]

	General ill health^a	Self-perceived ill health (US scale)^b	Long-term illness^c	Limited in activities^d	# Limitations (daily living)^e	Limitations (instrumental)^f	Subjective ill-health index^g
AUT	3.02	3.02	3.01	2.35	0.25	0.50	-0.09
BEL	3.01	3.01	3.08	2.36	0.30	0.51	-0.10
CHE	2.71	2.71	3.58	2.58	0.10	0.19	-0.44
CZE	3.36	3.36	2.78	2.25	0.26	0.47	0.12
DEU	3.26	3.26	2.53	2.29	0.24	0.35	0.06
DNK	2.57	2.57	2.94	2.51	0.17	0.34	-0.39
ESP	3.38	3.38	2.96	2.51	0.39	0.73	0.09
EST	3.87	3.87	2.07	2.11	0.36	0.63	0.51
FRA	3.22	3.22	3.11	2.39	0.25	0.43	-0.03
GRC	2.99	2.99	3.57	2.64	0.17	0.46	-0.27
HRV	3.34	3.34	2.61	2.29	0.25	0.48	0.11
HUN	3.67	3.67	2.28	2.25	0.28	0.63	0.33
IRL	2.56	2.56	3.46	2.62	0.22	0.33	-0.47
ISR	3.21	3.21	2.78	2.39	0.45	0.98	0.11
ITA	3.27	3.27	3.35	2.44	0.28	0.50	-0.04
LUX	3.08	3.08	3.05	2.36	0.22	0.40	-0.09
POL	3.69	3.69	2.33	2.18	0.40	0.63	0.38
PRT	3.73	3.73	2.85	2.24	0.44	0.63	0.34
SVN	3.34	3.34	2.99	2.33	0.25	0.49	0.06
SWE	2.78	2.78	2.83	2.43	0.18	0.32	-0.25

Source: SHARE 2004-2017

[a]: 1(good)-5(bad) European scale

[b]: 1(good)-5(bad) US scale

[c]: Yes (1) No (0).

[d]: Limited in activities because of health [3(no)-1 scale(severely) scale].

[e]: Number of limitations with activities of daily living(0-6 scale).

[f]: Number of imitations with instrumental activities of daily living(0-9 scale).

[g]: First principal component of a-f items (the higher, the worse is people' s perceived health). Principal component analysis is carried with all countries pooled. Displayed values correspond to the predicted score values divided by standard deviation.

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

	Hart attack	Hypertens.	Cholest.	Stroke	Diabete	lung disease	Cancer cancer	Ulcer	Parkinson	Cataract	Hip frac.	Other frac.	Alzheimer senility	Arthritis	Mobility limit.[a]	Max. strength grip[b]
AUT	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
BEL	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
CHE	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
CZE	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
DEU	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
DNK	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
ESP	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
EST	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
FRA	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
GRC	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
HRV	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
HUN	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
IRL	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
ISR	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
ITA	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
LUX	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
POL	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
PRT	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
SVN	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
SWE	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

Source: SHARE 2004-2017
[a]: Number of limitations (measured by interviewer)
[b]: 0-100 (measured by interviewer)

Table 4: Cognition (all ages pooled)

	Orientation[a]	Memory1[b]	Memory2[c]	Verbal[d] fluency test	Numeracy[e] test	Cognitive health index[f]
AUT	3.80	5.44	4.11	22.47	3.69	-0.36
BEL	3.77	5.20	3.70	20.25	3.36	-0.09
CHE	3.88	5.57	4.33	20.56	3.81	-0.40
CZE	3.76	5.27	3.56	21.24	3.47	-0.14
DEU	3.83	5.52	3.97	21.35	3.62	-0.31
DNK	3.79	5.62	4.36	22.92	3.60	-0.42
ESP	3.55	3.97	2.62	15.17	2.53	0.72
EST	3.77	5.23	3.66	21.67	3.23	-0.11
FRA	3.73	4.85	3.49	19.02	3.14	0.11
GRC	3.83	4.96	3.44	14.04	3.35	0.19
HRV	3.84	5.29	3.60	19.08	3.30	-0.06
HUN	3.73	5.14	3.59	17.12	3.35	0.06
IRL	3.76	5.30	4.14	15.86	3.39	-0.02
ISR	3.64	4.68	3.22	17.86	3.32	0.20
ITA	3.77	4.59	3.11	14.91	2.98	0.38
LUX	3.79	5.33	4.29	18.06	3.42	-0.15
POL	3.77	4.40	2.90	16.14	2.99	0.40
PRT	3.75	4.35	3.11	14.35	2.72	0.51
SVN	3.79	4.94	3.22	21.43	3.16	0.02
SWE	3.83	5.33	4.10	22.92	3.63	-0.35

Source: SHARE 2004-2017
[a]: Score of orientation in time test [0:bad 4:good]
[b]: Score of words list learning test - trial 1 [1-10 words]
[c]: Score of words list learning test - trial 2 [1-10 words]
[d]: Score of verbal fluency test [0-100]
[e]: Score of first numeracy test [0:bad 5:good]
[f]: first principal component all previous cognition items (the higher, the worse is people's cognitive performance). Principal component analysis is carried with all countries pooled. Displayed values correspond to the predicted score values divided by standard deviation.

5 Results

5.1 The evolution of ill health and poor cognition with age

Descriptive statistics from SHARE show that subjective physical health deteriorates regularly with age, across all European countries (Figure 1). The same holds for cognitive performance (Figure 2). Remember that these indices measure ill health (or poor cognitive performance): the higher the index on display on Figures 1,2, the more respondents declare suffering from ill health (or achieve poorly in the cognitive performance tests). Figure 1 depicts the situation of individuals aged 50 to 70 [the ones we focus on in terms of their work capacity]. Similarly, for our cognition index: the higher the index on Figure 2, the more people perform poorly in the memory and numeracy tests underpinning the index.

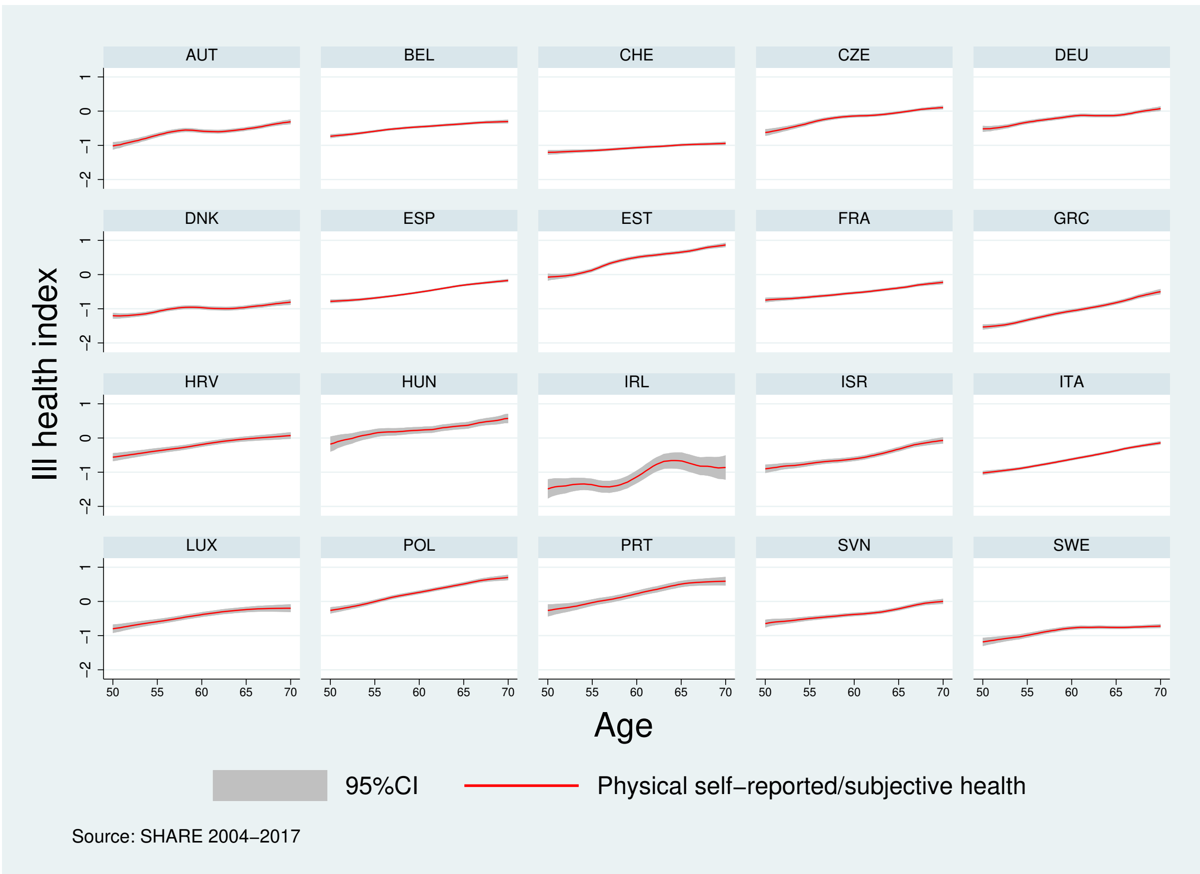

Figure 1: Age/ill-health index profiles, respondents aged 50-70

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 health index on age.

