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In order to counteract the negative effects of population ageing on the sustainability of pension schemes and on economic growth, higher labor force participation of older workers is advocated in western countries (Bongaarts 2004; Christensen et al. 2009; Vaupel and Loichinger 2005; Scherbov et al. 2014). Longer active lives are encouraged by raising the age at eligibility to pension benefits and by restricting access to early retirement benefits (OECD 2015). When taking such measures, governments implicitly assume that workers are healthy enough to keep working beyond the ages at which they currently retire. In other words, they assume that there is substantial unused capacity to work past the traditional retirement ages. If this proves right, workers are likely to respond to the policy changes and work longer. If this proves wrong, workers will retire due to poor health and the policy changes will have little effect on retirement behavior.

In this paper, we propose a new population level measure of capacity to work at older ages. Research that provided such measures is recent but flourishing. Following Wise (2017), we consider two groups of papers that followed two distinct methods. We first consider the group that applied the Milligan-Wise (MW) method (Milligan and Wise 2015; Coile et al. 2017a). The MW method is based on historical trends in the relationship between employment and mortality. In a recent application of the method to older American men (Coile et al. 2017b), the authors ask what would be the amount of employment if for each mortality rate in 2010, men aged 55- 69 would work as much as men with the same mortality rates in 1977. The authors find a "potential additional employment capacity" of 4.2 years (Coile et al. 2017, p.378); that is, men would work 4.2 more years if for each mortality rate between ages 55 and 69 in 2010, they worked as much as men with same mortality rate in 1977. The same method was applied to different countries (see Wise 2017), but results for women and population subgroups are still lacking.

The second group of papers applied the Cutler- Meara- Richards-Shubik (CMR) method (Cutler et al. 2013; Coile et al. 2017a) or other closely related methods (Rehkopf et al. 2017; Boissonneault and De Beer 2017). The CMR method consists in calculating the amount of employment that would be obtained if for each level of health, men and women aged 55 to 69 worked as much as men and women aged 50 to 54 with the same level of health. In an application of the method to older American workers, Coile and colleagues (2017b) find that men aged 60 to 64 have an additional capacity to work of about 17%, while men aged 65 to 69 have one of more than 30%. That is, men of these two age groups could work 17 and 30 percent more if for the same level of health, they worked as much as men aged 50 to 54. The authors also find important potential gains in employment for women. Again, other papers applied the CMR method to the situation of other countries (see Wise 2017).

Unlike the papers reviewed above, our approach does not infer ability to work based on the relationship between employment and mortality or health. Instead, we model capacity to work as a function of timing to retirement and the reason for having retired— i.e. due to poor health or not—thus reflecting more closely the experience of older workers. We then draw upon methods developed for the study of mortality and provide a single, easily interpretable indicator of the number of years that would be worked if workers only retired due to poor health. We apply our method to the case of American workers born between 1936 and 1947 and show the usefulness of our indicator in comparing population sub-groups. Similar to the work reviewed above, we find considerable unused capacity to work at older ages. In the meanwhile, we find evidence of important differences between races, educational levels and occupational classes.

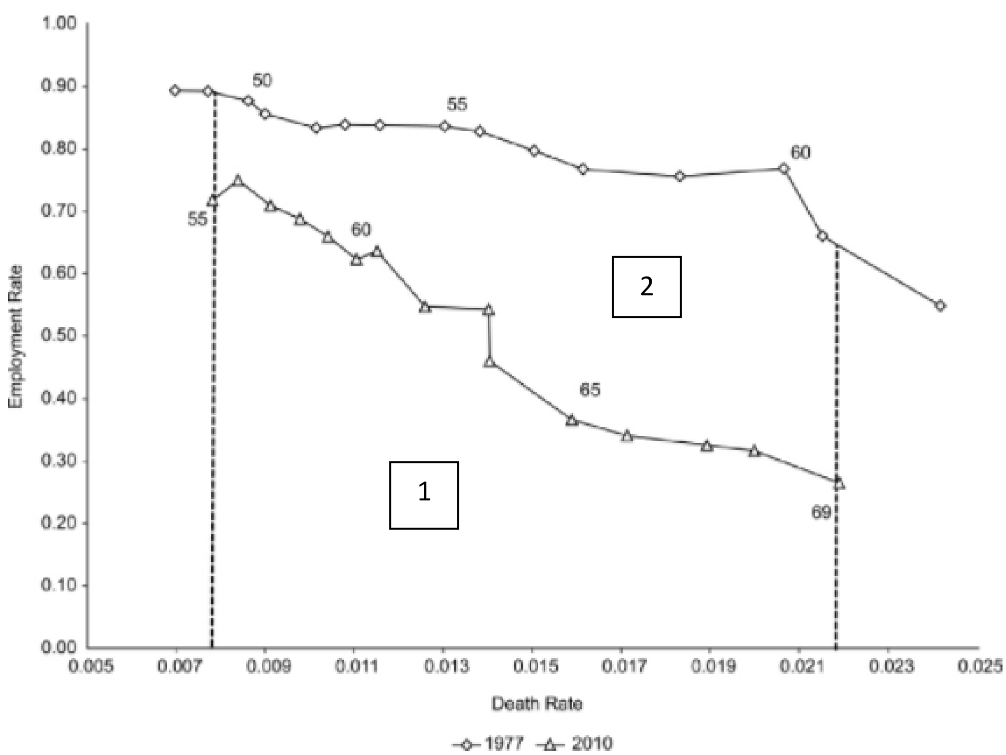
In the next section, we present our analytical approach in more detail. This includes a more detailed description of the WM method and an adaptation of the Andersen and colleagues' (2013) approach to cause-specific measures of years of life lost. The third section presents our data source, i.e. the Health and Retirement Study (HRS). The fourth section presents the results, including a breakdown of capacity to work among subgroups as defined by gender, race, education, occupation and cohort. The fifth section discusses the results and their implication for the ongoing changes in retirement legislation and future research on capacity to work at older ages.

