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Measuring Human Capital in Europe and Central Asia

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Abstract

This paper outlines an extension of the Human Capital Index that addresses the specific challenges in education and health faced by countries in Europe and Central Asia. Good basic education will not be enough, as job markets today demand higher levels of human capital than in the past. As the region's population becomes older, it is important that adults remain healthy to ensure productive aging. The Europe and Central Asia Human Capital Index (ECA-HCI) extends the Human Capital Index by adding a measure of quality-adjusted years of higher education to the original education component, and it includes the prevalence of three adult health risk factors—obesity, smoking, and heavy drinking—as an additional proxy for latent health status. This extension of the Human Capital Index could also be useful for assessing the state of human capital in middle-income countries in general.

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1. Introduction

In 2018, the World Bank launched the Human Capital Project (HCP), an initiative aimed at raising awareness among policy makers about the importance of investing in human capital. The HCP includes an advocacy component which features the Human Capital Index (HCI), a measure of the human capital that a child born today can expect to attain by age 18, given the risks of poor health and poor education that prevail in the country where she lives (Kraay, 2019).

The HCI quantifies the trajectory from birth to adulthood in terms of the consequences for productivity by means of three components: (1) a measure of whether children survive from birth to school age (age 5); (2) a measure of expected years of basic education (primary and secondary), adjusted for quality; and (3) two broad measures of health: child stunting rates and adult survival from age 15 to age 60. The index is constructed so that a value of 1 represents the productivity in adulthood of a child born today if he or she enjoyed complete education and full health until age 18. Countries are measured with respect to this benchmark; the value of the index can thus be interpreted as a percentage of that productivity level.

While useful in a global context, the original version of the HCI may not adequately reflect the education and health challenges that are relevant for specific regions of the world. Countries in Europe and Central Asia provide their citizens relatively good basic education and health services; the region's citizens begin their productive life in a much better position than their peers in other regions of the world. But job markets today demand higher levels of human capital than in the past. Good basic education will not be enough; higher education institutions must prepare students for the challenges the future of work may hold. Health care systems will need to ensure that citizens remain healthy throughout their adult life, as, more and more, learning and skill acquisition will take place along an individual's life cycle, not just in the initial years of life. This is also more important as the region's workforce is becoming, on average, older, and therefore improving adult health will be needed to ensure a productive aging for the region's population.

This paper outlines an extension of the HCI which addresses the relevant education and health challenges of Europe and Central Asia, namely by including higher education in the education component of the index and by looking at three crucial adult health risk factors -obesity, heavy alcohol consumption and tobacco smoking- in the health component. This extension could also be useful for assessing the state of human capital in middle income countries in general, particularly for those where basic education attainment and child health are less of a concern but where significant challenges remain as young people transition into the labor market.

This paper is organized as follows. Section 2 presents the main analytical framework of the ECA-HCI, the proposed extension of the original HCI. Section 3 discusses the education component and section 4 discusses the health component. Section 5 presents the overall results and section 6 concludes.

2. Main Framework

The basic structure of the Human Capital Index (HCI) is made up of three components:

$$HCI = \frac{p}{p^*} \times e^{\phi(S_{NG}-S^*)} \times e^{\gamma(Z_{NG}-Z^*)} \tag{1}$$

The first term captures forgone productivity caused by child mortality. The second term captures forgone productivity as a result lack of full education, where S_{NG} refers to the schooling level of the generation of children born today and S^* refers to the full education benchmark. The productivity return to education is measured by parameter φ. The third terms captures forgone productivity as a result of lack of proper health, where Z_{NG} refers to the expected adult health status of the generation of children born today and Z^* refers to the full health benchmark. The productivity return to good health is measured by parameter γ.

The HCI's measure of child mortality is the probability of survival to age five. The education component of the HCI uses learning-adjusted years of schooling, a quality-adjusted measure of years of basic education. The benchmark is set at 14 years of schooling, equivalent to the whole cycle of primary and secondary education plus two years of preprimary education. The parameter φ is set at 0.08, based on estimations of the average return of one year of basic education.

The health component of the HCI uses child stunting (when available) and the adult survival rate (the probability that a child age 15 reaches age 60) as health status indicators. The benchmark is zero stunting and 100 percent adult survival rate. To establish a quantifiable productivity return to good health, both variables are transformed into implied adult height in centimeters, which has a productivity return of 0.034 per centimeter. Adult height is implied to be the most relevant proxy variable for latent health status (captured by Z in the equation above). The value of γ is 0.35 for child stunting and 0.65 for the adult survival rate.

