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# Differentiating Retirement Age to Compensate for Career Arduousness

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## Abstract

Population ageing in Europe calls for an overall rise in the age of retirement. However, many argue that this age should be differentiated to account for individuals' career arduousness. This paper explores the relevance of this idea. It combines the 7<sup>th</sup> wave of the SHARE panel data on health at an older age and US occupational O\*NET data. With these unique data it first quantifies the impact of entire career arduousness on health at typical retirement age, relative to other key determinants (gender, childhood health, parental longevity). It then estimates the degree of retirement age differentiation that would be needed to compensate individuals for their career-related health handicap/advantage and get closer to “real” actuarial fairness. Using the age of 65 as a reference, results point at the need for differentiation ranging from 60 to 71. But the paper also shows that systematic retirement age differentiation would fail to match a significant portion of the full distribution of health at an older age. In a world where retirement policy compensates for career-related arduousness there would still be a lot of unaccounted health differences; in particular those related to health endowment. Using variance decomposition methods, we estimate that career-arduousness represents at most 5.83% of the model-explained variance of health at an older age.

**Keywords:** Ageing, Health, Retirement Policy, SHARE, O\*NET, Compensating Career Arduousness

**JEL Codes:** J14, I1, 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.<sup>1</sup> But this trend 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, say, R&D, 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. They have been explored theoretically and empirically (Acemoglu and Restrepo, 2018; Acemoglu, 2010). They comprise more capital-intensive production processes, productivity gains, a higher female participation to the labour force (at least in the countries where it remains very low), slightly longer hours of works, more flexible work arrangements,<sup>2</sup> less unemployment or even shorter initial education. 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 that indexing retirement age on (rising) life expectancy could stabilise old-age dependency ratios, 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 and Barrett, 2015), although from an historically low level (Costa, 1998).

However, one concern often raised is whether such policies are fair, as some workers had more demanding occupations than others, and that prospective retirees differ a lot in terms of their health status and remaining life expectancy.<sup>3</sup> This paper intends to analyse that question by focusing on the career-arduousness-related health gradient around the age at which retirement typically takes place.

The question we ask more specifically in this paper is: what would it take in terms of lowering(raising) the retirement age to neutralise the impact of low/high arduousness careers on expected health at the moment of retirement? The normative foundations can

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<sup>1</sup>Since the end of the 19<sup>th</sup> century, advanced economies have been gaining roughly 2.4 years of longevity every decade (Oeppen and Vaupel, 2002).

<sup>2</sup>To attract into paid employment people who otherwise stay completely out of the labour force.

<sup>3</sup>There is strong evidence that ill-health at 50 is correlated with a shorter life span/early death. De Nardi et al. (2016) show that lifespan is 3.3 years shorter for those with bad health than for those with good health, while Pijoan-Mas and Ríos-Rull (2014) show the equivalent numbers are 5.6 for men and 4.7 for women at age 50.

be characterised as Bismarkian, and also as “real” actual fairness. The perspective is Bismarkian because of the focus on *work-related* health differences; those that occurred during the contributory years.<sup>4</sup> The other normative reference is “real” actuarial fairness. Strictly speaking actuarial fairness means that lifetime contributions and benefits should equate.<sup>5</sup> But, in more utilitarian terms, arduousness differences indicate that some euros of accrued pension benefits have caused more disutility. And potential long-term health consequences of having exerted an arduous job suggest that people’s ability to enjoy pension benefits may vary a lot. What is more, there is no actual fairness, in its strict financial acception, if remaining life is significantly shorter for individuals who had more arduous careers.<sup>6</sup>

The rest of this paper is organised as follows. Section 2 reviews the existing literature on retirement age differentiation and exposes our contribution to that literature. In Section 3, we present the data used in this empirical paper: the SHARE data on (ill-)health and job history; and those from O\*NET on arduousness by occupation . Section 4 exposes how we compute the differentiated retirement ages. Section 5 presents the main results of the paper, while Section 6 concludes.

## 2 Literature

This paper contributes to the literature on ageing and retirement, and more precisely on the importance of health heterogeneity<sup>7</sup> at the age at which, in Europe, individuals usually retire.<sup>8</sup> It explores empirically what it would take in terms of retirement age differentiation to account for that heterogeneity; more precisely the part of the heterogeneity that can reasonably be ascribed to varying working conditions. This paper relates to the literature on health and retirement/labour supply, but with the important nuance that the focus

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<sup>4</sup>It is common to distinguish Bismarckian and Beveridgean pension regimes. Bismarckian ones are contributory and in that sense work-related. Benefits are paid *pro rata* the duration and level of contributions. This is a basic feature of the first fully-fledged public pension scheme introduced by German Chancellor Bismarck in 1889. By contrast, Beveridgean pensions (in reference to the British economist W. Beveridge who presided over the design the British system) are non-contributory and distribute means-tested benefits to people who do not qualify for a contributory pension (i.e. those who never worked...).

<sup>5</sup>That condition can be seen as the acturian’s version of the Bismarckian idea of a link between benefits and contributions.

<sup>6</sup>Appendix A.4. contains evidence from the data used in this paper that is supportive of negative work-arduousness/longevity relationship.

<sup>7</sup>And indirectly life expectancy heterogeneity

<sup>8</sup>In most parts of Europe the age of 65 has become the reference legal retirement age (OCDE, 2019).

is more on how the age of eligibility should vary to account for the existence of a work-related health gradient than on how the latter influences individuals’ timing of retirement.<sup>9</sup> That shift of focus partially reflects the European context underpinning this paper, where retirement is still largely driven by State-edicted rules, and decided paternalistically by the authorities. And of course, given its focus on work-related long-term health differences, this paper connects with the literature on demanding occupations and (early)retirement provision (Pestieau and Racionero, 2016; Vermeer et al., 2016).

The long-term impact of work on health has long been investigated in the epidemiology, psychology, and sociology literature; but to a lesser extent in economics (Barnay, 2016, Bassanini and Caroli, 2015). Most research and policy debates underline various negative consequences of work and working conditions such as stress, physical exhaustion, work-related disabilities, overall poor health as well as premature death. Using data from the US National Health Interview Survey (NHIS), Case and Deaton (2005) showed that manual workers, with low education or low wealth, have higher rates of health deterioration and that their physical health will deteriorate more rapidly with age than non-manual workers.

Beyond the link between work and health, many works underline that past (often early stages of life) personal experience can undermine health and professional pathways cumulatively over the life course Lindeboom (2012). There are long-lasting effects of family and social background, or childhood conditions on health status in adulthood, and thus also at an older age .

Our contribution to the literature is essentially fourfold.