Analytical approach

Similar to the MW method, our approach aims to provide a measure of capacity to work using a single, easily interpretable indicator. The authors of the MW method call this indicator *unused capacity to work*. Coile et al. (2017b) estimate unused capacity to work at the hand of data on the employment and mortality experience of American men for the years 2010 and 1977. The method is well summarized by a graph. The graph in Figure 1 shows two curves. The lower curve represents the association between mortality and employment in the year 2010. Each triangle represents one year of age between ages 55 and 69. The upper curve shows the levels of employment that correspond to the same mortality rates in the year 1977. The diamonds represent the years of age for which the mortality rates are the same as in 2010. These are much younger ages since the mortality conditions improved considerably between 1977 and 2010. Unused capacity to work is the difference between the lower and the upper curves. It is the difference in the level of employment between the years 2010 and 1977 for the same mortality rates. By integrating the surface between these two curves, the authors find an unused capacity to work of 4.2 years. We identified this surface with the digit "2".

As noted by Coile and colleagues, this unused capacity to work represents 53% of the "average amount of employment" observed in the year 2010. The average amount of employment is found by integrating the surface under the lower curve in Figure 1. We identified this surface with the digit "1" and the corresponding quantity is 7.9 years.

Figure 1. Employment versus mortality of men in the United States 1977-2010. The triangles show the level of employment according to the death rate at each age between 55 and 69 years old in 2010. The diamonds show the level of employment for the same death rates in 1977. The surface coded "2" gives the unused capacity to work. The surface coded "1" gives the average amount of employment in 2010.



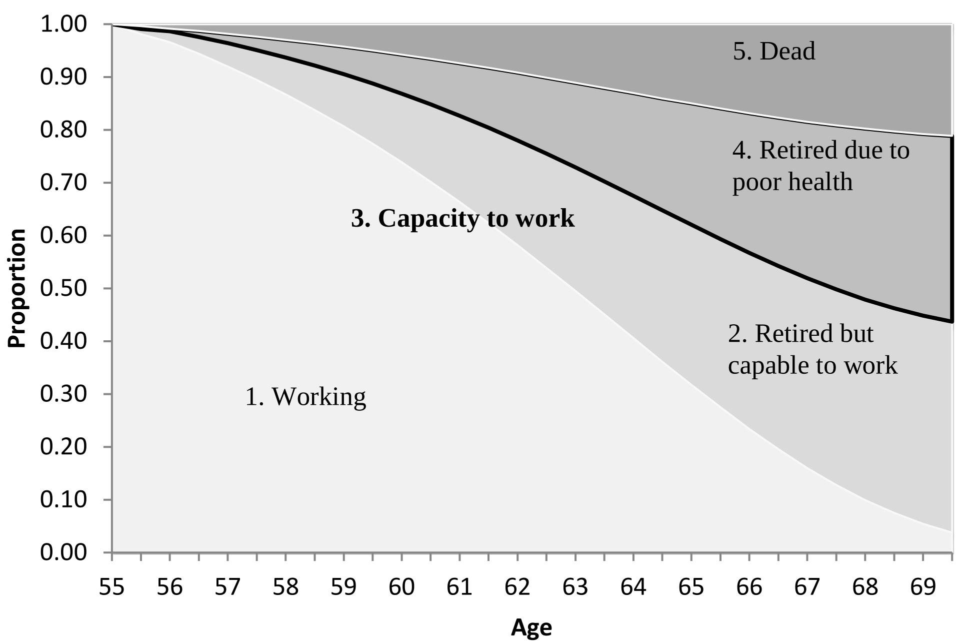
Source: Wise 2017, Fig. I.2 p. 377.