The HCI is calculated using the following formula:

$$HCI = \frac{1-Under\ 5\ mortality\ rate}{1} \times e^{0.08(LAYS-14^*)} \times e^{(0.35(Not\ Stunted\ Rate-1)+0.65(ASR-1))/2} \tag{2}$$

This paper outlines an alternative specification that may be particularly relevant for the education and health challenges faced in Europe and Central Asia. For the education component, we add higher education in addition to basic education. For the health component, we use a proxy of latent adult health status (based on the incidence of obesity, smoking, and alcoholism), along with the outcome proxy based on child stunting and adult survival rate used in the original HCI. The basic formulation of the Europe and Central Asia HCI (ECA-HCI) is as follows:

$$ECA - HCI = \frac{p}{p^*} \times e^{\eta(B-B^*)+\omega(C-C^*)} \times e^{\frac{\gamma_{RF}(RF-RF^*)+\gamma_O(O-O^*)}{2}} \tag{3}$$

where B refers to the quality-adjusted basic education schooling level of the generation of children born today, with an associated productivity return captured by parameter η and full basic education benchmark B^*; C refers to the quality-adjusted higher education schooling level, with an associated productivity return captured by parameter ω and full higher education benchmark C^*; RF refers to the prevalence of adult health risk factors (namely the share of non-obese individuals in the adult population, the share of adult nonsmokers, and the share of adults who report no heavy drinking), with an associated productivity return captured by parameter γ_{RF}. The benchmarks for these shares are set to 100 percent non-obese, nonsmokers, and non–heavy drinkers. O refers to the value of the relevant health outcomes (adult survival rate and child stunting); γ_o refers to their productivity effects, estimated via their relationship with adult height, as in the original HCI.

3. Education Component

The 2019 *World Development Report* highlights the changing nature of work across the globe. In high-income countries, which include most of the countries in Europe and Central Asia, having a good basic education will not be enough for individuals to be productively included in the labor market in the next decades; higher education of good quality will be necessary for the next generations to be productive workers. The education component of the ECA-HCI therefore extends the original education component by adding a measure of quality-adjusted years of higher education (QAYH) to the measure of learning-adjusted years of basic education. Like learning-adjusted years of basic education (LAYS), QAYH measures both quantity and quality.

The basic formulation of the education component of the ECA-HCI is the following:

$$ECA - HCI_{education} = e^{\eta(LAYS-LAYS^*)+\omega(QAYH-QAYH^*)} \tag{4}$$

Where η and ω are the productivity returns of one additional year of quality basic and higher education respectively, and $LAYS^*$ and $QAYH^*$ are the benchmark number of years equivalent to full basic and higher education respectively.

As shown in equation 4, the education component of the ECA-HCI includes two subcomponents. The first measures the basic education schooling level expected for the generation of children born today. This component is the same as the overall education component in the standard version of the HCI. The main variable is learning-adjusted years of education, a quality-adjusted measure of schooling years in basic education. The benchmark (*LAYS)* is set at 14 years of basic education. The associated return in productivity terms (η) is set at 0.08.

The second component focuses on higher education. A quality-adjusted measure of years of higher education requires two inputs: a measure of expected years of higher education and a measure of the quality of higher education. The basic structure of the main outcome variable—quality-adjusted years of higher education (QAYH)—is the following:

$$QAYH_c = EYH_C \times QA_c \tag{5}$$

where EYH_c represents the expected years of higher education of country *c*, and QA_c represents the average quality of higher education in country *c*, which has a maximum of 1 and a minimum of *m*. The minimum is greater than 0 on the assumption even very low-quality higher education has some intrinsic value, even if minimal. *QAYH* is expressed in years of higher education of maximum quality.

3.1 Expected years of higher education

The standard approach for estimating expected years of basic education uses the age-specific enrollment rates over all ages in the 4–18 age range as the main input. The nature of higher education requires a different treatment, for several reasons.

First, there is no theoretical age at which higher education is expected to happen. Second, higher education is not always carried out full time; many students combine their studies with part-time employment. Third, the number of years required to obtain a higher education degree varies across disciplines and across countries (the norm in EU countries, after implementation of the Bologna Process, is for initial degrees to take three years; in the Russian Federation, a bachelor's degrees take four years).