- First, we assemble information on respondents’ *entire* career using European job-history data. These provide a detailed account (at ISCO 4-digit level) of successive occupations, their length, whether work was on part-time vs. full-time basis. We merge these with US data on arduousness by occupation. As far as we know, this represents the first attempt by economists to quantify the arduousness of the entire career of a large representative sample of Europeans aged 50 and more.

- Second, the paper demonstrates that it is possible to quantify career arduousness and, what is more, its contribution to ill-health at an older age. Going from a “naive” regression (controlling only for gender and age) to a “complete” regression, controlling for initial health endowment (i.e. childhood health and parental longevity) and country fixed effects, we quantify the likely contribution of career arduousness to ill-health at the typical age at

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<sup>9</sup>For a review of the latter question see French and Jones (2017).

which Europeans retire (ie. 60-69). We provide evidence of the existence of a systematic (and statistically significant) association between arduousness and ill-health at an older age.

- Third, the paper tries to inform the policy debate. The paper provides realistic estimates of the degree of retirement age differentiation that would be needed to compensate for career-related health differences at older age, and get a step closer to “real” actuarial fairness. Our best estimates suggest that the individuals with the most arduous careers should be allowed to retire at the age of 60-61 while those with the least arduous professional histories should go at the age of 70-71.<sup>10</sup>

- Four, we quantify the relative importance of career arduousness in comparison with other determinants of ill-health at an older age, and we show that the former makes a relatively small contribution to the variance in health. Other determinants play a greater role. And this tentatively stresses the potential role of other policies (e.g. early-life public health interventions) in addition to retirement age differentiation to allow healthy ageing.

### 3 Data

One of our main variables is ill-health amongst older Europeans. That information comes from the Survey on Health, Ageing and Retirement in Europe (SHARE). All individuals in SHARE are 50 or older when interviewed for the first time. We use waves 1-2 and 4-7 (2004-2017) of the SHARE survey to assess people’s health at old age and how it evolves with biological ageing. In most analyses reported hereafter we focus on respondents aged 60-69. SHARE contains a rich set of items describing people’s physical health status that we use extensively here. Most health items are self-reported, and many are subjective in the sense that they correspond to how people self-assess their overall health status. But SHARE also explicitly refers to specific health conditions, diagnosed by health professionals: heart attack, hypertension, cholesterol, stroke, diabetes, lung disease, cancer, .... Descriptive statistics about our SHARE health items are reported in Appendix A.1. (Table 4). SHARE interviewers also realise measurements like the maximum grip strength of respondents (next to the last column of Table 4). In what follows, we will make extensive use of a physical ill-health index. The latter is computed as the first principal component<sup>11</sup> of items listed in Table 4.

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<sup>10</sup>We impose that the median arduousness corresponds to retirement at the age of 65.

<sup>11</sup>The values reported later have been standardised internationally. This means that a one-unit change of the index corresponds to one standard deviation of the international distribution of the health index.

Another key variable in our analysis is career arduousness/arduousness. We use detailed information about people’s entire career to quantify the arduousness of their successive occupations. The information on the job history self comes from the 7<sup>th</sup> wave of SHARE. This wave was conducted across 28 European countries and Israel in 2017. The point is that the 7<sup>th</sup> wave contains several “retrospective” modules, whose aims are to provide detailed data about each respondent’s history. The data work-history module consists of the successive ISCO08 4-digit occupations people have been through since their entrance into the labour market. We also know which has been their main occupation, the length of the employment spells for each occupation, or whether these were a part-time or full-time job spell.

As to the quantification of the arduousness for each occupation reported in SHARE Wave 7, this paper uses data from O\*NET. This is a thorough, US-based, assessment of job and occupation content. O\*NET contains information on more than 1,000 occupations and describe,<sup>12</sup> among others, the tasks, knowledge, skills, abilities necessary to perform the job as well as the work context. We link the American job classification used in O\*NET to the SHARE ISCO08 4-digit code<sup>13</sup> and collapse the O\*NET data into a arduousness index. The O\*NET modules we use are related to interpersonal relationship at work (e.g. contact with others, responsibility for other’s health and safety, face-to-face discussions), physical working conditions (e.g. exposition to contaminants, spending time bending or twisting the body, working in very hot or cold temperatures) and structural job characteristics (e.g. consequence of error, time pressure, freedom to make decisions). We use a principal component analysis (PCA) to obtain a summary indicator of occupation arduousness (the first component). Table 5 in Appendix A.2. displays the full list of O\*NET items we use and the factors loading of the first component. Variables related to “harsh” working conditions are positively loaded. For example, working in very hot or cold temperatures has a factor loading of 0.200 and being exposed to hazardous equipment, one of 0.204. The factors loading associated with better work conditions are negatively loaded. Doing a lot of electronic mail is associated with a factor loading of -0.163 and spending time sitting is associated with one of -0.172. Only factors loading superior to 0.12 are reported in the table for clarity purposes.

Figure 1 presents the average value of the arduousness index that we have been able to compute from O\*Net for the each of the SHARE main occupation that people report

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<sup>12</sup>O\*NET information is collected using a two-stage design in which a statistically random sample of businesses expected to employ workers in the targeted occupations is identified and a random sample of workers in those occupations within those businesses is selected. The data is collected by surveying job incumbents using standardized questionnaires.

<sup>13</sup>We partially draw from the code written by Hardy et al. (2018).

in wave 7.<sup>14</sup> It is computed as the weighted average of all O\*NET-estimated principal components for the consecutive ISCO08 4-digit occupations. The weights reflect the duration in years of the occupation spells. Note that the years have been multiplied by .5 and if occupation was declared to be always part-time, 1 if always full-time and .75 when variable. Hereafter, we will mostly use the entire (average) career arduousness index. And often we will resort to the country-specific *percentile* of that index. Occasionally, we will also use the arduousness index for jobs held before the age of 30 or the age of 40. On Figure 1 we can see that people who declare more manual/outdoor occupations as main occupation (like building and related trades works) belong the higher percentile, while intellectual/indoors professions (like ITC or teaching occupations) form the lower percentiles.

Another strength of this paper is that SHARE wave 7 allows controlling for the initial health “endowment”. We are not only able to control for the health status of the individual during childhood, but also for the inherited health endowment. Childhood health status (ie. from birth to the age 15) corresponds to six items.<sup>15</sup> We also proxy the health endowment by the death status of the parents. To do so, we consider whether parents are currently alive, and if they have died we consider whether they died “prematurely”.<sup>16</sup> These parental items can be considered as a proxy of the “genetic” background of the respondent under the assumption of intergenerational transmission of health Trannoy et al. (2010).