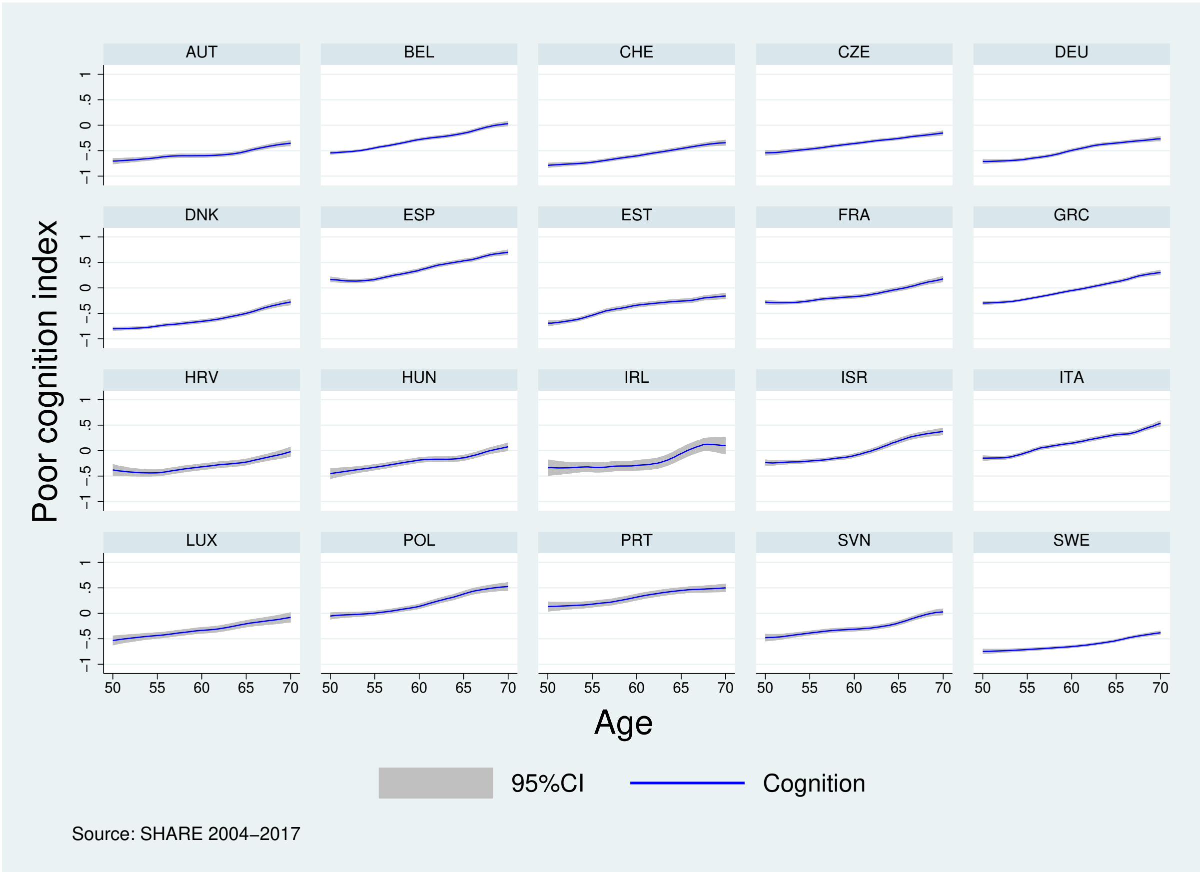

Figure 2: Age/Poor cognition index profiles, respondents aged 50-70

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 cognition index on age.

What is visible on Figures 1,2 is confirmed by a simple econometric analysis aimed at capturing the impact of an additional year of age on ill health and poor cognition (Figure 3). The reported results are point estimates, calculated separately for each age band of 5 years for individuals aged 50 to 80. All countries are pooled, but the regression equations contain country and also gender X education fixed effects. A coefficient of 0.05 means that an additional year of age leads to a rise of 5% of one standard deviation of our ill health/ poor cognition indices. Figure 3 shows that the impact of an additional year is always synonymous of a decline of health. Age band 50-54 seems to experience a larger deterioration per additional year of age than the 60-64 age band. But beyond 70, the deterioration unambiguously accelerates. As to cognition, there seems to be no impact of ageing in the age band 50-54, but then a steady deterioration of performance from 55 onward, and at a pace that clearly rises with age.

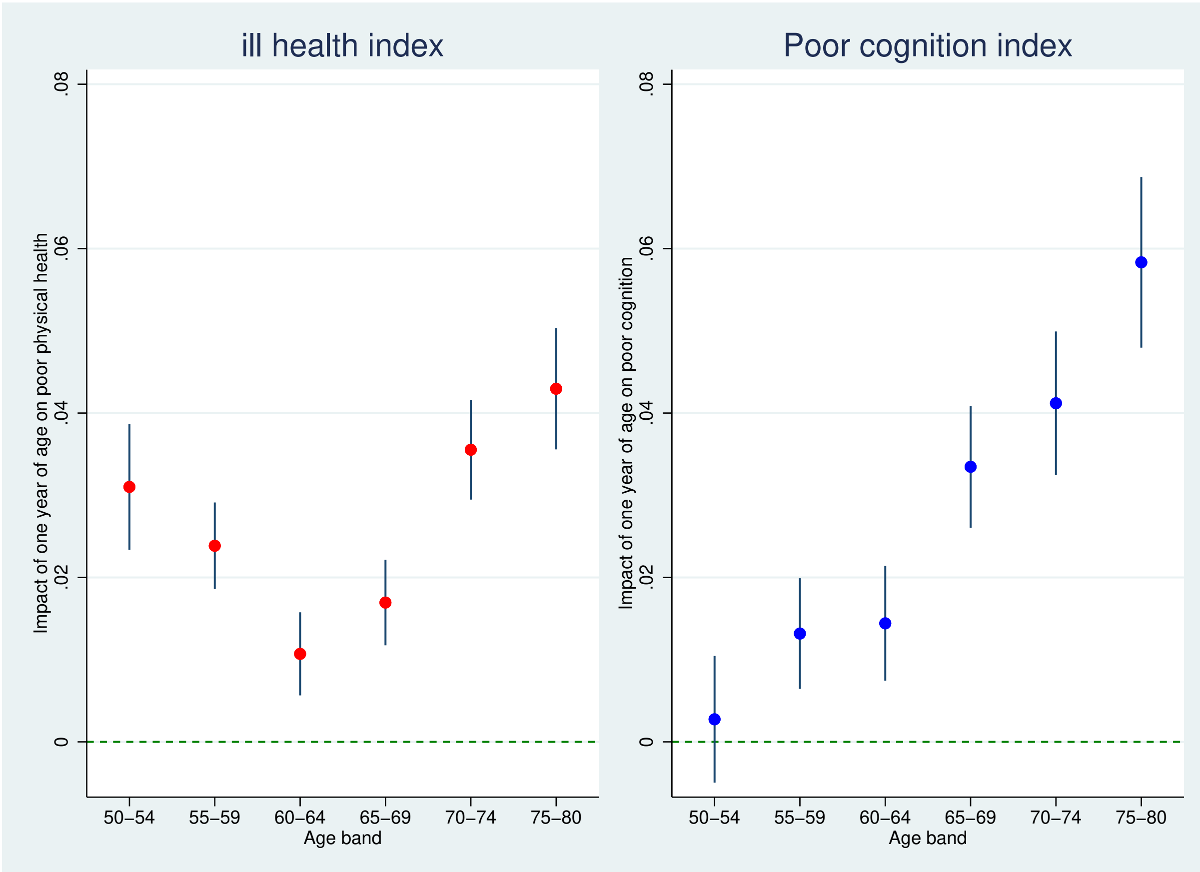

Figure 3: Marginal impact of ageing on ill physical health or poor cognition[a]

[a]: 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 one standard deviation of the health or cognition index. Vertical bars represent 95% confidence intervals. All countries are pooled but the regression equations contain educational attainment X gender and country X year fixed effects.

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

5.2.1 Stage-one results

In this section, we focus on what forms the core of this paper i.e. the likely impact of ill health and/or cognition on the work capacity of individuals aged 55-70.

Table 5 contains stage-one results delivered by our preferred IV model where subjective health is instrumented by "objective" health items listed in Table 3.[9] Those delivered by OLS are reported in the Appendix, Table 7. The upper part of Table 5 (panel A) reports the impact of ill health on work of individuals aged 50-54. The first line (β_h^{WORK}) shows the sizeable negative effect of ill health on overall work ($WORK$) i.e. the total number of hours worked in the 50-54 population. All countries display a negative statistically significant coefficient. In the case of Sweden (SWE), a value of -8.95 means that a 1 standard deviation of our ill-health index leads to almost 9 hours of reduction of the average number of hours worked in the 50-54 population. The next line (β_h^{EMPL}) captures the impact of a 1 standard deviation on the employment rate ($EMPL$). All coefficients are negative and statistically significant. And again the effects are large. Consider again the case of Sweden (SWE): a 1 standard-deviation rise of the value of the ill-health index is associated with an 18 percentage-point reduction of the employment rate. The last line (β_h^{HOURS}) of the upper part of Table 5 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 it suggests that the extensive margin (i.e. 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) exposes the results for cognition. It is immediate to see that the association between poor cognition and work among individuals aged 50-54 is weaker, whatever the dimension of work considered. That is even more visible in Figure 5 where we plot ill health and poor cognition estimates (β_h^{WORK}), (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 what we see for ill health. The tentative conclusion is that ill health plays a much greater role in determining people's participation to work than poor cognition. A nuance however it that SHARE is perhaps weaker at measuring cognition than health, or at least the components of cognition that matter for employment at the age of 50-54. One could argue that items listed in Table 4 point at 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 age band 55-59, the marginal impact of ageing on the poor cognition index is positive and statistically significant.

Before turning to stage-two results, it is worth stressing that our stage-one correction for endogeneity seems to matter. A comparison of IV- and OLS estimates for ill health (Figure 4) suggests that OLS leads to an underestimation of the negative impact of ill health on work

[9]Note that we only instrument health. We assume that our cognition index, as it assembles test scores administered by interviewers, is much less exposed to endogeneity problems.

among those aged 50-54. In the case of Sweden (SWE), we have seen that a rise of 1 standard deviation along the ill-health index causes a reduction of $WORK$ of 8.95 hours. It is only 6.78 with OLS. The other countries display similar magnitudes of IV-estimated coefficients being larger (in absolute value) than the OLS equivalent. This tentatively suggests the absence of a strong "justification bias". The above results are rather supportive of measurement-error problem inherent to the absence of a proper measure of the overall "stock" of health, that is synonymous with attenuation bias. Note that in Table 8 in the Appendix, we report the detailed outcome of the comparison of the predicted overall work ($WORK$) decline using OLS vs IV. Table 9 contains the results of the tests for weak instruments or under-identification. For all countries we reject the null of no statistically significant relationship between the subjective health index and the objective health measures. This demonstrates that our "objective" measures of health are strong predictors of the subjective health index. Finally, also in the appendix, we report the results of the comparison between two specifications of the IV model Table 10: one with physical health only, vs. one with physical health and cognition. We find no strong evidence in support of the richer specification that includes cognition. In the richer model, the coefficients for the ill-health index barely deviate from what they are in the richer model.