Note that surface 1 in Figure 1 is equivalent to what is known as working life expectancy (Wolfbein 1949; Willekens 1980; Denton and Spencer 2013). Working life expectancy is the number of years that a worker can expect to work given a set of age-specific rates of exit from work into retirement. Similar to life expectancy, it is obtained by integrating the person-years lived in the state "working" between two years of age. To interpret surface 2, we call upon the approach to cause-specific years of life lost introduced by Andersen et al. (2013). The Andersen and colleagues' approach is to some extent a simplified version of the better known associated single decrement life table or "cause-deleted" life table (Gardner and Sanborn 1990; Preston et al. 2001). These approaches are used by demographers and epidemiologists to study the impact of specific causes of death on mortality. The Andersen et al. approach takes the period comprised between two years of age and partitions it between the years spent in the state "alive" and the years "lost" to different causes of death. Years of life lost to a specific cause of death are obtained by integrating, between two years of age, the amount of years spent in the state "dead" following death from a specific cause. Each year of age comprised between age x and age $x+n$ can be partitioned between the time spent in the state "alive" and the time lost to the different causes of death. As a result, the sum of the life expectancy and the years lost to all causes of death between age x and age $x+n$ equals n.

Similar to the MW method, we partition the years spent between age 55 and age 69 between the years spent at work and the years spent not working but capable to work. This is pictured in Figure 2. Surface 1 represents the time spent working and surface 2 the time spent not working but capable to work. We go beyond the MW method and introduce three more quantities. The first one is represented by surface 3. We call surface 3 *Total capacity to work*. Total capacity to work is the total amount of time that workers would work if they only retire due to poor health. This quantity allows to better compare subgroups since unlike unused capacity to work, it is not affected by the amount of time spent working. The rest of the graph depicted in Figure 2 represents the time spent not working due to an incapacity to work. This time is partitioned between time spent retired due to poor health and death. The corresponding surfaces are attributed the digits 4 and 5, respectively.

In the MW method, unused capacity to work is obtained through a counterfactual analysis in which the relationship between mortality and the level of employment in a reference year is taken to estimate unused capacity to work. Two conditions must be met for this approach to be an accurate approximation of actual capacity to work. First, for each mortality rate in the reference year, all men who are capable to work must work. Second, change in mortality over time must be equivalent to change in capacity to work over time. Clearly, these conditions are not met. As the authors show (Coile et al. 2017a), different results are obtained when taking different reference years. Another limitation of the MW method is that it does not allow to analyze the situation of women since employment rates of women were much lower 40 years ago. Also, mortality and employment data are not available for long time periods for population subgroups, which makes it impossible to make comparisons between them. Our approach, in contrast, arguably reflects better true capacity to work, can be interpreted similarly between men and women, and easily allows to compare population subgroups.

Figure 2. Years spent working, years lost to retirement due to other reasons, years lost to retirement due to poor health, years lost to death and capacity to work for a hypothetical cohort of workers age 55 to 69



We understand capacity to work in the sense of Ilmarinen's concept of *work ability* (Ilmarinen 2001). Work ability is defined as "a process of human resources in relation to work" (p. 549). Human resources include education, competences and the health resources. Work, on the other hand, has intrinsic demands attached to it such as psychological and physical demands. A worker is therefore able to work as long as his or her human resources are sufficient to cope with the work demands.

We assume that age-related change in human resources is mostly affected by a decline in the health resources, as most education and competences are acquired earlier in the life course and stay rather unaffected thereafter. Work ability is therefore sufficient as long as the health resources are superior to the work demands. If the health resources become less than the work demands, then retirement due to poor health ensues. We define capacity to work as the amount of years that a worker can work before his or her health resources become insufficient to cope with the work demands.

Total capacity to work is based on timing to first complete retirement of individuals who declare to have retired due to poor health. This is a valid measure of capacity to work to the extent that individuals who retire make a correct assessment of whether their health resources were still sufficient to perform their work upon retirement. We assume no retirements prior to age 55 and follow workers until their first complete retirement. Therefore, we see our measure as a measure of capacity to work on a career job. Workers may partly or gradually retire before they retire completely. Workers who are partly retired arguably have lower work demands, which can affect capacity to work positively. At the same time, we avoid that our measure is affected by retirement from jobs that are performed after a period of retirement, which arguably affects capacity to work negatively.

Data and methods

We illustrate our approach to the measurement of capacity to work using HRS data. HRS is a longitudinal survey that is representative of the American population age 51 and older. The HRS started in 1992 and has been conducted biannually since then. Data is available up to the year 2014. The HRS follows participants until they die or drop out from the survey. In depth information about the work, health and retirement of the participants is collected, resulting in a large number of variables. The combination of the high number of waves and variables makes this survey a very complex one. Reflecting this complexity, different data products are available for researchers. We used different data sets that answered our different needs.

Information on gender, the moment of birth, the level of educational attainment, race and the moment of death is taken from the tracker file, a single file that contains basic, time invariant information on every individual who ever participated to the HRS (Health and Retirement Study 2017b). We consider in our analyses three education categories: without a high school degree, with a high school degree only and with at least some college degree. Race was reconverted into a binary variable, indicating whether the participant is non-Hispanic white or of any other race or ethnicity.