Data limitations of different sorts (missing values or variables, absence of repeated observations as the country participated only in one wave) explain that we retain in the analysis only 23 out of the 28 participating countries (AUT, BEL, BGR, CHE, CYP, CZE, DEU, DNK, ESP, FIN, FRA, ISR, ITA, LTU, LUX, LVA, MLT, POL, ROU, SVK, SVN, SWE).

Descriptive statistics of the sample can be visualized in Table 1.

Finally, despite this being very preliminary evidence, it is interesting to see on Figure 2 that there is a positive association between our O\*NET career arduousness index percentile and our SHARE ill-health index at old age.

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<sup>14</sup>In SHARE people not only report the ISCO08-4 digit code for each of their consecutive occupations, but also the main one over their entire career.

<sup>15</sup>1: excellent health, 2: very good, 3: good 4: fair, 5: poor, 6: varied a lot.

<sup>16</sup>They died younger than the median age at death in the considered country or not.



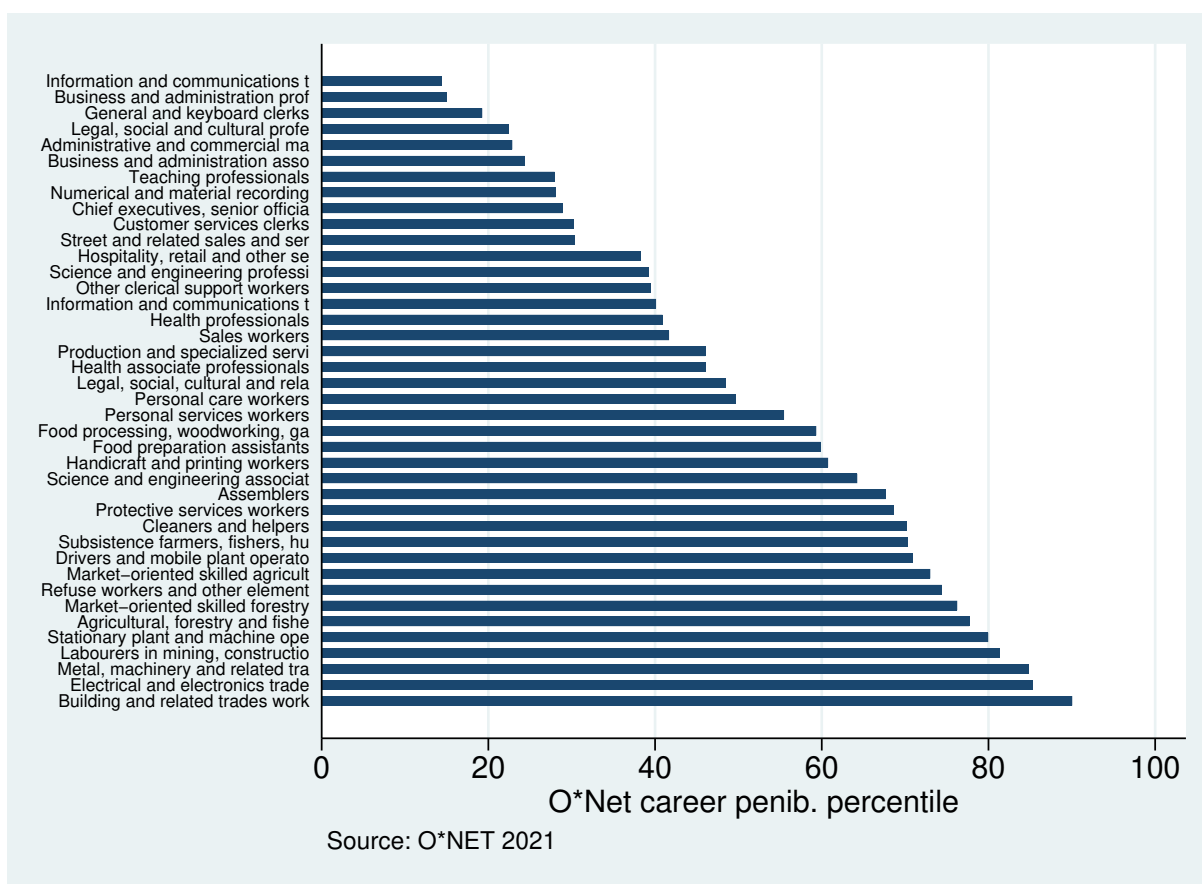


Figure 1: O\*NET career arduousness percentile and SHARE main occupation

Table 1: Key variables: descriptive statistics (mean), respondents aged 60-69

	Ill-health Index	Average Career arduousness Index	Age	Female	Childhood health status <sup>a</sup>	Mother longevity <sup>b</sup>	Father longevity <sup>c</sup>
AUT	-0.15	-0.01	65.38	0.60	2.21	2.16	2.45
BEL	-0.09	-0.18	64.51	0.50	1.93	2.14	2.36
BGR	0.02	0.24	65.16	0.59	1.66	2.31	2.41
CHE	-0.47	-0.28	64.79	0.51	2.25	2.07	2.42
CZE	-0.02	0.17	65.16	0.61	2.27	2.17	2.38
DEU	0.01	-0.05	64.82	0.50	2.34	2.14	2.40
DNK	-0.39	-0.25	64.79	0.51	1.58	2.20	2.38
ESP	-0.22	0.22	64.71	0.50	2.32	2.19	2.38
EST	0.32	0.12	65.15	0.63	2.70	2.24	2.46
FIN	-0.01	0.08	64.88	0.54	2.21	2.14	2.44
FRA	-0.09	-0.04	64.91	0.53	2.15	2.05	2.38
ISR	-0.33	-0.26	65.53	0.56	1.92	2.09	2.39
ITA	-0.37	0.05	64.94	0.42	1.92	2.09	2.40
LTU	0.28	0.23	64.57	0.60	2.35	2.33	2.48
LUX	-0.14	-0.16	64.60	0.54	2.15	2.08	2.36
LVA	0.10	0.13	65.10	0.59	2.84	2.40	2.54
MLT	-0.15	0.26	65.30	0.44	1.73	2.28	2.48
POL	0.29	0.32	64.62	0.51	2.26	2.23	2.45
ROU	0.12	0.69	64.46	0.45	2.15	2.32	2.44
SVK	-0.48	0.32	64.37	0.48	1.80	2.21	2.39
SVN	-0.13	0.08	64.90	0.56	2.17	2.14	2.41
SWE	-0.32	-0.13	65.22	0.54	1.83	2.08	2.37

Source: SHARE 2004-2017, O\*NET 2021

<sup>a</sup>: From birth until the age of 15 health was 1. Excellent, 2. Very good, 3. Good, 4. Fair, 5. Poor, 6. Health varied a great deal