Table 5: Stage one results [IV^a]: impact of physical health & cognition on work of individuals aged 50-54 (point estimates β_h^Z,β_c^Z of the effect of a one standard deviation increment of the index on [a] work^b, [b] employment, and [c] hours)

	AUT	BEL	CHE	CZE	DEU	DNK	ESP	EST	FRA	GRC	HRV	HUN	IRL	ISR	ITA	LUX	POL	PRT	SVN	SWE
A.ill-health index																				
β_h^{WORK}	-10.41***	-7.96***	-4.46***	-12.22***	-8.70***	-9.84***	-8.83***	-9.30***	-6.27***	-4.24***	-8.85***	-11.44***	-6.76**	-9.00***	-5.47***	-6.26***	-11.72***	-6.23***	-8.95***	-8.95***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h^{EMPL}	-0.28***	-0.20***	-0.14***	-0.29***	-0.21***	-0.23***	-0.18***	-0.23***	-0.18***	-0.10***	-0.22***	-0.30***	-0.19**	-0.23***	-0.12**	-0.12*	-0.24***	-0.23*	-0.17***	-0.18***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.002)	(0.014)	(0.000)	(0.014)	(0.000)	(0.000)
β_h^{HOURS}	-0.02	-1.81	1.20	-1.02	-0.58	-2.02**	-3.24	-0.83	-0.80	-0.84	-2.42**	-0.90	-7.55*	0.71	-2.91*	-2.22	0.23	-3.23	-3.53	-2.15
	(0.993)	(0.066)	(0.165)	(0.279)	(0.391)	(0.009)	(0.077)	(0.424)	(0.402)	(0.625)	(0.002)	(0.651)	(0.015)	(0.628)	(0.012)	(0.233)	(0.908)	(0.556)	(0.063)	(0.127)
B. Poor cognition index																				
β_c^{WORK}	-3.34**	-1.57***	-2.10*	0.03	-0.07	-1.00	-4.15***	-1.82	-3.07***	0.39	1.53	-1.15	-2.57	-1.26	-3.99***	0.65	-0.75	0.24	-1.56	0.50
	(0.001)	(0.000)	(0.046)	(0.976)	(0.933)	(0.389)	(0.000)	(0.077)	(0.000)	(0.698)	(0.383)	(0.490)	(0.333)	(0.515)	(0.000)	(0.750)	(0.717)	(0.880)	(0.347)	(0.686)
β_c^{EMPL}	-0.05	-0.06***	-0.03*	-0.00	-0.04***	-0.05	-0.10***	-0.03	-0.04***	-0.01	0.06	-0.05	0.08	-0.03	-0.09***	0.01	-0.04	0.02	-0.03	0.02
	(0.113)	(0.000)	(0.026)	(0.808)	(0.000)	(0.079)	(0.000)	(0.161)	(0.001)	(0.567)	(0.122)	(0.196)	(0.327)	(0.404)	(0.000)	(0.796)	(0.305)	(0.673)	(0.413)	(0.411)
β_c^{HOURS}	-2.54*	0.40	-0.33	-0.19	1.25*	-0.70	-0.84	-0.04	-2.15***	0.65	-0.25	1.65*	-6.87***	-1.59*	-2.37***	0.85	0.65	2.03	-0.23	0.04
	(0.010)	(0.409)	(0.750)	(0.731)	(0.033)	(0.353)	(0.425)	(0.921)	(0.000)	(0.602)	(0.803)	(0.034)	(0.000)	(0.026)	(0.000)	(0.671)	(0.586)	(0.568)	(0.594)	(0.958)
N	18,373	27,750	13,966	22,209	20,680	17,206	24,474	22,369	22,644	13,710	4,822	4,523	1,003	10,880	23,137	4,372	10,265	4,010	13,478	18,772

Source: SHARE 2004-2017

p-values in parentheses. Underlying standard errors have been bootstrapped (100 iterations)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

^{a}: Physical/subjective health index instrumented by objective variables listed in Table 3

^{b}: The combination of hours ($HOURS$) and employment ($EMPL$)

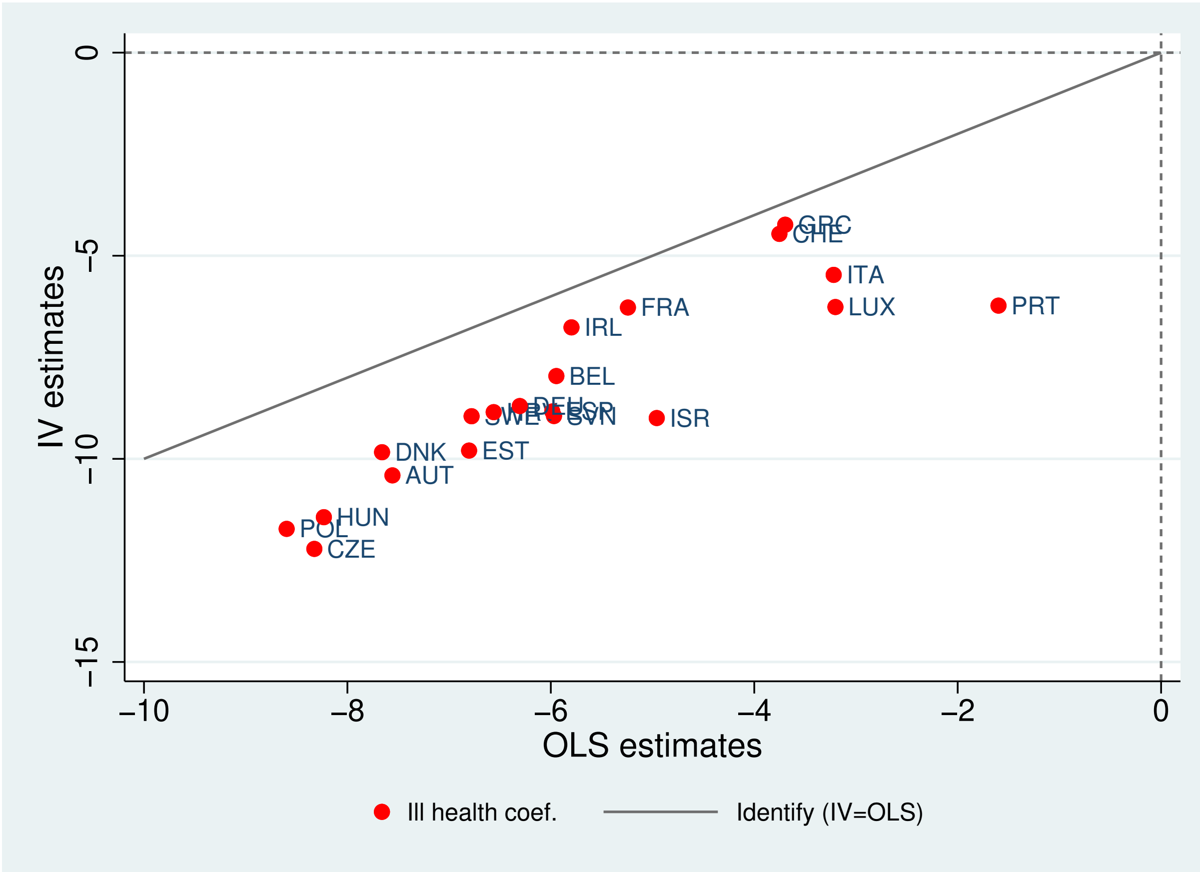

Figure 4: Comparison of IV- vs OLS- estimated impact of ill health on overall work (β_h^{WORK}). Individuals aged 50-54.

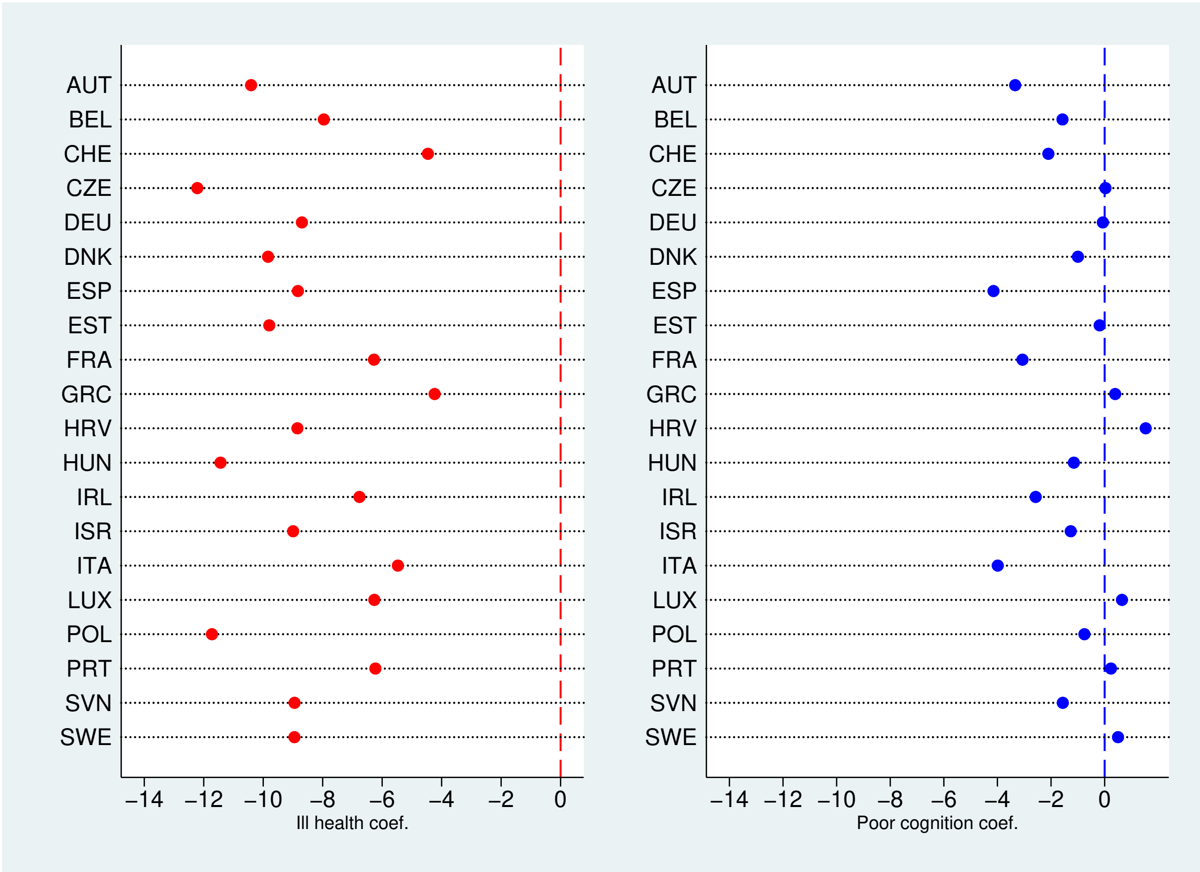

Figure 5: Comparison of ill health (β_h^{WORK}) vs poor cognition (β_c^{WORK}) impact on overall work. Individuals aged 50-54.