Information on retirement status and occupational class comes from the RAND HRS data set (RAND HRS 2016). The RAND HRS data set is an easy to use longitudinal data set based on the HRS data. This single file contains most of the information collected since the start of the HRS for all respondents. Some variables have been subject to imputation to correct for inconsistencies across waves (Chien et al. 2015). Retirement status includes four categories: not retired, partly retired, completely retired and not relevant. Not relevant was assigned most of the time to women who were homemakers according to other HRS labor force status variables. Occupation is classified according to the 1980 Census Occupation Classification System (IPUMS 2017) and contains 17 categories. We grouped the respondents according to three broad occupation classes: 1) Managerial and Professional specialty occupations; 2) Technical, sales and administrative support occupations and Service occupations; 3) Farming, Forestry and Fishing occupations, Precision production, craft and repair occupations and Operators, fabricators and laborers. In the remaining of this article, we will refer to the first group as *Managers*, the second as *Intermediary occupational group* and the third as *Manual workers*. Participants with inconsistent occupation classes across waves are assigned the one that is observed the most often over the whole of the follow up. We further use from this data set the variables Labor force status and Self-assessed health. These variables are only used in the imputation model described below. Labor force status is divided into the categories works full time, works part-time, unemployed, partly retired, retired, disabled and not in the labor force. Information on this variable was interpolated in the cases in which the participant temporary dropped out of the survey. Self-reported health contains five categories: Excellent, very good, good, fair and poor.

Information on the role of health in the retirement decision comes from the RAND enhanced fat files (Health and Retirement Study 2017a), which contain in separate files all the information collected at each wave. Participants who declare to be completely retired but who were not completely retired in the previous wave are asked whether health played a very important role, a moderately important role, a somewhat important role or no role at all in their retirement decision. We consider respondents who declare that health played a very important role in their retirement decision to have retired due to poor health, while we consider the other respondents to have retired due to other reasons.

Imputation model

Information about the retirement status was only gathered among respondents who were interviewed face-to-face rather than via a proxy, which led to a significant amount of missing information (8.6% of the whole sample). Furthermore, we discovered missing information about the importance of health in the retirement decision (24.1% of the completely retired participants), the occupational class (18.1%) and, to a lesser degree, about self-assessed health (4.3%). We ran an imputation model on these variables to maintain the representativeness of the sample (Rubin 2004). We ran a two steps, chained model. First, we ran a multinomial model on the variables retirement status, occupational class and self-reported health. Second, we ran a logistic model on the variable indicating whether retirement was due to poor health or not, conditional on the retirement status "completely retired". The model is further based on the variables labor force status, gender, race and level of education as regular (non-imputed) variables. We ran the imputation model using the command *mi impute* on Stata 14 (Stata corp. 2015). The figures presented below are based on the average of ten imputed data sets.

Years spent working and years lost to the different causes of career termination

Retirement timing is measured following a survival analysis approach. We follow respondents from age 55 until they retire due to poor health, retire due to other reasons, die, or until they are censored. Censoring occurs when respondents reach the last wave of the survey, age 70, or are lost to follow-up without having experienced any event of interest Events are assumed to take place halfway between interviews. Respondents that are completely retired at onset are excluded. We ignore transitions between the retirement statuses "Not retired" and "Partly retired" as we have no information on the reason to move to partial retirement. We consider that retirement coincides with the transition to the retirement status "Not relevant" when it is not followed by the retirement statuses "Not retired" or "Partly retired". Finally, we exclude respondents who are never observed in either the retirement status "Not retired" or the retirement status "Partly retired".

We include respondents who were born between1936 and 1947 only. The lower limit is imposed by the fact that older cohorts had already reached age 55 or older at the moment at which the survey began. The upper limit was set arbitrarily having in mind that each younger cohort is exposed to a greater risk of being censored before we can observe any event of interest.

The number of years spent working and the number of years lost to the different types of career termination are computed following the Stata 14 (Stata corp. 2015) pseudo-observation procedure proposed by Parner and Andersen (2010) and updated in Overgaard et al. (2015). The procedure computes pseudo-observations which make it possible to fit linear models on different types of survival outcomes in the presence of censored data. The pseudo-observations are obtained using the Kaplan-Meier method. After declaring the data to be survival time data, we used the Stata commands *stpmean* and *stplost* for computing time spent in the state working and years lost to the different types of career termination, respectively.

Results

Results are presented in four parts. First, we describe the sample, including a description of the survival data set. Second, we present in detail our estimation of capacity to work between ages 55 and 69 for American workers born between 1936 and 1947. The third and fourth parts compare our estimates of capacity to work between subgroups in a univariate and a multivariate analysis, respectively.

Sample description

Table 1 shows some of the characteristics of the survival data set. Among our specified cohort range, we identified a total of 7 675 persons who were part of the HRS at the moment of turning 55 years old. We excluded 1,429 persons because they entered observation completely retired or because they were never observed in the retirement statuses “partly retired” or “not retired”. This leaves us with a total of 6,246 observations accounting for 48,474 persons-years in total.

More than half the sample retired due to reasons other than poor health, which is about three times more than the number of participants who retired due to poor health. A total of 278 participants died before retiring or being censored. Slightly less than one-fourth of the sample was either lost to follow-up or reached 70 years old without having experienced any event of interest.