<sup>b,c</sup>: 1: Still alive 2: Premature death 3: Normal death

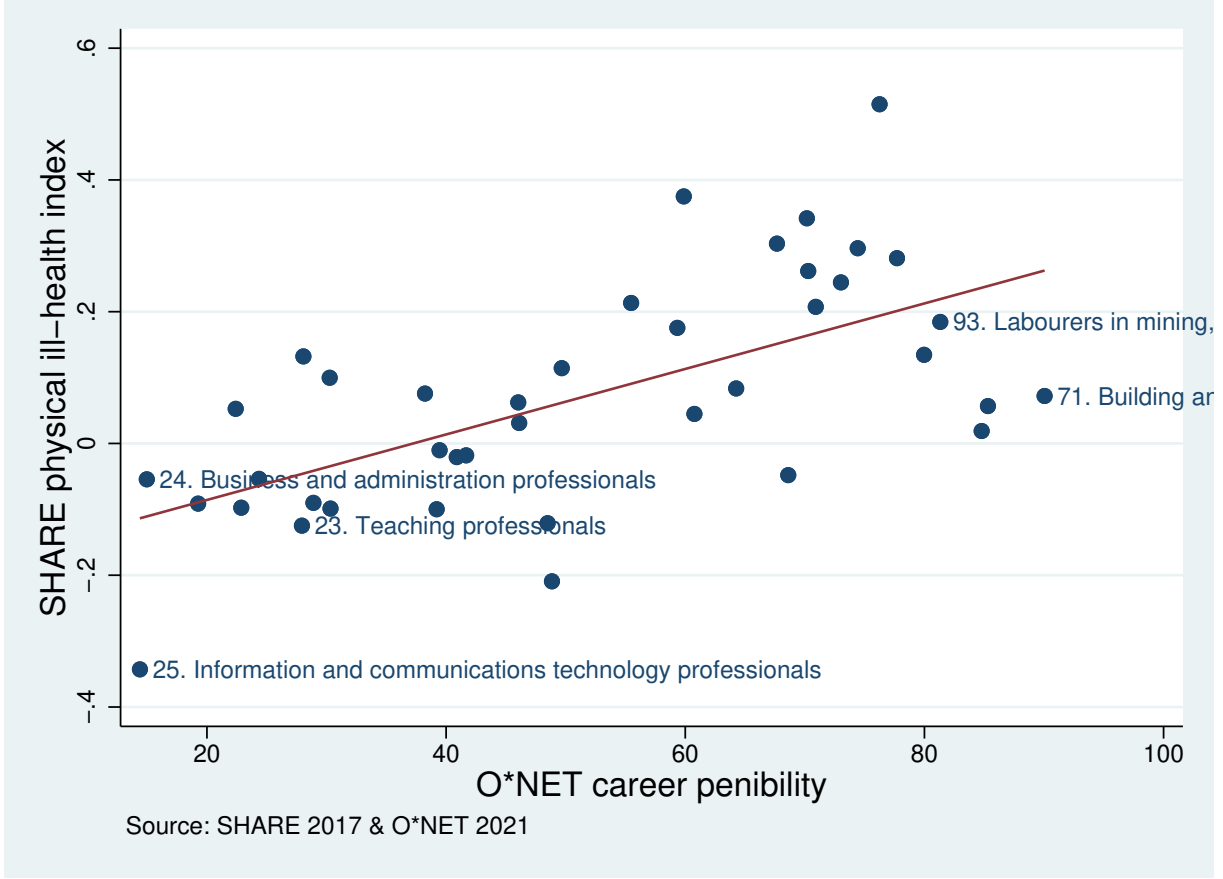


Figure 2: O\*NET career arduousness percentile and SHARE ill-health index (respondents aged 60-69)

## 4 Analytical Framework

One of the main aims of this paper is to quantify the link between career arduousness and health at an older age, and to compute the corresponding degree of (compensatory) retirement age differentiation. Let us consider  $ihealth_{i,j}$ , a measure of ill health of individual  $i$  in country  $j$ . We consider that it is a function of career arduousness that can be written as follows:

$$ihealth_{i,j} = \alpha + \lambda penib_{i,j}^p + \gamma X_{i,j} + \delta_j + \epsilon_{i,j} \quad (1)$$

where  $penib_{i,j}^p$  is our O\*NET career arduousness index percentile,  $X_{i,j}$  a vector of controls and  $\delta_j$  a country fixed effect. We estimate 5 different versions of this model. In version 1,  $X$  consists of age and gender plus country fixed effect ( $\delta_j$ ). In version 2, we add childhood

health status. In version 3 we add parental longevity. In version 4 we replace the average (entire) career O\*NET arduousness percentile with the corresponding value covering the occupations held before the age of 30. The rationale for this is to account for the possibility that end-of-career arduousness and ill-health at older age are endogenous/simultaneous. In version 5, we go a step further as we instrument (IV) average (entire) career arduousness using before-40 arduousness.

The (compensatory) differentiated retirement age (*dretage*) is computed as

$$dretage(p) = 65 - \frac{\hat{\lambda}(p - 50)}{\widehat{\beta(p)}} \quad (2)$$

with  $p = 1, \dots, 100$

Key with such a setting are estimates of the  $\lambda$ s and  $\beta$ s. The former come from the estimation of equ. 1) (see Appendix A.3. Table 6 for the detailed results). As to the  $\beta$ s, we resort to fixed-effect estimation (FE) that exploits the panel dimension of SHARE data (remember that SHARE consists of up to 7 waves, measuring individuals' ill-health every 2-3 years). In other words, the estimated  $\beta$ s only reflect the within-respondent deterioration of health over time. This eliminates many of the biases that may contaminate estimates based on cross-sectional data. Note that we allow for the estimated  $\beta$  to vary with the career arduousness percentile of the respondent. The age band considered is always 60-69.

Further in the paper, we decompose the model-explained variance of ill-health at an older age and quantify the contribution of each variable or group of variables. This is because we can use the model-predicted outcome as linearly decomposable measures in each regressors ( $penib_{i,j}^p, X_{i,j}, \delta_j$ ).

$$\widehat{ihealth}_{i,j} = \widehat{\lambda}penib_{i,j}^p + \widehat{\gamma}X_{i,j} + \widehat{\delta}_j \quad (3)$$

We note the career arduousness part  $\widehat{ihealth}_{i,j}^{penib} \equiv \widehat{\lambda}penib_{i,j}^p$ , and similarly for the other variables of the ill-health equ. 1. Following Fields (2003) and Jusot et al. (2013), we propose quantifying the contribution of the different regressors (or group of regressors) to ill-health using the variance of the model-predicted labour outcomes ( $\sigma(\widehat{ihealth}_{i,j})$ ) as a reference. That variance is decomposable by sources. And the decomposition has certain properties.<sup>17</sup>

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<sup>17</sup>Symmetry, independence of the level of disaggregation, consistent decomposition and population symmetry.