5.2.2 Stage-two results

Table 6 displays stage-two results. They are based on stage-one coefficients obtained with IV (Table 5 5) i.e. those we consider as the most robust one from an econometric viewpoint. They consist mostly of predictions as to what work should be, were health and cognition be its only determinants. As to these predictions, they are for individuals aged 70 and are calculated in deviation from the work capacity of individuals aged 50. In panel A, for instance for Sweden, we see that the employment rate should drop by 4.08 percentage points. And the overall work should decline by 2.193 hours. Panel B reports the same computations but in relative terms. Perhaps more interestingly, panel C presents our estimates of $\delta^{Z,50-70}$ (eq. 3,5 in Section 3): the share of the observed work decline between 50 and 70 that can be ascribed to the health/cognition-driven deterioration of work capacity. For Sweden (SWE) health/cognition deterioration only accounts for 2.48 percentage points of the observed decline of weekly hours. And 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 considering the overall work, we also get a health/cognition-related share of about 6.61 percentage points. Turning to the other countries, we see that shares explained by health/cognition decline are always statistically significant for the extensive margin (i.e. the employment rate). Also, these shares can rise to 35% in the case of Poland (POL). Luxembourg (LUX) is the only country for which we find a share that is not statistically different from zero.

Figure 6 visualises and extends the results of Table 6, as it displays the predicted work capacity for all possible ages between 50 and 70. The pattern that emerges — and more so it seems if relatively rich countries like Austria (AUT), Switzerland (CHE), Germany (DEU), Denmark (DNK) or Sweden (SWE) — is that of a relatively limited and smooth decline between 50 and 70. Across all countries, we predict a very small reduction of the hours worked ($HOURS$). 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. Also, and still in line with stage one results, we see we mostly predict a reduction of employment ($EMPL$). And, logically, the prediction of the decline of the overall labour supply ($WORK$) almost perfectly parallels what appends at the extensive margin.

Figures 7, 8, 9 are the graphical extensions of Table 6, panel C. They confront *i)* our work capacity predictions to *ii)* the actual work observed among individuals older than 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 (SWE) (Figure 7, last graph), we predict a reduction of the overall work ($WORK$) from 37.8 to 34 hours, between the age of 50 and the age of 70. By contrast, the actual work at that age is close to zero. The gap is less dramatic if we consider individuals aged 65 or 60, but still quite important; suggesting that even at those ages the unused work capacity is important. It is only below the age of 60 that we get some (visual) alignment between the health/cognition-driven prediction and the observed level of work. Figure 7 also reveals the heterogeneity across European countries regarding the moment a significant gap opens between the estimated work capacity and the actual work. Sweden (SWE) is, in fact, the country where it opens the latest; reflecting the well-publicised performance of the country when it comes to maintaining its older citizens in employment (Martin, 2018).

A final consideration is that of the relationship between our *i)* age 70 work capacity predictions and *ii)* the economic wealth of the different countries examined here. Although these are all European[10], and thus are relatively similar at the global level, they diverge quite significantly in terms of relative living conditions. For instance, the GDP per head of Switzerland (CHE) is more than double that of POLAND (POL), and significantly larger than that of Belgium (BEL). Do these differences matter for work capacity beyond the age of 50? A simple plot (Figure 10) suggests that the answer might be yes. We see that — particularly for 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 head and the average health of a population and how the latter declines with age.

[10] Except Israel(ISR).

Table 6: Stage-two results: work reduction among 70 year olds (ref. 50-year-olds) explained by poor physical health and/or cognition. Estimates based on stage one IV-estimated health/cognition to work relationship, see Table 5

	AUT"	BEL	CHE	CZE	DEU	DNK	ESP	EST	FRA	GRC	HRV	HUN	IRL	ISR	ITA	LUX	POL	PRT	SVN	SWE
A. Level of reduction predicted by health and/or cognition decline (0= 50-54 level)																				
$WORK^b$	-3.068***	-4.224***	-0.623	-6.785***	-2.660***	-3.887***	-5.347***	-6.201***	-4.112***	-0.460	-3.875**	-6.566***	-5.307*	-5.735***	-4.192***	0.510	-8.107***	0.942	-5.368***	-2.193**
	(0.000)	(0.000)	(0.408)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.672)	(0.004)	(0.000)	(0.028)	(0.000)	(0.000)	(0.730)	(0.000)	(0.451)	(0.000)	(0.001)
$EMPL$	-0.0778***	-0.122***	-0.0605***	-0.155***	-0.107***	-0.101***	-0.131***	-0.140***	-0.0980***	-0.0288	-0.0865**	-0.176***	-0.0812	-0.174***	-0.112***	-0.0233	-0.240***	-0.0965**	-0.120***	-0.0408**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.211)	(0.009)	(0.000)	(0.050)	(0.000)	(0.000)	(0.425)	(0.000)	(0.003)	(0.000)	(0.004)
$HOURS$	-0.372	-0.128	1.680*	-1.185*	1.471**	-0.0539	-1.701*	-0.855*	-1.297***	0.296	-0.457	0.561	-4.743*	0.0482	-0.913	1.266	2.664	4.054*	-1.234*	-0.488
	(0.506)	(0.764)	(0.027)	(0.031)	(0.003)	(0.903)	(0.030)	(0.046)	(0.001)	(0.789)	(0.419)	(0.559)	(0.024)	(0.971)	(0.224)	(0.185)	(0.050)	(0.023)	(0.030)	(0.264)
B. % of reduction predicted by health and/or cognition decline (1= 50-54 level)																				
$WORK$	-0.111***	-0.151***	-0.0210	-0.204***	-0.0951***	-0.120***	-0.213***	-0.195***	-0.136***	-0.0201	-0.160**	-0.246***	-0.186*	-0.234***	-0.164***	0.0179	-0.311***	0.0893	-0.181***	-0.0611**
	(0.000)	(0.000)	(0.412)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.672)	(0.003)	(0.000)	(0.021)	(0.000)	(0.000)	(0.735)	(0.000)	(0.469)	(0.000)	(0.001)
$EMPL$	-0.109***	-0.162***	-0.0722***	-0.192***	-0.141***	-0.119***	-0.199***	-0.178***	-0.121***	-0.0492	-0.152**	-0.269***	-0.115*	-0.264***	-0.159***	-0.0303	-0.383***	-0.153**	-0.161***	-0.0458**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.213)	(0.007)	(0.000)	(0.044)	(0.000)	(0.000)	(0.423)	(0.000)	(0.003)	(0.000)	(0.004)
$HOURS$	-0.00195	0.0126	0.0553**	-0.0152	0.0531***	-0.00119	-0.0171	-0.0214	-0.0164	0.0306	-0.00897	0.0326	-0.0805	0.0413	-0.00603	0.0497	0.117*	0.287*	-0.0248	-0.0160
	(0.893)	(0.305)	(0.008)	(0.305)	(0.000)	(0.936)	(0.376)	(0.069)	(0.107)	(0.263)	(0.564)	(0.259)	(0.105)	(0.399)	(0.758)	(0.103)	(0.012)	(0.050)	(0.082)	(0.279)
C. Share of observed work reduction explained by health and/or cognition decline (1=100%), $\delta^{Z,50-70\ a,b}$																				
$WORK$	0.117***	0.174***	0.0238	0.223***	0.102***	0.140***	0.229***	0.256***	0.149***	0.0229	0.255**	0.272***	0.200*	0.263***	0.193***	-0.0205	0.638***	-0.0791	0.205***	0.0661**
	(0.000)	(0.000)	(0.411)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.673)	(0.003)	(0.000)	(0.019)	(0.000)	(0.000)	(0.735)	(0.000)	(0.462)	(0.000)	(0.001)
$EMPL$	0.109***	0.165***	0.0781***	0.197***	0.142***	0.125***	0.203***	0.207***	0.124***	0.0499	0.150**	0.269***	0.124*	0.313***	0.167***	0.0306	0.355***	0.157**	0.163***	0.0476**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.213)	(0.007)	(0.000)	(0.041)	(0.000)	(0.000)	(0.423)	(0.000)	(0.003)	(0.000)	(0.004)
$HOURS$	0.0245	0.0150	-0.128	0.129	-0.225	0.00547	0.206	0.101	-2.949	0.0999	-0.0377	-0.108	1.167	-0.00232	0.175	-0.135	-0.145	1.275	0.0599	0.0248
	(0.607)	(0.991)	(0.054)	(0.930)	(0.826)	(0.912)	(0.249)	(0.077)	(0.344)	(0.928)	(0.554)	(0.729)	(0.933)	(0.971)	(0.973)	(0.960)	(0.051)	(0.872)	(0.361)	(0.266)
N	18,373	27,750	13,966	22,209	20,680	17,206	24,474	22,369	22,644	13,710	4,822	4,523	1,003	10,880	23,137	4,372	10,265	4,010	13,478	18,772

Source: SHARE 2004-2017

p-values in parentheses. Underlying standard errors have been bootstrapped (100 iterations)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a]: Corresponding to eq. 4 and eq. 5 in Section 3