Table 1 Characteristics of survival dataset

At risk	Observations	Proportion in sample
Baseline	7,675	
In sample (% of baseline)	6,246	(81.4)
Person years	48,474	
Mean years observed	7.76	
Events (% of whole sample)		
Retirement due to other reasons	3,359	(53.8)
Retirement due to poor health	1,086	(17.4)
Deaths	278	(4.5)
Lost to follow-up	816	(13.1)
Censored (reached age 70 without retiring)	707	(11.3)

Table 2 breaks down the sample according to the different categories of the five variables included in our analysis. Women make up a little more than half the sample, while whites make up almost three quarters of the whole sample. About half of the sample has only a high school degree, while the rest is almost equally divided between people with no high school degree and people with at least a college degree. The intermediary occupational group makes up a little bit less than half of the sample. Manual workers and managers both account for approximately one fourth of the sample. Respondents are about equally divided between the three cohorts.

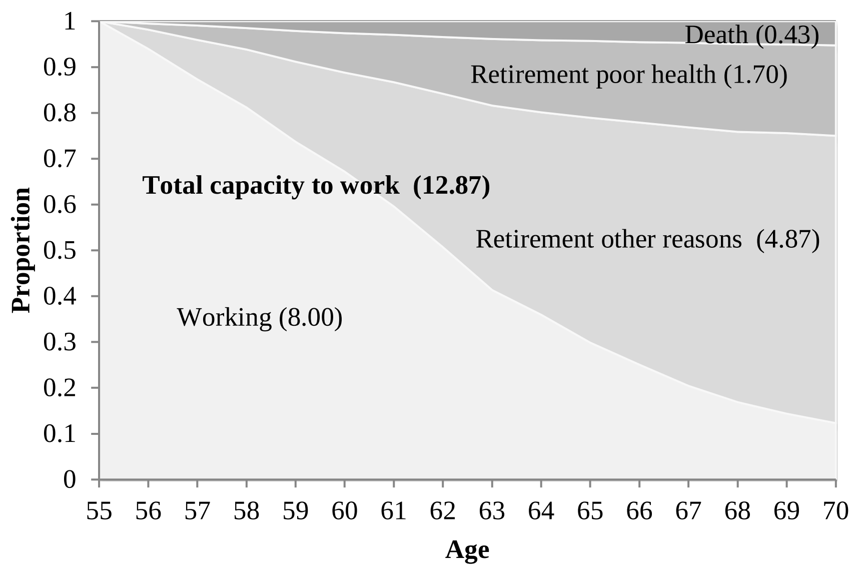
Table 2 Sample description according to the different groups

Group	**Number of observations**	**Proportion in sample (%)**
Gender		
Men	2,710	43.4
Women	3,535	56.6
Race		
White	4,585	73.4
Non-White	1,660	26.6
Education		
No High school	1,489	23.8
Only High school	3,165	50.7
At least some college	1,591	25.5
Occupational class		
Manual workers	1,604	25.7
Intermediary group	2,895	46.4
Managers	1,746	28.0
Cohorts		
1936-1939	2,406	38.5
1940-1943	2,274	36.4
1944-1947	1,565	25.1

Measuring the capacity to work among older American workers

Figure 3 breaks down the time comprised between age 55 and age 69 between time spent working and time lost to the different causes of career termination, for the whole sample. We see that American workers born between 1936 and 1947 spent exactly 8 years working and lost 4.87 years to retirement due to other reasons. The total capacity to work, which is defined as the sum of the years spent working and the years lost to retirement due to other reasons, is therefore 12.87 years. This represents a 61% increase compared to the actual amount of years spent working. These workers further lost 1.7 years to retirement due to poor health and 0.43 years to death.

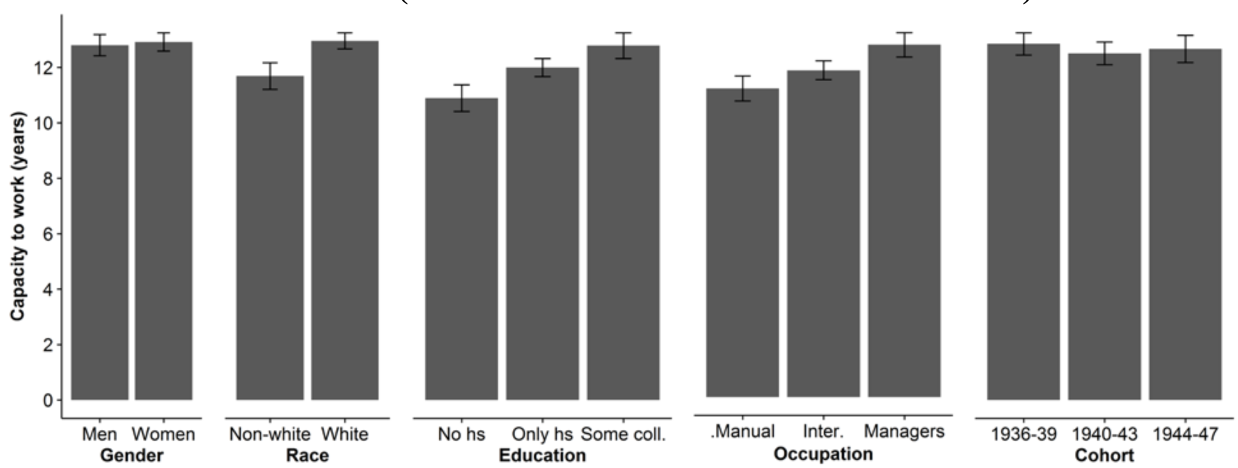
Figure 3. Years spent working, years lost to retirement due to other reasons, years lost to retirement due to poor health and years lost to death among American workers born between 1936 and 1947