Whatever the exact list regressors, or estimation method used (OLS, IV) for estimating equ. 1, the decomposition of the model-explained variance is simply given by the covariance between each regressor (or group of regressors) and the outcome of interest.

$$\sigma^2(\widehat{ihealth}_{i,j}) = \sigma(\widehat{ihealth}_{i,j}, \widehat{ihealth}_{i,j}^{penib}) + \sigma(\widehat{ihealth}_{i,j}, \widehat{ihealth}_{i,j}^X) + \sigma(\widehat{ihealth}_{i,j}, \widehat{ihealth}_{i,j}^\delta) \quad (4)$$

Therefore, the relative importance of a particular variable (or group of variables) is the ratio of its covariance divided by the total model-explained variance. For instance, the importance of career arduousness is equal to

$$ratio^{PENIB} = \frac{\sigma(\widehat{ihealth}_{i,j}, \widehat{ihealth}_{i,j}^{penib})}{\sigma^2(\widehat{ihealth}_{i,j})} \quad (5)$$

## 5 Results

Our key results appear on Table 2. The underlying econometric results corresponding to our five versions of equation 1 are reported in the Appendix A.3., Table 6. The left-hand part of Table 2 reports the differentiated retirement age. Each row corresponds to a career arduousness percentile. So the last row suggests that individuals forming the very top of the arduousness distribution<sup>18</sup> should be granted the right to retire at the age of 60-61, whereas the individuals forming the lowest career arduousness percentile should be required to keep on toiling until they turn 70-71. Note that the reference age of 65 is logically the one applicable to the median (50<sup>th</sup> percentile). The marginal impact of career arduousness ( $\lambda$ ) has been estimated using 5 different specifications of equ. 1. This does not fundamentally affect the outcome. Using  $\lambda$  using version [5], we get a bit more retirement differentiation compared to what we get using  $\lambda$  stemming from version [1]. Note finally that the estimated  $\beta$ s rise with arduousness, reflecting the fact the marginal impact of one extra year of age on ill-health is more important for respondents who had more p nible careers.

The results of the variance decomposition are reported in Table 3. The latter was carried out using the coefficients of the estimation of version [3] of equ. 1. The first line indicates

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<sup>18</sup>The distributions are country-specific.

that the career arduousness percentile explains at most 6% of the model-explained variance. The next one quantifies the contribution of the health endowment variables (i.e. childhood health status & longevity of parents). And it represents a big part of the variance (29.72%), stressing the important contribution of inherited endowments and early life health conditions on health at an older age. This result aligns with those of Chen et al. (2020) who estimate that childhood circumstances may explain 14-30 percent of health inequality in old age in the USA. The third line captures the role of age<sup>19</sup> at 7.6%, while that of gender at 8.5% is reported on the 4<sup>th</sup> line. The last line suggests that country fixed effects (and whatever they may capture in terms of GDP per head differences<sup>20</sup>, average lifestyle – diet, propensity to exercise – or overall quality of health care at country level) are also a big contributor (48.3%) to the variance of health at an older age.

Finally, we have also gathered indirect evidence of a link between arduousness and longevity. In the Appendix A.4. (Table 7) we report the result of a very simple regression analysis where the dependant variable is our O\*NET career arduousness index percentile. The right-hand variables comprise educational attainment, gender, a country fixed effect but also the *age band* of the respondent. And the coefficients for the latter are supportive a strong negative correlation between age and arduousness. In other words the older respondents in SHARE (i.e. those who survived up to the considered age) seem to have had less arduous careers *ceteris paribus*.

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<sup>19</sup>Within the 60-69 age band.

<sup>20</sup>On the strong link between ill-health and GDP per capita, see Fig. 3 in Appendix A.5.

Table 2: Differentiated retirement ages that compensate career arduousness [ref=65]

Penib. perc.	Differentiated retirement age <sup>a</sup>					Impact 1%-point penib.( $\lambda$ ) <sup>a</sup>					Impact of 1 y. of age( $\beta$ ) <sup>b</sup>
	[1]	[2]	[3]	[4]	[5]	[1]	[2]	[3]	[4]	[5]	
1	71.9	71.1	71.0	70.5	70.7	0.0035	0.0031	0.0031	0.0028	0.0029	0.026
10	70.3	69.7	69.6	69.3	69.4	0.0035	0.0031	0.0031	0.0028	0.0029	0.027
20	68.8	68.4	68.3	68.1	68.1	0.0035	0.0031	0.0031	0.0028	0.0029	0.028
30	67.5	67.2	67.1	67.0	67.0	0.0035	0.0031	0.0031	0.0028	0.0029	0.029
40	66.2	66.1	66.0	66.0	66.0	0.0035	0.0031	0.0031	0.0028	0.0029	0.030
50	65.0	65.0	65.0	65.0	65.0	0.0035	0.0031	0.0031	0.0028	0.0029	0.031
60	63.9	64.0	64.0	64.1	64.1	0.0035	0.0031	0.0031	0.0028	0.0029	0.032
70	62.9	63.1	63.1	63.3	63.2	0.0035	0.0031	0.0031	0.0028	0.0029	0.033
80	61.9	62.2	62.3	62.5	62.4	0.0035	0.0031	0.0031	0.0028	0.0029	0.034
90	61.0	61.4	61.5	61.8	61.7	0.0035	0.0031	0.0031	0.0028	0.0029	0.035
100	60.1	60.7	60.7	61.1	61.0	0.0035	0.0031	0.0031	0.0028	0.0029	0.036

Source: SHARE 2004-2017, O\*NET 2021

<sup>a</sup>: Each column correspond to one of the 5 versions of the ill-health arduousness equ. 1 estimated for respondents aged 60-69. In version [1],  $X$  consists of age+ gender and also have country fixed effects ( $\delta_j$ ). In version [2] we include childhood (i.e. from birth to age 15) health status. In version [3] we add parental longevity. In version [4] we replace average (entire) career O\*NET arduousness by that for occupations held before the age of 30. In version [5] we instrument average (entire) career arduousness using the arduousness accumulated before the age of 40.

<sup>b</sup>: Estimated using FE, applied to the respondents aged 60-69 for which we have at least 2 consecutive measures of ill-health, and allowing for estimates to vary with the career arduousness percentile.