[b]: The combination of hours and employment

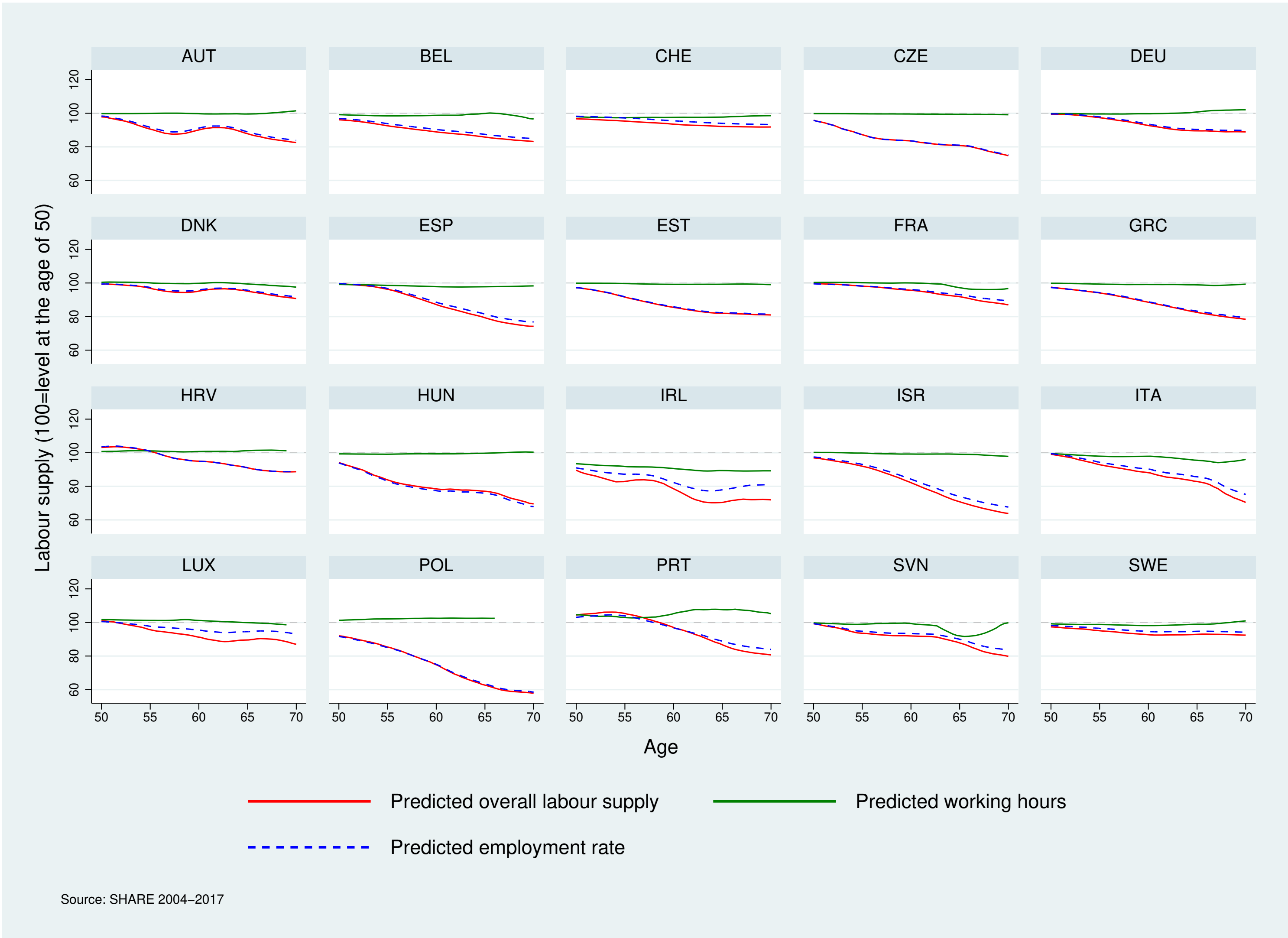

Figure 6: Predicted working hours ($HOURS$), employment rate ($EMPL$) & overall work ($WORK$). Individuals aged 50-70

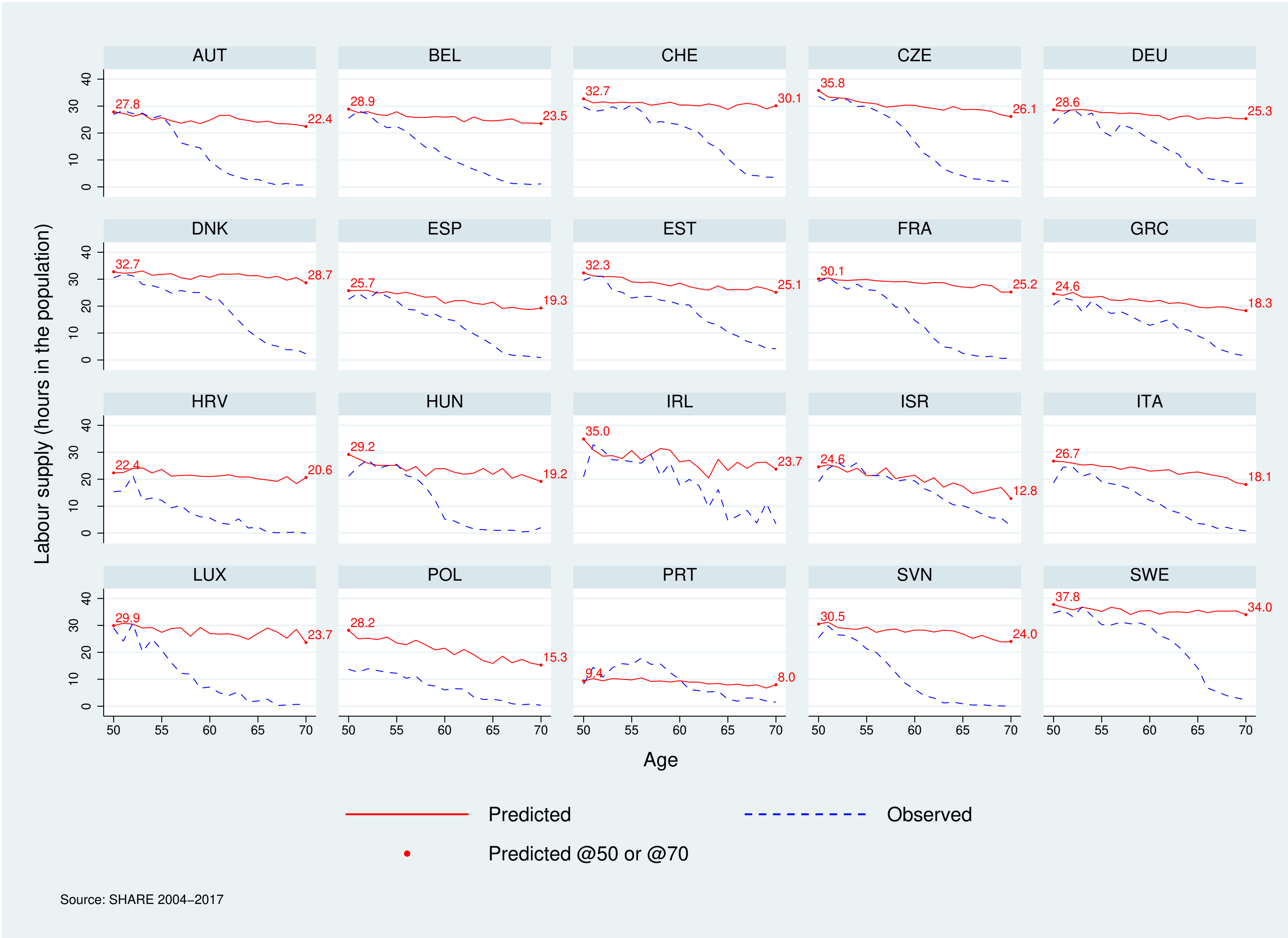

Figure 7: Predicted vs. observed overall work ($WORK$). Individuals aged 50-70

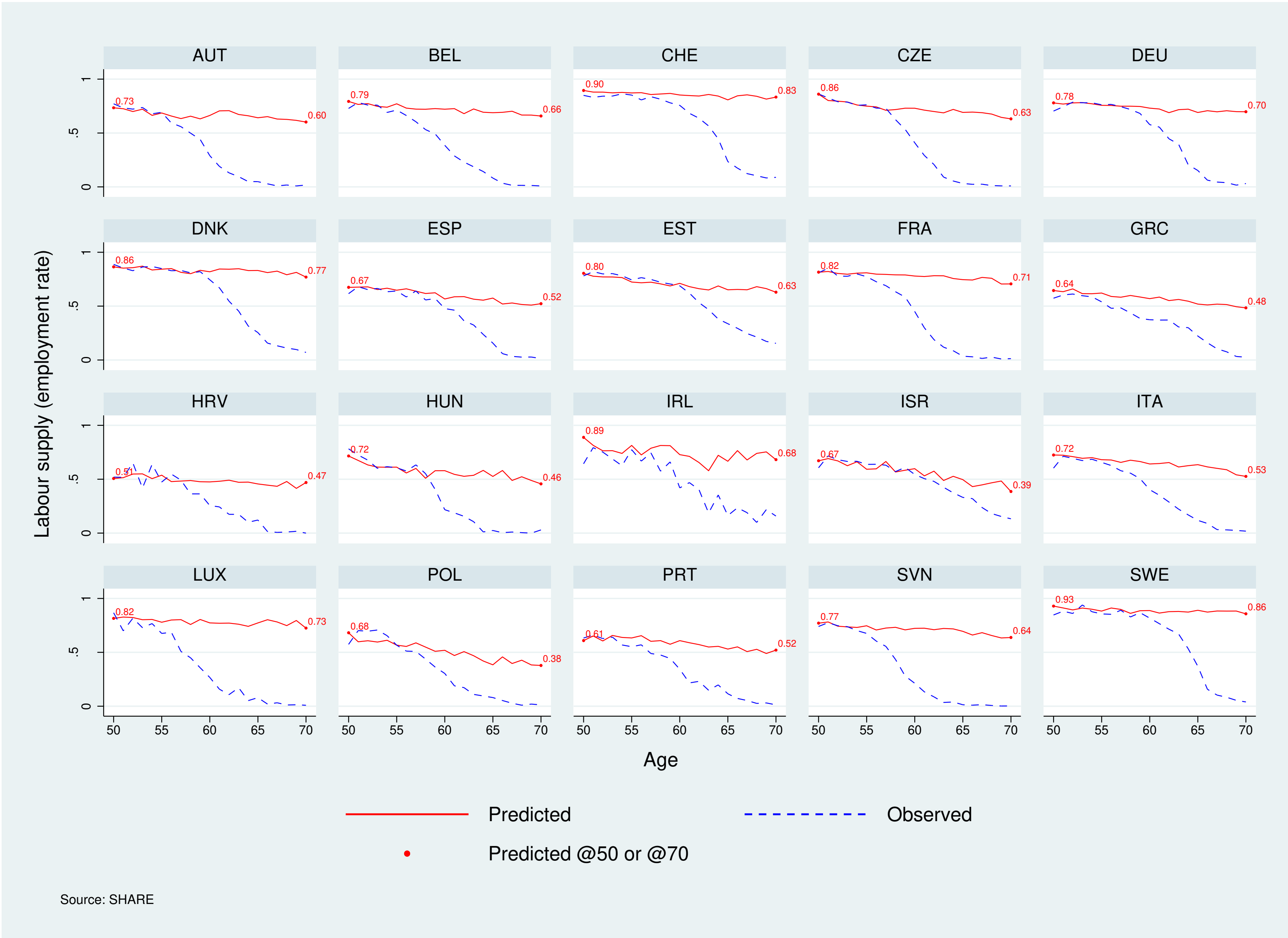

Figure 8: Predicted vs. observed employment rate ($EMPL$). Individuals aged 50-70