Comparing capacity to work between population sub-groups

Figure 4 compares total capacity to work between subgroups as defined by the variables gender, race, education, occupation and cohort. No significant differences are to be found between men and women or between the different cohorts. Significant differences are to be found inside of the groups defined by race, education and occupational class. Whites have a significantly higher capacity to work than non-whites, a difference that reaches almost 1.3 years. Variation in capacity to work between education subgroups follows the expected gradient. People without a high school degree have a significantly lower capacity to work than the two other groups. In fact, their capacity to work is almost exactly two years below the one of people with at least a college degree. If we turn to occupational subgroups, no significant difference is to be found between manual workers and the intermediary occupational group. Managers have a significantly higher capacity to work than the two other subgroups. The difference in capacity to work between managers and manual workers is of 1.7 years.

Figure 4. Capacity to work among five groups as defined by gender, race, education, occupation and moment of birth (the error bars show the 95% confidence interval)



Since all years between age 55 and 69 have to be spent in one state or the other, capacity to work depends on the interaction between the values associated to each of these different states. For example, significant differences in capacity to work may be due to differences in the years lost to poor health but not in the number of years lost to regular retirement.

Table 3 breaks down the period comprised between 55 and 69 years old according to the number of years spent working, the years lost to retirement due to other reasons, the years lost to retirement due to poor health and the years lost to death, for each category of our five variables. First, we see that women spent a larger amount of years working than men. Although this result may appear surprising, it is driven mostly by the fact that women were more often associated to the retirement status “not relevant”. The amount of years working may thus not have the same meaning for women as for men since women are more likely to have been housewives. Men and women also differ significantly in terms of the years lost to retirement due to other reasons. Although the number of years lost to death differs significantly between the two sexes, the number of years lost to retirement due to poor health is almost the same. Thus, the difference in time spent working is compensated by the difference in years lost to retirement due to other reasons, resulting in similar capacity to work between men and women.

Table 3 further shows that whites spent more time working than non-whites. Non-whites also lost a bigger amount of years to retirement due to poor health. Both groups spent a similar amount of time in retirement due to other reasons. Thus, the difference in capacity to work between whites and non-whites is mostly due to the difference in years lost to retirement due to poor health. There is a big and significant amount of variation in both the amount of time spent working and the amount of years lost to retirement due to poor health among education subgroups. Once again, the differences in capacity to work between these subgroups is mostly due to the years lost to retirement due to poor health. The picture is somewhat more complicated between occupational classes. Manual workers spent fewer years working than the two other groups and lost more years to retirement due to poor health. They also lost more years to death than managers. People part of the intermediary occupational group lost fewer years to retirement due to other reasons than the two other groups. They also lost more years to retirement due to poor health than managers. In other words, manual workers and people part of the intermediary occupational class are both disadvantaged in terms of years lost to retirement due to poor health, but they attribute their remaining years in a different way between work and retirement due to other reasons. Finally, people born between 1936 and 1939 spent less time working than the two other groups, they lost more time to retirement due to other reasons, and lost less time to retirement due to poor health. The younger cohorts thus worked longer, but also lost more years to retirement due to poor health.

Table 3. Number of years spent working and lost to other reasons, poor health or to death, by subgroup

Group	Working		Lost to other reasons		Lost to poor health		Lost to death	
	Estimated	(95% int.)	Estimated	(95% int.)	Estimated	(95% int.)	Estimated	(95% int.)
Gender								
Men	7.69	(7.50- 7.88)	5.11	(4.91- 5.31)	1.64	(1.50- 1.79)	0.55	(0.46- 0.64)
Women	8.24	(8.07- 8.40)	4.68	(4.51- 4.85)	1.74	(1.61- 1.87)	0.34	(0.28- 0.41)
Race								
White	8.24	(8.09- 8.38)	4.98	(4.83- 5.13)	1.35	(1.25- 1.45)	0.44	(0.37- 0.50)
Non-White	7.35	(7.11- 7.59)	4.57	(4.31- 4.83)	2.65	(2.42- 2.88)	0.43	(0.33- 0.54)
Education								
No High school	7.08	(6.83- 7.32)	4.66	(4.39- 4.94)	2.80	(2.55- 3.05)	0.46	(0.34- 0.57)
Only High school	7.97	(7.81- 8.14)	4.96	(4.78- 5.14)	1.61	(1.48- 1.75)	0.45	(0.38- 0.53)
At least some college	8.89	(8.65- 9.14)	4.89	(4.63- 5.14)	0.84	(0.70- 0.98)	0.38	(0.28- 0.47)
Occupational class								
Manual workers	6.97	(6.74- 7.20)	5.09	(4.83- 5.35)	2.39	(2.16- 2.61)	0.55	(0.43- 0.67)
Intermediary group	8.20	(8.02- 8.38)	4.58	(4.39- 4.76)	1.79	(1.64- 1.93)	0.44	(0.36- 0.52)
Managers	8.61	(8.38- 8.85)	5.16	(4.91- 5.40)	0.92	(0.77- 1.06)	0.32	(0.23- 0.40)
Cohorts								
1936-1939	7.58	(7.39- 7.78)	5.46	(5.25- 5.68)	1.43	(1.28- 1.57)	0.53	(0.43- 0.62)
1940-1943	8.15	(7.94- 8.35)	4.54	(4.33- 4.75)	1.91	(1.74- 2.08)	0.40	(0.32- 0.49)
1944-1947	8.42	(8.17- 8.66)	4.44	(4.19- 4.69)	1.80	(1.60- 2.00)	0.34	(0.25- 0.43)