The approach adopted in this paper uses the percentage of individuals with a higher education degree at age 30–34 as the measure of educational attainment. To express it in years of education, we assume that a university degree is equivalent to 3.5 years of higher education, to account for differences across disciplines and educational systems. The calculation of expected years of higher education (*EYH*) is straightforward:

$$EYH_c = Tertiary\ attainment_c^{age\ 30-34} \times 3.5 \tag{6}$$

where *Tertiary attainment* corresponds to the share of individuals 30–34 in country *c* who hold a tertiary degree.

3.2 Quality adjustment of higher education attainment

Quality adjustment of higher education should be done primarily by measuring the quality of outputs, such as the skill proficiency of university graduates (just as harmonized test score results are used to measure the quality of learning among primary and high school students). However, measures of adult skill proficiency (from the Programme for the International Assessment of Adult Competencies [PIAAC] or Skills Towards Employability and Productivity [STEP] surveys, for example) are available only for a limited set of countries.[1] The ECA-HCI therefore measures the quality of inputs—such as the quality of universities—which are more widely available. However, measures of the quality of universities and adult skill proficiency correlate very well for countries for which both measures are available (see appendix A for a comparison of the input-based quality adjustment presented here and an alternative skill-based quality adjustment).

The quality of higher education is calculated under the assumption that a high-quality degree is a degree that makes its holders more productive in the labor market—the working assumption of the broad literature on the effects of college quality on earnings in the United States. Standard ordinary least squares (OLS) estimates of the impact of college quality (usually measured by the average SAT score of admitted students) on earnings show that there is a positive and significant association between them. Given the existence of a selection process into college—high school students decide which colleges to apply to—these estimates may suffer from a substantial selection bias.

To address this issue, the literature has followed two approaches. The first is a "selection-on-observables" approach, in which the decision to apply to a given type of college is modeled based on observable variables such as net college costs or high school grade point average (Brewer, Eide, and Ehrenberg 1999; Andrews, Li, and Lovenheim 2016). This approach has confirmed the existence of a positive and significant return of the quality of college education on earnings.

The second is a "selection-on-unobservables" approach, in which, rather than modeling college choice, the researcher compares the outcomes of students who were admitted to the same set of colleges but chose to go to different ones (Dale and Krueger 2002, 2014). This approach is a "self-revelation" method, because it assumes that the set of students admitted to a given college share the same "unobservable" characteristics. This method shows that, for the average student, there is no significant effect of college quality on earnings. The effect is significant for minority students and those from poor backgrounds, however.

[1] For a comparison of output quality in tertiary education, see Loyalka and others (2019), who compare the computer science skills of computer science undergraduates in their last year in China, India, the Russian Federation, and the United States.

The quality-adjustment factor in our study is calculated in the following way:

$$QA_c = m \times e^{\beta \times Q_c} \tag{7}$$

where *m* corresponds to the productivity of a tertiary degree coming from a "zero-quality" institution; *Q* corresponds to the average quality score of universities in country *c*, ranging from 0 to 100; β is a productivity-adjustment factor that transforms the quality score into productivity units; and *m* is scaled in a way that quality adjustment (QA_c) equals 1 if Q_c equals 100.

The measure of quality corresponds to the information collected by global university rankings. These rankings, published by private, for-profit companies, have grown in number over the years. They are usually based on an underlying score that is usually a weighted average of scores on different aspects of higher education (the volume and quality of research, research influence, the quality of teaching, international outlook, links to industry). These rankings do not include all higher education institutions (universities need to send their information, usually at a cost, to the publishers), and they use different methodologies. Our analysis relies on a combination of several of these ranking, including the scores from the Times Higher Education (THE) ranking; the Quacquarelly Symonds (QS) ranking; the Academic Ranking of World Universities (ARWU, also known as the "Shanghai" ranking); the Center for World University Rankings (CWUR); the U.S. News Global Universities Ranking; and the U-Multirank ranking (a nonnumeric, user-defined ranking). These rankings contain information on 400–1,000 universities in 43 countries in Europe and Central Asia. We generate a country-level average by averaging the scores for all the universities in a given country included in each ranking, yielding six values for each country (one for each ranking source). As detailed later, we normalize each of them, and then take the average of them as the aggregate quality score.