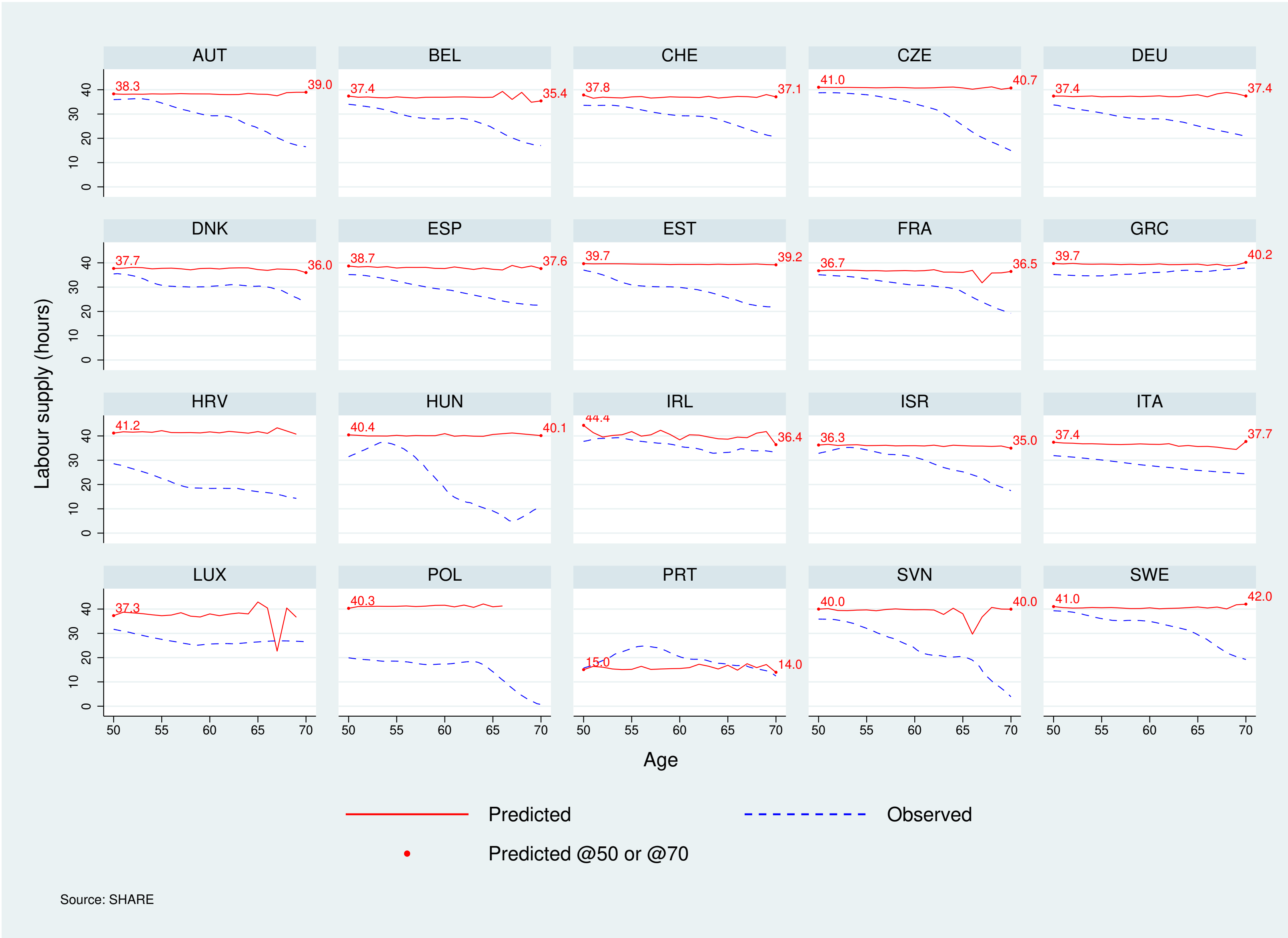

Figure 9: Predicted vs. observed working hours ($HOURS$). Individuals aged 50-70

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/cognitive capacity to work longer. This paper explores this question by asking how much older individuals (on average) could work were they obeying the same health/cognition to work relationship as individuals aged 50-54. The method assumes 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.... up 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 et al. (2015) for a review of the (rather mixed) evidence.[11] The results exposed in the paper should be interpreted with these limitations in mind.

Contrary to most existing papers this one quantifies work capacity simultaneously for 20 countries (AUT, BEL, CHE, CZE, DEU, DNK, ESP, EST, FRA, GRC, HUN, IRL, ISR, ITA, LUX, PRT, SVN, SWE) who tend to differ quite significantly in many respects (GDP par capital, welfare but also labour-market institutions). It uses comparable fully harmonised microdata, amassed via the SHARE survey. Another strength of the paper is that it considers physical health, but also cognition — a dimension of ageing that has received less attention.[12] What is more, health is not just subjective; it encompasses many "objective" items (i.e. diagnosed conditions). Also — and to our knowledge this is also new among papers on work capacity — we examine both the extensive and the intensive margins of work. Most existing papers only consider the former.[13] Another clear strength of our paper 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 aged 50-54. We show that OLS, as used in Wise, 2017, underestimate the negative impact of ill health on people's capacity to work.

[11] Some papers point at work, in particular long hours or night shifts, accelerating health decline; while others suggest exactly the opposite. There is abundant literature asking whether retirement is good for health. The is also a sizeable literature that discusses whether retirement is good or armful for cognition (Mazzonna et al., 2012; Bonsang et al., 2012).

[12] A notable exception is Blundell et al. (2017) for the UK and the USA. Other authors have examined the relationship between cognition and earnings but not work (Anger et al., 2010).

[13] A relatively recent survey by OECD et al. (2016) only mentions Pelkowski et al. (2004) and Moran et al. (2011) who both conclude to a negative impact of ill health not just on employment but also hours.

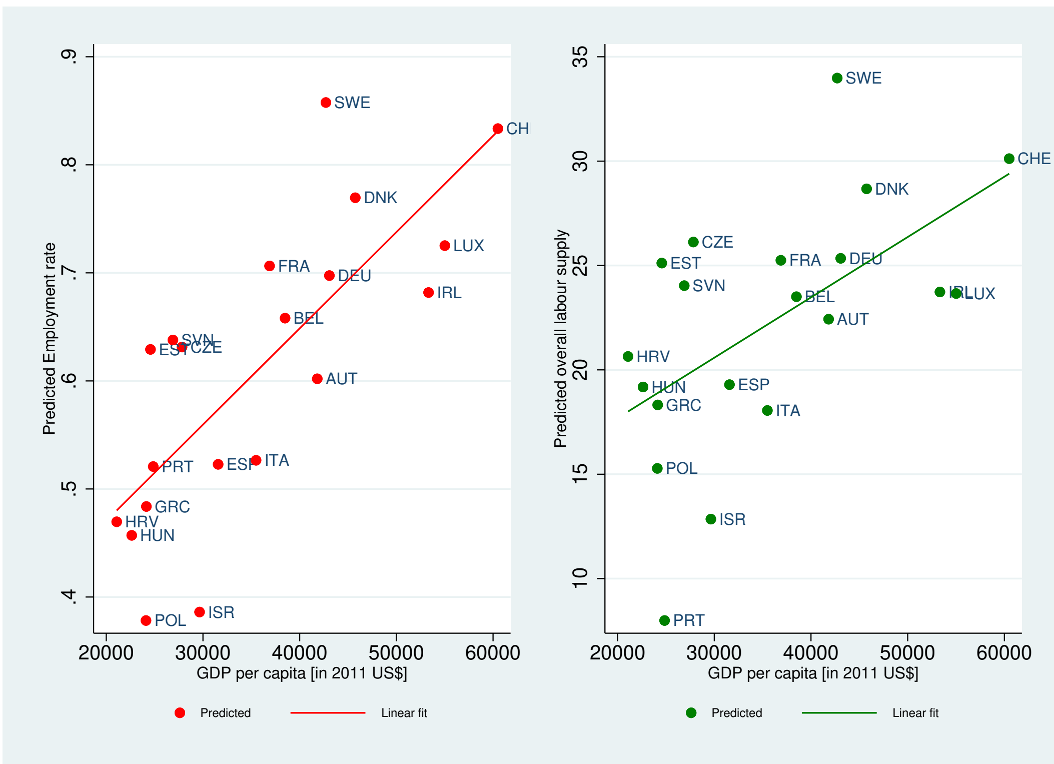

Figure 10: Predicted work capacity at the age of 70 & GDP[a] per capita (predicted employment rate ($EMPL$) & overall work ($WORK$)

[a]: Real GDP at constant 2011 national prices.

The results gathered in this paper are essentially fivefold.

First, there is solid evidence that people aged 50-54 with health problems significantly reduce their participation in employment. This result is relatively unsurprising and aligns with those already published by economists using the Cutler method (Wise, 2017; Coile et al., 2016; Banks et al., 2016; Cutler et al., 2013a).

Second, a novelty of our paper is to simultaneously examine the impact of declining health on hours worked (i.e. the intensive margin of work). We find evidence that the latter impact is also negative, but is of much smaller magnitude and 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 physical health, we detect no impact of poor cognition 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 aligns with the recent findings of Blundell et al. (2017) for the UK and the US.

Fourth, we find no evidence of health "justification bias". Our results rather point at approximation problems when people describe their health, causing measurement errors. Previous research (e.g. Bound, 1991) has conjectured that subjective self-reports of health cause upward bias in the OLS-estimated effect of ill health on work. To justify the fact that they don't work, non-working respondents may classify a given health problem as a more serious work limitation than working respondents. We rather find the opposite when we instrument (IV) self-reported health by objective health measures provided by SHARE i.e. doctor-diagnosed conditions, plus some results to physical/dexterity tests implemented by the SHARE investigators. We argue that this is supportive of a rather more potent measurement-error problem known to create a downward bias.

Fifth, this paper shows that declines in health/cognition explain at most 35% of the observed work reduction between the age of 50 and 70 — and smaller percentages if we consider slightly younger categories of older workers. Our results support the idea that many old individuals, across a relatively large and diverse set of European countries, have the capacity to work up to the age of 70. This result aligns with those of Wise (2017). Note an interesting extension that does not appear in the Wise (2017) study: we find a positive correlation between GDP per capita and work capacity at the age of 70.