Multivariate analysis of subgroup differences

In this last part of the results section, we analyze whether there is any change in the inter-group differences witnessed so far when controlling for our set of five variables. For that we ran a linear regression model with capacity to work as a dependent variable as estimated with the pseudo-observation procedure described above. Table 4 shows that the variables gender, race, education and occupational class entertain a similar association with capacity to work as in the univariate analysis. Indeed, their sign stays unchanged and the significant differences remain. These differences are however somewhat smaller in each case, highlighting a certain degree of association between race, education and occupational class.

Table 4. Results of linear regression model with capacity to work as dependent variable

Independent variables	**Coefficient**
Gender	
Men	(Reference)
Women	0.06
Race	
White	(Reference)
Non-White	-0.92***
Education	
No High school	(Reference)
Only High school	0.82***
At least some college	1.30***
Occupational class	
Manual workers	(Reference)
Itermediary	0.51**
Managers	1.00***
Cohort	
1936-1939	(Reference)
1940-1943	-0.47***
1944-1947	-0.44**

** $p < 0.01$; *** $p < 0.001$

We witness one major difference in comparison with Figure 5. Namely, the differences between the cohort 1936-1939 and the cohorts 1940-1943 and 1944-1947 are now bigger and significant. The similar capacity to work between these three groups witnessed in the univariate analysis is therefore at least partly attributable to the other variables in the model. Other analyses (not shown here) confirmed that the higher education of the younger cohorts, and to a lesser extent the differences in the composition according to the occupational classes are responsible for masking the differences in the univariate analysis.

Discussion

In this paper, we presented a new population level approach to estimate capacity to work among older workers. Our approach was based on a survival analysis of retirement behavior in which we followed older workers from age 55 until retirement due to poor health, retirement due to other reasons, or death. We then applied the Andersen and colleagues' (Andersen et al. 2013) approach to cause-specific years of life lost to our survival data. This allowed us to calculate the number of years spent working, the number of years lost to retirement due to other reasons, the number of years lost to retirement due to poor health, and the number of years lost to death. We defined the sum of the years spent working and the number of years lost to retirement due to other reasons as total capacity to work. Total capacity to work was in turn defined as a measure of the age at which the health resources become insufficient to cope with the work demands (Ilmarinen 2001). We see our approach as a complement to the already existing Milligan-Wise (MW) (Milligan and Wise 2015) and Cutler-Meara-Richards-Shubik (CMR) (Cutler et al. 2013) methods (Wise 2017). In comparison to these methods, our approach gives closer insights into how individuals experience retirement and capacity to work. Furthermore, our approach allowed us to study differences among groups as defined by gender, race, education, occupational class and moment of birth, something that was not done using the above-mentioned methods.

Our results show a considerable amount of unused capacity to work among older American workers. According to our estimates, American workers born between 1936 and 1947 spent exactly 8 years in the state working between age 55 and 69. Furthermore, they lost 4.87 years to retirement due to other reasons, meaning that they could have worked 12.87 years out of 15 if they only retired due to poor health or death. This represents a capacity to work that is 61 percent higher than the actual time spent working. This figure is higher than the 53 percent figure obtained by Coile and colleagues (2017b) applying the MW method to American workers ages 55-70 in the year 2010. As discussed in the introduction, the lower figure obtained by Coile and colleagues is probably due to the restrictive assumptions made by the method, i.e. that the link between mortality rates and employment captures well the capacity to work in some reference year, and that this link remains constant over time. These results, as well as the ones from the previous studies that were based on other methods (e.g. the CMR method), however all point towards substantial unused capacity to work at older ages among older workers (Cutler et al. 2013; Rehkopf et al. 2017; Boissonneault and de Beer 2017).

We also provided insights into the differences in capacity to work inside of population subgroups. The difference in capacity to work between whites and non-whites was found to be 1.3 years, the one between people with a college degree or more and people without a high school degree was almost two years, and the one between managers and manual workers 1.7 years. These differences were explained by the fact that disadvantaged groups (i.e. non-whites, lower educated people and manual workers) lost a significantly bigger amount of years to retirement due to poor health. This finding has serious implications in the context of changing retirement regulations. In the United States like in many economically developed countries, laws were passed that raised (or will raise) the age at availability to retirement benefits. If inequalities concerning the capacity to work persist, disadvantaged groups might have to rely more on disability benefits before they reach the age at which they are entitled to retirement benefits. This can have negative effects on the well-being in old age (Halleröd et al. 2013). In such a context, the new regulations might therefore increase inequalities in front of retirement.