Table 3: Model-explained ill-health variance decomposition<sup>a</sup> (respondents aged 60-69)

Career Penib.	5.836*** (5.65)
Health Endow. <sup>b</sup>	29.72*** (13.47)
Age	7.595*** (6.11)
Gender	8.523*** (6.11)
Country FE	48.32*** (21.02)

Source: SHARE 2004-2017, O\*NET 2021

$p$ -values in parentheses

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

<sup>a</sup>:It has been carried out using the coefficients of the version 3 of our estimation of equation 1.

Bootstrapped standard errors and  $p$ values, with 1000 replications. <sup>b</sup>: Childhood health status parental longevity.

## 6 Concluding Remarks and Discussion

In this paper we have explored the idea of a differentiated retirement age policy aimed at compensating people for diverging degrees of career arduousness. We innovate in the sense that we quantifies not just people’s health at the typical retirement age, but also the arduousness of their *entire* career. We first measure the intensity of the relationship between career arduousness and the ill-health gradient of SHARE respondents aged 60-69. Separately, we estimate the impact of one year of (biological) ageing on ill-health. With these two estimates we compute the degree of retirement age differentiation that would be required to compensate for health differences that can be ascribed to career arduousness. Finally, we combine regression and variance decomposition analyses to assess the importance of career arduousness in explaining health past the age of 60, and that in comparison with other key determinants of people’s long-term health status.

The results of this paper are essentially fourfold

- First, it is not only possible to *quantify* health differences among elderly citizens in Europe but also their career hardship differences. This is thanks to the availability of *retrospective* modules in SHARE that provide detailed information about the employment history of elderly individuals, but also the availability of the US O\*NET detailed descriptions of occupations that can be used to compute occupation arduousness scores. The latter can then be imported into SHARE to compute average career arduousness indices.

- Second. There is strong evidence that career arduousness relates to ill-health differences at the typical age or retirement. People who endured more arduous jobs and careers are more likely to be in poor health *ceteris paribus*. We also provide indirect evidence of a link with longevity.<sup>21</sup>

- Third, it is possible to calculate the degree of retirement age differentiation that would compensate career arduousness-driven health differences around the typical retirement age of 65. In this paper, we estimate that it should vary between 60-61 (for the highest percentile of career arduousness) to 70-71 (for the lowest career arduousness percentile).<sup>22</sup>

- Fourth, career arduousness only accounts for 5.83% of total (model-explained) variance of health at an older age. Whilst occupation arduousness is a statistically significant contributor to poor health at later age, it is still (quantitatively) a minor determinant. Initial health

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<sup>21</sup>See Appendix A.4.

<sup>22</sup>The age of 65 is set to correspond to median arduousness.



endowment (proxied here by childhood health and the longevity of the respondent’s parents) and country fixed effects (that presumably capture the role GDP per capita differences<sup>23</sup>) explain a larger part of health differences *ceteris paribus*.

In policy terms, our findings provide justification to policymakers wishing to differentiate pension policy based on people’s career. “Real” actuarial fairness<sup>24</sup> calls for retirement age differentiation.<sup>25</sup> But this research also underlines the importance of other determinants. And these comprise people’s initial health endowment. The latter result calls for further research, but in policy terms, it tentatively suggests that *fully* accounting for retirees’ health heterogeneity<sup>26</sup>, and by extension for longevity differences, calls for more than retirement age differentiation. It probably requires early-life interventions, targeting inherited or childhood health inequalities, via public health and related policies.

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<sup>23</sup>See Fig. 3 in Appendix A.5.

<sup>24</sup>i.e where attention is paid not just to equalising the contributed and received euro, but also the disutility endured when earning the right to that euro or the utility it will represent upon retirement.

<sup>25</sup>Other forms of differentiation can be imagined. For instance, replacement rates could be inversely proportional to career arduousness.

<sup>26</sup>Remember that the differentiated retirement ages that we compute in this paper only compensate for *work-related* poor health.

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## Appendix

### A.1. SHARE, physical ill-health items

SHARE contains a rich set of items describing people’s work (incl. their employment status and hours of work) but also their physical health status. In SHARE, the numerous physical health items can be split into two broad categories: “subjective” and “objective”. Most physical health items in SHARE are self-reported/subjective 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 two columns before last of Table 4).

Table 4: Physical ill-Health items

	Poor health <sup>a</sup>	Long-term illness <sup>b</sup>	Limited act. <sup>c</sup>	Limits <sup>d</sup>	Limits <sup>e</sup>	Hart attack	Hyper- tension	Cholest.	Stroke	Diab.	Lung disease	Cancer	Ulcer	Park.	Catar	Hip	Mobility <sup>f</sup> strength	Max. grip index <sup>g</sup>	Physical ill-health
AUT	2.93	0.50	2.43	0.07	0.19	0.10	0.46	0.22	0.04	0.12	0.05	0.04	0.02	0.00	0.07	0.00	1.06	34.57	-0.15
BEL	2.99	0.50	2.43	0.18	0.25	0.09	0.38	0.34	0.03	0.11	0.06	0.05	0.05	0.00	0.06	0.01	1.18	36.47	-0.09
BGR	3.16	0.52	2.49	0.21	0.36	0.12	0.57	0.11	0.03	0.13	0.04	0.03	0.03	0.00	0.03	0.02	1.46	28.89	0.02
CHE	2.69	0.34	2.63	0.05	0.06	0.08	0.29	0.17	0.02	0.08	0.04	0.05	0.01	0.01	0.05	0.02	0.65	36.51	-0.47
CYP	2.90	0.35	2.65	0.03	0.09	0.14	0.42	0.43	0.02	0.13	0.07	0.04	0.02	0.00	0.08	0.02	1.01	30.75	-0.21
CZE	3.06	0.53	2.40	0.11	0.21	0.10	0.53	0.32	0.03	0.18	0.07	0.04	0.03	0.01	0.06	0.01	1.27	34.83	-0.02
DEU	3.24	0.61	2.36	0.13	0.11	0.10	0.48	0.22	0.03	0.13	0.07	0.06	0.02	0.01	0.06	0.01	1.12	37.13	0.01
DNK	2.54	0.55	2.61	0.09	0.13	0.08	0.37	0.29	0.02	0.08	0.05	0.04	0.02	0.00	0.05	0.01	0.70	38.37	-0.39
ESP	3.10	0.39	2.67	0.04	0.08	0.08	0.40	0.25	0.02	0.12	0.04	0.04	0.02	0.00	0.04	0.01	0.83	32.43	-0.22
EST	3.76	0.71	2.19	0.18	0.26	0.12	0.47	0.20	0.03	0.14	0.05	0.04	0.05	0.01	0.05	0.01	1.59	34.60	0.32
FIN	3.16	0.61	2.40	0.11	0.10	0.09	0.42	0.32	0.03	0.15	0.07	0.08	0.04	0.00	0.06	0.01	0.87	35.83	-0.01
FRA	3.16	0.46	2.45	0.10	0.16	0.13	0.34	0.24	0.02	0.11	0.06	0.03	0.05	0.01	0.06	0.01	1.05	34.58	-0.09
ISR	2.77	0.44	2.75	0.09	0.20	0.10	0.34	0.31	0.03	0.21	0.02	0.04	0.02	0.00	0.05	0.01	0.64	30.83	-0.33
ITA	2.94	0.32	2.71	0.08	0.11	0.08	0.37	0.24	0.01	0.10	0.04	0.02	0.02	0.00	0.03	0.01	0.75	35.44	-0.37
LTU	3.58	0.63	2.37	0.17	0.32	0.18	0.55	0.24	0.08	0.09	0.07	0.07	0.11	0.00	0.06	0.02	1.75	34.35	0.28
LUX	3.02	0.48	2.47	0.09	0.13	0.10	0.36	0.34	0.02	0.11	0.06	0.07	0.04	0.00	0.08	0.01	1.10	35.48	-0.14
LVA	3.71	0.49	2.53	0.13	0.20	0.11	0.45	0.15	0.03	0.10	0.04	0.04	0.06	0.00	0.03	0.03	1.16	36.38	0.10
MLT	3.08	0.42	2.67	0.06	0.17	0.06	0.47	0.37	0.01	0.20	0.01	0.04	0.04	0.01	0.05	0.01	0.99	31.67	-0.15
POL	3.53	0.68	2.29	0.17	0.21	0.17	0.49	0.29	0.04	0.17	0.07	0.06	0.07	0.00	0.07	0.01	1.74	34.24	0.29
ROU	3.52	0.46	2.42	0.23	0.30	0.08	0.46	0.18	0.05	0.15	0.04	0.02	0.07	0.00	0.04	0.01	1.77	34.06	0.12
SVK	2.70	0.28	2.61	0.06	0.15	0.04	0.29	0.14	0.01	0.08	0.01	0.01	0.03	0.00	0.04	0.01	1.02	34.62	-0.48
SVN	3.16	0.45	2.42	0.07	0.10	0.07	0.46	0.28	0.04	0.13	0.05	0.02	0.03	0.00	0.05	0.00	1.04	36.80	-0.13
SWE	2.77	0.54	2.49	0.06	0.10	0.08	0.36	0.15	0.02	0.11	0.05	0.04	0.02	0.00	0.05	0.01	0.74	36.55	-0.32