[14]However, one might argue that this result points at SHARE being less good at measuring cognition than physical health, at least the dimensions that matter for work.

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 old employment. They comprise supply-side ones like a preference for leisure, the fact that spouses' retirement decisions tend to be correlated, caretaking obligations or still — despite many pension reforms aimed at addressing the problem — financial disincentives to postpone retirement. More on the demand side (i.e. that of firms and employers in general), older individuals' capacity to work may be seriously hampered by rampant age discrimination (Neumark et al., 2015), or an employability handicap driven by a low productivity/labour-cost ratio compared to prime-age or young workers (Dostie, 2011; Vandenberghe, 2011, Vandenberghe, 2013; van Ours et al., 2011).

Also, it is important to repeat that the conclusion of the paper is not to say that all those whose health/cognition means that they could work should necessarily work. Some individuals may well prefer to choose to retire early and receive a smaller pension. And some countries could afford or would be willing to pay for retirement before work capacity declines markedly. After all, most old-age pension schemes in place in Europe have not been primarily (or are no longer) designed as invalidity schemes.[15]

Finally, it is useful to recall that the methods and results presented in this paper address the work capacity of the population overall. Even if, as amply shown by this paper, the health/cognition of most individuals are sufficiently good to work up to 70, there are many individuals that are too sick to work. Already some (relatively) young individuals aged 50-54 are prevented from working due to their bad health condition.[16] Thus, as already stated by Coile et al. (2016) or 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 the absence or limited capacity to work.

Acknowledgement

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[15]For an in-depth analysis of the long-term evolution of the role of pension schemes in the USA see Costa (1998).

[16]Otherwise, we would not be able to estimate the relation between health and work, and compute estimates of work capacity.

5, 6, 7. See Börsch-Supan et al. (2013) for methodological details. The SHARE data collection has been funded by the European Commission through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA No 211909, SHARE-LEAP: GA No 227822, SHARE M4: GA No 261982) and Horizon 2020 (SHARE-DEV3: GA No 676536, SERISS: GA No 654221) and by DG Employment, Social Affairs & Inclusion. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C) and from various national funding sources is gratefully acknowledged (see www.share-project.org)

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.* Working Paper, Working Paper Series 24421. 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". *The Review of Economics and Statistics* 97 (1): 71–87.

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

Banks, James, Carl Emmerson, and Gemma Tetlow. 2016. *Health Capacity to Work at Older Ages: Evidence from the United Kingdom.* Working Paper, Working Paper Series 21980. 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: 13–37.

Blöndal, Sveinbjörn, and Stefano Scarpetta. 1999. *The Retirement Decision in OECD Countries.* OECD Economics Department Working Papers 202. OECD Publishing.

Blundell, Richard, et al. 2017. *The impact of health on labour supply near retirement.* IFS Working Papers W17/18. 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 series 201422. Munich Center for the Economics of Aging (MEA) at the Max Planck Institute for Social Law and Social Policy.

Börsch-Supan, Axel, et al. 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.

Chang, Angela, et al. 2019. "Measuring population ageing: an analysis of the Global Burden of Disease Study 2017". *The Lancet Public Health* 4 (): e159–e167.

Coile, Courtney, Kevin S Milligan, and David A Wise. 2016. *Health Capacity to Work at Older Ages: Evidence from the U.S.* Working Paper, Working Paper Series 21940. National Bureau of Economic Research.

Costa, Dora L. 1998. "The Evolution of Retirement". In *The Evolution of Retirement: An American Economic History, 1880-1990*, 6–31. University of Chicago Press.

Cutler, David M., Ellen Meara, and Seth Richards-Shubik. 2013a. *Health and Work Capacity of Older Adults: Estimates and Implications for Social Security Policy.*

Cutler, David M, Kaushik Ghosh, and Mary Beth Landrum. 2013b. *Evidence for Significant Compression of Morbidity In the Elderly U.S. Population.* Working Paper, Working Paper Series 19268. National Bureau of Economic Research.

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?" *The Journal of the Economics of Ageing* 13 (C): 72–83.

Delmez, Francoise, 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, and Olivia Mitchell. 1999. “Health problems as determinants of retirement: Are self-rated measures endogenous?” *Journal of Health Economics* 18 (2): 173–193.

Hutchens, Robert. 1986. “Delayed Payment Contracts and a Firm’s Propensity to Hire Older Workers”. *Journal of Labor Economics* 4 (4): 439–57.

— . 2010. “Worker characteristics, job characteristics, and opportunities for phased retirement”. *Labour Economics* 17 (6): 1010–1021.

Jousten, Alain, et al. 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*, 47–76. NBER Chapters. National Bureau of Economic Research, Inc.

Martin, John. 2018. *Live Longer, Work Longer: The Changing Nature of the Labour Market for Older Workers in OECD Countries.* IZA Discussion Papers 11510. Institute of Labor Economics (IZA).

Martins, Joaquim Oliveira, et al. 2005. *The Impact of Ageing on Demand, Factor Markets and Growth.* OECD Economics Department Working Papers 420. OECD Publishing.

Mazzonna, Fabrizio, and Franco Peracchi. 2012. “Ageing, cognitive abilities and retirement”. *European Economic Review* 56 (4): 691–710.

Milligan, Kevin S, and David A Wise. 2012. *Health and Work at Older Ages: Using Mortality to Assess the Capacity to Work across Countries.* Working Paper, Working Paper Series 18229. 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, no. 3 (): 505–514.

Neumark, David, Ian Burn, and Patrick Button. 2015. *Is It Harder for Older Workers to Find Jobs? New and Improved Evidence from a Field Experiment.* NBER Working Papers 21669. National Bureau of Economic Research, Inc.

O’Donnell, Owen, Eddy Van Doorslaer, and Tom Van Ourti. 2015. “Chapter 17 - Health and Inequality”. In *Handbook of Income Distribution*, ed. by Anthony B. Atkinson and François Bourguignon, 2:1419–1533. Handbook of Income Distribution. Elsevier.

OECD and European Union. 2016. *Health at a Glance: Europe 2016.* 200.

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

Pelkowski, Jodi Messer, and Mark C Berger. 2004. "The impact of health on employment, wages, and hours worked over the life cycle". *The Quarterly Review of Economics and Finance* 44 (1): 102–121. ISSN: 1062-9769.

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 (1): 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, and Lenny Stoeldraijer. 2011. "Age, Wage and Productivity in Dutch Manufacturing". *De Economist* 159 (2): 113–137.

Vandenberghe, V., F. Waltenberg, and M. Rigo. 2013. "Ageing and employability. Evidence from Belgian firm-level data". *Journal of Productivity Analysis* 40 (1): 111–136.

Vandenberghe, Vincent. 2020. *Ageing Calls for Shorter Full-Time Tertiary Education and Increased Continuing Education.* IRES Discussion Papers 2020001. UCLouvain-IRES.

— . 2013. "Are firms willing to employ a greying and feminizing workforce?" *Labour Economics* 22 (C): 30–46.

— . 2011. "Boosting the Employment Rate of Older Men and Women". *De Economist* 159 (2): 159–191.

Wise, David A. 2017. *Social Security Programs and Retirement around the World: The Capacity to Work at Older Ages.* NBER Books 22. National Bureau of Economic Research, Inc.

Appendix

Table 7: Stage one results [OLS]: impact of physical health & cognition on work of individuals aged 50-54 (point estimates β_h^Z,β_c^Z of the effect of a one standard deviation increment of the index on overall work[a] [a], employment [b] and hours [c])

	AUT"	BEL	CHE	CZE	DEU	DNK	ESP	EST	FRA	GRC	HRV	HUN	IRL	ISR	ITA	LUX	POL	PRT	SVN	SWE
										A.ill-health index										
β_h^{WORK}	-7.56***	-5.95***	-3.75***	-8.32***	-6.30***	-7.66***	-5.99***	-6.80***	-5.24***	-3.70**	-6.56***	-8.23***	-5.80***	-4.96***	-3.22***	-3.20***	-8.60***	-1.60	-5.97***	-6.78***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.328)	(0.000)	(0.000)
β_h^{EMPL}	-0.19***	-0.15***	-0.11***	-0.21***	-0.16***	-0.19***	-0.14***	-0.17***	-0.15***	-0.07**	-0.15***	-0.20***	-0.14***	-0.12***	-0.07***	-0.08*	-0.20***	-0.16***	-0.12***	-0.15***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.017)	(0.000)	(0.000)	(0.000)	(0.000)
β_h^{HOURS}	-0.35	-0.76	-0.35	-1.03	-0.62	-1.45***	-2.13*	-0.21	-0.27	-1.86	-1.15	-1.78	-5.43***	-0.46	-1.23	-1.75***	-0.25	2.83	-2.01	-1.98*
	(0.723)	(0.115)	(0.672)	(0.195)	(0.156)	(0.000)	(0.014)	(0.788)	(0.501)	(0.178)	(0.072)	(0.153)	(0.000)	(0.731)	(0.072)	(0.001)	(0.745)	(0.283)	(0.085)	(0.042)
										B. Poor cognition index										
β_c^{WORK}	-0.67	-2.49***	-2.41*	-2.49**	-0.64	-1.68**	-4.35***	-1.90**	-3.04***	0.39	1.15	-1.25	-3.44	-2.09	-3.96***	-0.35	-0.66	0.10	-2.77*	-0.73
	(0.254)	(0.000)	(0.024)	(0.001)	(0.334)	(0.003)	(0.000)	(0.004)	(0.000)	(0.726)	(0.375)	(0.517)	(0.109)	(0.111)	(0.000)	(0.749)	(0.717)	(0.953)	(0.026)	(0.512)
β_c^{EMPL}	-0.02*	-0.07***	-0.05***	-0.04	-0.04**	-0.03*	-0.09***	-0.02	-0.04***	-0.01	0.04	-0.05	0.02	-0.05	-0.08***	-0.01	-0.04	-0.03	-0.06*	0.00
	(0.038)	(0.000)	(0.000)	(0.074)	(0.003)	(0.013)	(0.000)	(0.145)	(0.001)	(0.471)	(0.129)	(0.337)	(0.798)	(0.056)	(0.001)	(0.731)	(0.284)	(0.336)	(0.033)	(0.941)
β_c^{HOURS}	-0.38	0.18	-0.33	-1.22	0.93	-0.39	-1.85*	-0.93**	-2.06***	1.04	0.32	2.26	-5.32*	-0.70	-2.15***	0.78	1.14	1.58	-0.58	0.07
	(0.600)	(0.763)	(0.781)	(0.077)	(0.088)	(0.476)	(0.030)	(0.004)	(0.001)	(0.403)	(0.624)	(0.058)	(0.010)	(0.499)	(0.000)	(0.519)	(0.125)	(0.576)	(0.273)	(0.942)
N	18,373	27,750	13,966	22,209	20,680	17,206	24,474	22,369	22,644	13,710	4,822	4,523	1,003	10,880	23,137	4,372	10,265	4,010	13,478	18,772