Other important findings were provided by our analysis of capacity to work between cohorts. More specifically, we found that the older cohort (born 1936-1939) would have had a higher capacity to work than the two younger cohorts (born 1940-1947) if the composition in the educational groups and occupational classes had been the same between them. Furthermore, although the younger cohorts spent more time working, they also lost a bigger amount of years to retirement due to poor health. This raises new questions in the debate about intergenerational equity (Sanderson and Scherbov 2014). Younger cohorts may be living longer, but they seem to be spending a bigger proportion of their healthy lives at work rather than enjoying retirement. However, our analysis assessed differences in capacity to work over a rather limited range of cohorts, therefore future research should compare capacity to work over a wider range of cohorts to verify whether there is any significant trend.

Our approach faces limitations. It rests on people's assessment of the role of health in the retirement decision. Two assumptions are thereby made. First, it is assumed that reasons for retiring are independent and mutually exclusive. In practice, people often retire due to multiple reasons (Beehr 2014). These limitations should be born in mind when interpreting the results, although it is unclear whether they introduced any bias in our estimates. A second assumption is that workers make a fair assessment of the role of poor health in their retirement decision. There is a good amount of research that showed that early retirees have worse self-assessed health than what objective measures of health suggest (Kalwij and Vermeulen 2008; Lindeboom and Kerkhofs 2009). The justification hypothesis was put forward to explain this phenomenon, which states that early retirees have social or economic incentives to report poor health (Chririkos and Nestel 1984; Anderson et al. 1985; Bound 1991). Furthermore, there exists systematic differences in reporting health between population subgroups (Kakwani et collab. 1997 ; Kerkhofs et Lindboom, 1995 ; Kreider, 1999). We are however not aware of any research that compared response patterns in reasons for retiring among early retirees and other retirees, or between population subgroups. Therefore, we cannot assess with any certainty whether this affected our results.

Another limitation is that we studied retirement timing and reasons for having retired based on an arguably simplistic retirement framework. More specifically, we did not consider the impact of partial or phased retirement (Johnson 2011) or of bridge-employment (Beehr 2015; Kerr and Armstrong-Stassen 2011) on capacity to work. These two phenomena have been gaining importance in the American retirement landscape over the last decades (Maestas 2010; Fisher 2015). Both can be understood as a job that is held after a career job (Beehr and Bowling 2013). These jobs are likely better suited to the resources of the older worker, and are therefore probably less psychologically and physically demanding than a career job. In our approach, we followed workers until their first complete retirement. First complete retirement may be preceded by partial retirement and can also be followed by a return to work. Therefore, our approach may have captured some work-related adjustment that happens in the latter part of a career, though not all of it. This can result in higher estimates of capacity to work compared to what would have been obtained had we measured capacity to work immediately after retirement from a career job only, but in lower ones had we measured capacity to work after retirement from any job.

Despite these limitations, we consider that our approach makes a significant contribution to further defining and measuring capacity to work at older ages at the population level. Our approach is novel in the sense that it studied the impact of health on retirement by combining survival analysis to the Andersen and colleagues' approach to cause-specific measures of years of life lost. There is still only a handful of scientific papers that aimed to estimate capacity to work at older ages at the population level. Our approach has the advantages that it gives close insights into people's behavior in retirement, and that it easily allows for subgroups comparisons. Future research can apply our approach to other countries, for which there is growing data availability on retirement and health (see the HRS sister studies, HRS 2017). Furthermore, our approach can be expanded, for example to include different stages of the retirement process. Such research will prove useful in the context of changing retirement landscapes in Europe, North America and other parts of the world.

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Higher labor force participation of older workers is being advocated in western countries. Measures such as raising the official age at retirement will be effective only to the extent that people are physically and mentally able to work longer. Previous methods that were proposed to quantify capacity to work at older ages (namely, the Milligan-Wise and Cutler-Meara-Richards-Shubik methods) do not reflect the actual experience of workers. Moreover, they do not address the differences in capacity to work between population subgroups. We propose a new approach that is based on a survival analysis of retirement and the Anderson and colleagues' approach to cause-specific years of life lost, which allows to quantify the number of years that would be worked if workers would only retire when they become unable to work. We apply our approach to American workers born between 1936 and 1947 and find an unused capacity to work of almost 5 years between age 55 and 69. Moreover, we find that workers with a college degree have the capacity to work two more years compared to workers without a high school degree, and that managers have the capacity to work 1.7 more years compared to manual workers.

The Netherlands Interdisciplinary Demographic Institute (NIDI) is an institute for the scientific study of population. NIDI research aims to contribute to the description, analysis and explanation of demographic trends in the past, present and future, both on a national and an international scale. The determants and social consequences of these trends are also studied.

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