Source: SHARE 2004-2017, O\*NET 2021

<sup>a</sup>: 1 (good) -5 (bad) European scale<sup>b</sup>: Yes (1) No (0).<sup>c</sup>: Limited in activities because of health:1 severely, 2 not severely, 3 not limited<sup>d</sup>: Number of limitations with activities of daily living(0-6 scale).<sup>e</sup>: Number of imitations with instrumental activities of daily living(0-9 scale).<sup>f</sup>: Mobility, arm function and fine motor limitations<sup>g</sup>: First principal component of all items (the higher, the worse is people' s health)

## A.2. O\*NET

O\*NET is a thorough US-based assessment of job and occupation content <https://www.onetonline.org/>. It assembles information on more than 1,000 occupations and describes, among others, the tasks, knowledge, skills, abilities necessary to perform the job as well as the work context. Table 5 below displays the factors loading of the first component we use to quantify the arduousness of each of the occupation exercised over the course of respondents' career. Variables related to “harsh” working conditions are positively loaded. For example, working in very hot or cold temperatures has a factor loading of 0.200 and being exposed to hazardous equipment, one of 0.204. The factors loading associated with better work conditions are negatively loaded. Doing a lot of electronic mail is associated with a factor loading of -0.163 and spending time sitting is associated with one of -0.172. Only factors loading superior to 0.12 are reported in the table for clarity purpose.

Table 5: Factor loadings of the arduousness indicator

	Factor loadings
Cramped work space, awkward positions	.196
Electronic mail	-.163
Exposed to contaminants	.203
Exposed to hazardous conditions	.176
Exposed to hazardous equipment	.204
Exposed to high places	.174
Exposed to minor burns, cuts, bites, or stings	.206
Exposed to whole body vibration	.169
Extremely bright or inadequate lighting	.192
In an open vehicle or equipment	.175
Indoors, environmentally controlled	-.170
Indoors, not environmentally controlled	.175
Letters and memos	-.125
Outdoors, exposed to weather	.154
Outdoors, under cover	.135
Pace determined by speed of equipment	.163
Responsible for others' health and safety	.155
Sounds, noise levels are distracting or uncomfortable	.184
Spend time bending or twisting the body	.198
Spend time climbing ladders, scaffolds, or poles	.171
Spend time keeping or regaining balance	.186
Spend time kneeling, crouching, stooping, or crawling	.183
Spend time sitting	-.172
Spend time standing	.168
Spend time using your hands to handle, control, or feel objects, tools, or controls	.164
Spend time walking and running	.171
Very hot or cold temperatures	.200
Wear common protective or safety equipment such as safety shoes, glasses, gloves, hearing protection, hard hats, or life jackets	.195
Wear specialized protective or safety equipment such as breathing apparatus, safety harness, full protection suits, or radiation protection	.164

The table shows the factor loading of the first component of the O\*NET PCA (file “Work context” only). Only factor superior to 0.12 are shown for clarity purpose. The whole description of the different items can be found at [https://www.onetonline.org/find/descriptor/browse/Work\\_Context/](https://www.onetonline.org/find/descriptor/browse/Work_Context/). The factor loading are positively linked to arduous environment (e.g. very hot or cold) and negatively linked to soft environment (e.g. spending time sitting).

### A.3. Ill-health equation. Econometric results

Table 6: Econometric results of the estimation of the ill-health/career arduousness equ. 1. Version 1 to 5