Source: SHARE 2004-2017
p-values in parentheses. Underlying standard errors have been bootstrapped (100 iterations)
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a]: The combination of hours and employment

Table 8: Stage one results: impact of physical health & cognition on overall work $(WORK)^a$ of individuals aged 50-54 Comparison: OLS vs IV^b

	AUT”	BEL	CHE	CZE	DEU	DNK	ESP	EST	FRA	GRC	HRV	HUN	IRL	ISR	ITA	LUX	POL	PRT	SVN	SWE
	Model 1: OLS ill-health index & poor cognition index																			
β_h^{WORK} OLS	-7.56***	-5.95***	-3.75***	-8.32***	-6.30***	-7.66***	-5.99***	-6.80***	-5.24***	-3.70***	-6.56***	-8.23***	-5.80**	-4.96***	-3.22***	-3.20*	-8.60***	-1.60	-5.97***	-6.78***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.017)	(0.000)	(0.247)	(0.000)	(0.000)
β_c^{WORK} OLS	-0.67	-2.49***	-2.41**	-2.49***	-0.64	-1.68**	-4.35***	-1.90**	-3.04***	0.39	1.15	-1.25	-3.44	-2.09	-3.96***	-0.35	-0.66	0.10	-2.77**	-0.73
	(0.353)	(0.000)	(0.006)	(0.001)	(0.303)	(0.002)	(0.000)	(0.004)	(0.000)	(0.703)	(0.470)	(0.442)	(0.134)	(0.074)	(0.000)	(0.790)	(0.559)	(0.947)	(0.008)	(0.380)
	Model 2: IV ill-health index & poor cognition index																			
β_h^{WORK} IV	-10.41***	-7.96***	-4.46**	-12.22***	-8.70***	-9.84***	-8.83***	-9.80***	-6.27***	-4.24**	-8.85***	-11.44***	-6.76*	-9.00***	-5.47***	-6.26*	-11.72***	-6.23***	-8.95***	-8.95***
	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.012)	(0.000)	(0.000)	(0.021)	(0.000)	(0.000)	(0.000)	(0.000)
β_c^{WORK} IV	-3.34	-1.57*	-2.10*	0.03	-0.07	-1.00	-4.15***	-0.19	-3.07***	0.39	1.53	-1.15	-2.57	-1.26	-3.99***	0.65	-0.75	0.24	-1.56	0.50
	(0.081)	(0.025)	(0.018)	(0.982)	(0.927)	(0.420)	(0.000)	(0.878)	(0.000)	(0.725)	(0.406)	(0.547)	(0.349)	(0.404)	(0.000)	(0.731)	(0.551)	(0.905)	(0.231)	(0.604)
	Comparison models 1 & 2																			
β_h^{WORK} IV-OLS	-2.85**	-2.02**	-0.71	-3.89***	-2.39***	-2.18**	-2.85**	-2.99**	-1.03	-0.54	-2.29	-3.20*	-0.97	-4.04***	-2.25*	-3.06	-3.13**	-4.63**	-2.98**	-2.17*
	(0.008)	(0.001)	(0.536)	(0.001)	(0.001)	(0.005)	(0.009)	(0.003)	(0.162)	(0.628)	(0.093)	(0.013)	(0.621)	(0.001)	(0.034)	(0.150)	(0.003)	(0.005)	(0.010)	(0.036)
β_c^{WORK} IV-OLS	-2.66	0.92*	0.31	2.52*	0.58	0.68	0.20	1.72	-0.03	-0.00	0.38	0.10	0.87	0.82	-0.03	1.00	-0.09	0.14	1.20	1.22
	(0.142)	(0.047)	(0.345)	(0.037)	(0.104)	(0.539)	(0.781)	(0.074)	(0.930)	(0.997)	(0.674)	(0.901)	(0.658)	(0.294)	(0.952)	(0.398)	(0.879)	(0.920)	(0.169)	(0.065)
N	6,364	10,327	4,558	8,134	8,472	5,925	8,614	7,177	8,154	7,038	2,387	2,966	991	3,845	8,563	2,004	2,905	2,023	5,100	6,866

Source: SHARE 2004-2017

p-values in parentheses. Underlying standard errors have been bootstrapped (500 iterations)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a]: The combination of hours and employment

[b]: Physical/subjective health index instrumented by objective variables listed in Table 3

[c]: Level of reduction predicted by health and/or cognition decline (0= 50-54 level)

Table 9: Validity of objective health items as instruments of subjective health index

	Cragg-Donald Wald F statistic[a]	Kleibergen-Paap rk Wald F statistic[a]	Cragg-Donald Wald LM statistic[b]	Cragg-Donald Wald LM statistic [p-value]
AUT	58.24	65.4328	213.50	0.0000
BEL	168.70	161.9989	483.90	0.0000
CHE	49.99	51.7269	165.68	0.0000
CZE	69.22	186.2675	300.69	0.0000
DEU	97.95	93.0086	414.24	0.0000
DNK	99.80	97.2003	328.62	0.0000
ESP	93.70	81.0782	370.97	0.0000
EST	89.56	189.0850	340.82	0.0000
FRA	113.21	103.6121	401.69	0.0000
GRC	82.54	70.1884	325.32	0.0000
HRV	30.00	70.2251	128.47	0.0000
HUN	28.63	51.4255	103.54	0.0000
IRL	18.43	102.7409	35.75	0.0011
ISR	43.39	57.4291	163.60	0.0000
ITA	72.38	64.7244	344.10	0.0000
LUX	13.03	40.7144	64.67	0.0000
POL	49.46	123.2353	198.35	0.0000
PRT	17.07	19.0707	72.35	0.0000
SVN	40.00	40.8839	147.94	0.0000
SWE	38.31	41.0943	147.58	0.0000

Source: SHARE 2004-2017

[a]: The Cragg-Donald/Kleibergen-Paap Wald test are weak identification tests. They are in essence a F-test (i.e. it test the significance of all stage-on regressors to be jointly equal to zero) that accounts for the presence of heteroscedasticity.

[b]: The underidentification test is an LM test of whether the equation is identified, i.e., 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, the statistic is distributed as chi-squared with degrees of freedom=(L1-K1+1). A rejection of the null indicates that the matrix is full column rank, i.e., the model is identified.

Table 10: Stage one and stage two results: impact of physical health & cognition on overall work ($WORK^a$) of individuals aged 50-54. Comparison : IV[b] physical health only vs. physical health plus cognition

	AUT"	BEL	CHE	CZE	DEU	DNK	ESP	EST	FRA	GRC	HRV	HUN	IRL	ISR	ITA	LUX	POL	PRT	SVN	SWE
										A. Model 1 - IV ill-health index only										
β_h^{WORK}	-8.97***	-7.95***	-4.70**	-10.22***	-8.16***	-8.80***	-8.90***	-7.87***	-6.58***	-3.83**	-5.49**	-10.78***	-7.18**	-9.44***	-4.84***	-4.87	-6.25***	-5.34***	-8.11***	-8.75***
	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)	(0.009)	(0.000)	(0.007)	(0.000)	(0.000)	(0.067)	(0.000)	(0.001)	(0.000)	(0.000)
Reduction[c] [A]	-6.56	-6.11***	-3.61	-12.59	-3.89***	-6.91	-8.62**	-7.03***	-6.76***	-5.28***	-7.67***	-18.13***	-4.12	-12.08***	-6.10*	-6.40*	-6.07*	3.85*	-9.05***	-10.88***
	(0.173)	(0.000)	(0.487)	(0.053)	(0.000)	(0.132)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.128)	(0.000)	(0.021)	(0.013)	(0.027)	(0.029)	(0.000)	(0.000)
										B. Model 2- IV ill-health index & poor cognition index										
β_h^{WORK}	-7.62***	-6.85***	-5.34***	-9.14***	-6.59***	-8.27***	-6.52***	-7.23***	-5.90***	-5.63***	-7.37***	-9.18***	-6.99***	-5.45***	-4.03***	-5.88***	-8.92***	-2.15	-6.97***	-7.92***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.107)	(0.000)	(0.000)
β_c^{WORK}	-0.92	-3.35***	-1.51	-3.18***	-1.99**	-2.20***	-5.76***	-2.61***	-3.99***	-1.15	-0.41	-3.01*	-2.04	-4.42***	-6.06***	-0.31	-0.85	-0.86	-4.87***	-1.47
	(0.250)	(0.000)	(0.093)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.263)	(0.793)	(0.032)	(0.390)	(0.000)	(0.000)	(0.812)	(0.437)	(0.485)	(0.000)	(0.068)
Reduction[c] [B]	-2.86***	-4.30***	-2.07***	-7.08***	-4.03***	-3.93***	-7.32***	-5.78***	-4.24***	-4.23***	-4.12***	-7.56***	-3.97*	-8.52***	-6.24***	-2.90**	-7.76***	-1.49*	-6.62***	-2.62***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.014)	(0.000)	(0.000)	(0.003)	(0.000)	(0.048)	(0.000)	(0.000)
										C. Comparison models 1 & 2										
Reduction[c] [B]-[A]	3.71	1.81*	1.54	5.51	-0.14	2.98	1.30	1.25	2.52	1.05	3.55*	10.56***	0.15	3.55	-0.14	3.50	-1.69	-5.34**	2.43*	8.26**
	(0.439)	(0.018)	(0.767)	(0.395)	(0.884)	(0.515)	(0.619)	(0.131)	(0.052)	(0.368)	(0.020)	(0.000)	(0.954)	(0.108)	(0.957)	(0.134)	(0.523)	(0.003)	(0.022)	(0.005)
N	6,364	10,327	4,558	8,134	8,472	5,925	8,614	7,177	8,154	7,038	2,387	2,966	991	3,845	8,563	2,004	2,905	2,023	5100	6866

Source: SHARE 2004-2017

p-values in parentheses. Underlying standard errors have been bootstrapped (500 iterations)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a]: The combination of hours and employment

[b]: Physical/subjective health index instrumented by objective variables listed in Table 3

[c]: Level of reduction predicted by health and/or cognition decline (0= 50-54 level)