	[1]	[2]	[3]	[4] <sup>a</sup>	[5] <sup>b</sup>
Penib(all)	0.0035*** (0.000)	0.0031*** (0.000)	0.0031*** (0.000)		0.0029*** (0.000)
Penib(<30)				0.0028*** (0.000)	
Female	0.2169*** (0.000)	0.2004*** (0.000)	0.1993*** (0.000)	0.1997*** (0.000)	0.1952*** (0.000)
Child health very good <sup>c</sup>		0.0760*** (0.000)	0.0752*** (0.000)	0.0761*** (0.000)	0.0755*** (0.000)
Child health good		0.1976*** (0.000)	0.1960*** (0.000)	0.1985*** (0.000)	0.1969*** (0.000)
Child health fair		0.4237*** (0.000)	0.4218*** (0.000)	0.4243*** (0.000)	0.4226*** (0.000)
Child health poor		0.5850*** (0.000)	0.5782*** (0.000)	0.5796*** (0.000)	0.5791*** (0.000)
Child health varied		0.4641** (0.001)	0.4676** (0.001)	0.4786*** (0.001)	0.4674** (0.001)
Premature death (mother) <sup>d</sup>		0.1665*** (0.000)	0.1412*** (0.000)	0.1416*** (0.000)	0.1419*** (0.000)
Normal death (mother)		0.0807* (0.015)	0.0628 (0.064)	0.0627 (0.064)	0.0631 (0.063)
Premature death (father) <sup>e</sup>			0.1045*** (0.000)	0.1059*** (0.000)	0.1051*** (0.000)
Normal death (father)			0.0103 (0.653)	0.0110 (0.633)	0.0107 (0.642)
Const.	-0.6011*** (0.000)	-0.7924*** (0.000)	-0.8119*** (0.000)	-0.7996*** (0.000)	-0.8014*** (0.000)
<i>N</i>	10984	10984	10984	10984	10984

*p*-values in parentheses

Source: SHARE 2004-2017, O\*NET 2021

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

<sup>a</sup>: Uses before-age-30 arduousness percentile instead of entire career arduousness percentile

<sup>b</sup>: Entire career arduousness percentile instrumented by before age 40 arduousness percentile.

<sup>c</sup>: Ref.= excellent.

<sup>d,e</sup>: Ref.= still alive

## A.4. Indirect evidence of the impact of career arduousness on longevity

It is possible to use SHARE and O\*NET data to get some idea of the negative association between career arduousness and longevity. The Table 7 below reports the results of a regression where the left-hand term is our O\*Net-based estimate of peoples' career arduousness. The right-hand regressors comprise educational attainment, gender, a country fixed effect but also the age band of the respondent. And the coefficients for the latter are supportive of a strong negative correlation between age and arduousness. In other words, the older respondents in SHARE (i.e. those who survived up to the considered age) seem to have had less arduous careers.

Table 7: O\*NET career arduousness percentile and age (respondents aged 50+)

Dep. var= arduousness percentile	
Age [55-60[	-0.771 (-1.21)
Age [60-65[	-1.677* (-2.55)
Age [65-70[	-4.189*** (-6.11)
Age [70-75[	-5.701*** (-7.91)
Age [75-80[	-6.149*** (-8.08)
Age [80-85[	-5.633*** (-6.84)
Age [85+[	-7.432*** (-8.12)
<i>N</i>	31,291
Controls	Gender, childhood health status, parental longevity + country fixed effects

Source: SHARE 2004-2017, O\*NET 2021.

*p*-values in parentheses

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



## A.5. Ill-health beyond the age of 50 and GDP

It is interesting to visualise how much our SHARE ill-health index (average per country, respondents aged 60-69) parallels GDP per capita differences (Fig. 3). The higher GDP per head from the Penn World Tables, the lower the SHARE physical ill-health index.

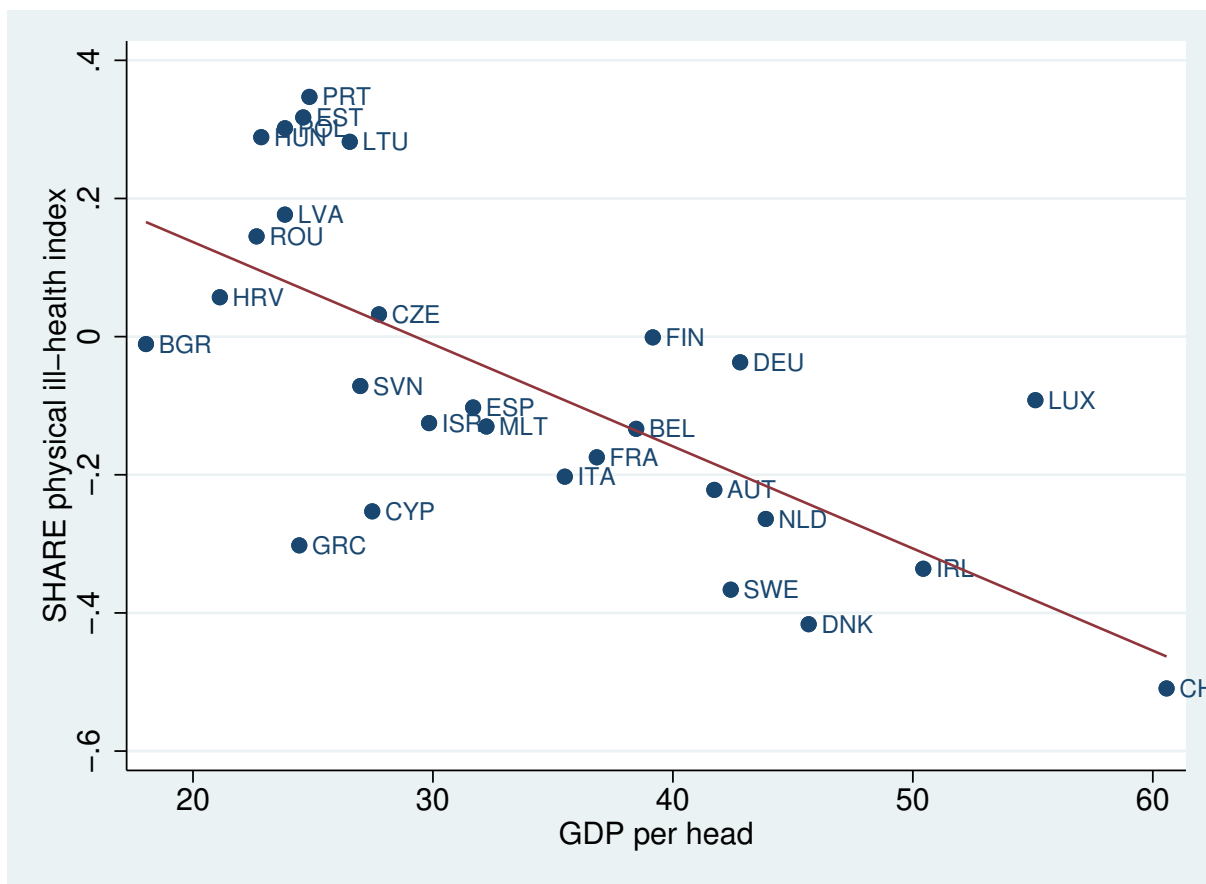


Figure 3: SHARE physical ill-health (country average for respondents aged 60-69) and GDP per capita<sup>a</sup>

Source: SHARE 2004-2017, Penn World Table v.9.1

<sup>a</sup>Penn World Table v.9.1, at PPP in th. 2015 US\$.