University rankings

Table 1 describes the six university rankings used in this analysis. The CWUR includes the largest number of universities (2,000); the ARWU/Shanghai includes the smallest number (1,000). The rankings include 385–1,040 higher education institutions in Europe and Central Asia. The total number of countries covered ranges from 63 to 98; the number of countries in Europe and Central Asia ranges from 32 to 43. Five of the six rankings (THE, QS, ARWU, CWUR, and U.S. News rankings) have scores that (theoretically) range from 0 to 100, although no institution included in any of the rankings has a score of 0. The U-Multirank is a nonnumeric, multidimensional, user-defined ranking. To use it, we imputed numeric values (ranging from 0 to 100) to the letter-based scores assigned. The CWUR has the highest minimum score (65.8) and the lowest dispersion (5.07). The ARWU/Shanghai overall score is reported only for the world's top 100 universities.

Given that the six rankings include subcomponents on the quality of research, faculty performance, and reputation, an alternative score can be estimated as the simple average of the scores of those subcomponents—the research, teaching, and citations (RTC) quality score. This score captures the quality of the subcomponents that are common to all the rankings. This calculation is not possible for the CWUR and U.S. News rankings, which do not publish the scores on the subcomponents.

Table 1 Descriptions of six systems of university ranking

Item	*Times Higher Education (THE)*	*Quacquarelly Symmonds (QS)*	*Academic Ranking of World Universities (ARWU)*[a]	*Center for World University Rankings (CWUR)*[b]	*U.S. News Global Universitie s Ranking*	*U-Multirank (UMR)*[c]
Number of universities included	1,397	1,021	1,000	2,000	1,500	1,666
Of which in ECA	540	418	385	708	556	1,041
Number of countries	91	85	63	98	81	92
Of which in ECA	37	35	32	36	36	43
Ranking components covered						
Research/ innovation on outputs	✓	✓	✓	✓	✓	✓
Faculty performance	✓	✓	✓	✓	✓	✓
Internationalization	✓	✓			✓	✓
Reputation	✓	✓	✓	✓	✓	
STEM focus			✓			
Overall score						
Global mean	34.57	29.90	37.00	71.64	42.45	59.27
Dispersion	17.07	19.75	12.71	5.07	16.28	14.41
Range	16.4–95.4	10.7–100	26–100	65.8–100	15.5–100	16.7–100
Research, Teaching, and Citations score[d]						
Global mean	33.43	30.83	20.96	n.a.	n.a.	63.56
Dispersion	17.45	20.00	9.82	n.a.	n.a.	16.54
Range	9.3–96.4	10.7–99.9	8.2–92.7	n.a.	n.a.	20–100

Note: ECA = Europe and Central Asia; STEM = science, technology, engineering, and mathematics.

a. The overall score for the ARWU ranking is published only for the top 100 universities. For the remaining institutions, only the individual subcomponents are published.
b. The CWUR publishes only the overall score, not the subcomponent scores.
c. The UMR provides a letter-based, not a numeric, score. To estimate a numeric equivalent, the following scale was used: A = 100; B = 75; C = 50, D =2 5, E = 0. The overall score represents the average of the numeric score of all the UMR categories (teaching and learning, research, knowledge transfer, international orientation, and regional engagement).
d. The Research, Teaching, and Citations score is composed of the simple average of the components of research, faculty performance, and reputation.

The correlation between these rankings is very high. Partial correlations across the rankings for a subset of 98 U.S. universities included in the six rankings range from 0.64 to 0.97 (Table 2). Partial correlations across the country averages for the 54 countries that have at least one university present in all six rankings are also high, ranging from 0.61 to 0.91 (Table 3).

Table 2 – Partial correlation across US universities (n=98)

	Ov. THE	Ov. QS	RTC ARWU	Ov. CWUR	Ov. US News	Ov. UMR
Overall THE	1					
Overall QS	0.9728	1				
RTC ARWU	0.8762	0.8895	1			
Overall CWUR	0.9375	0.9492	0.9396	1		
Overall US News	0.9395	0.9350	0.9381	0.9620	1	
Overall UMR	0.6886	0.7374	0.6486	0.7187	0.7274	1

	RTC THE	RTC QS	RTC ARWU	Ov. CWUR	Ov. US News	RTC UMR
RTC THE	1					
RTC QS	0.9544	1				
RTC ARWU	0.8771	0.8735	1			
Overall CWUR	0.9384	0.9437	0.9396	1		
Overall US News	0.9386	0.9246	0.9381	0.9620	1	
RTC UMR	0.7230	0.7666	0.6412	0.7246	0.7476	1

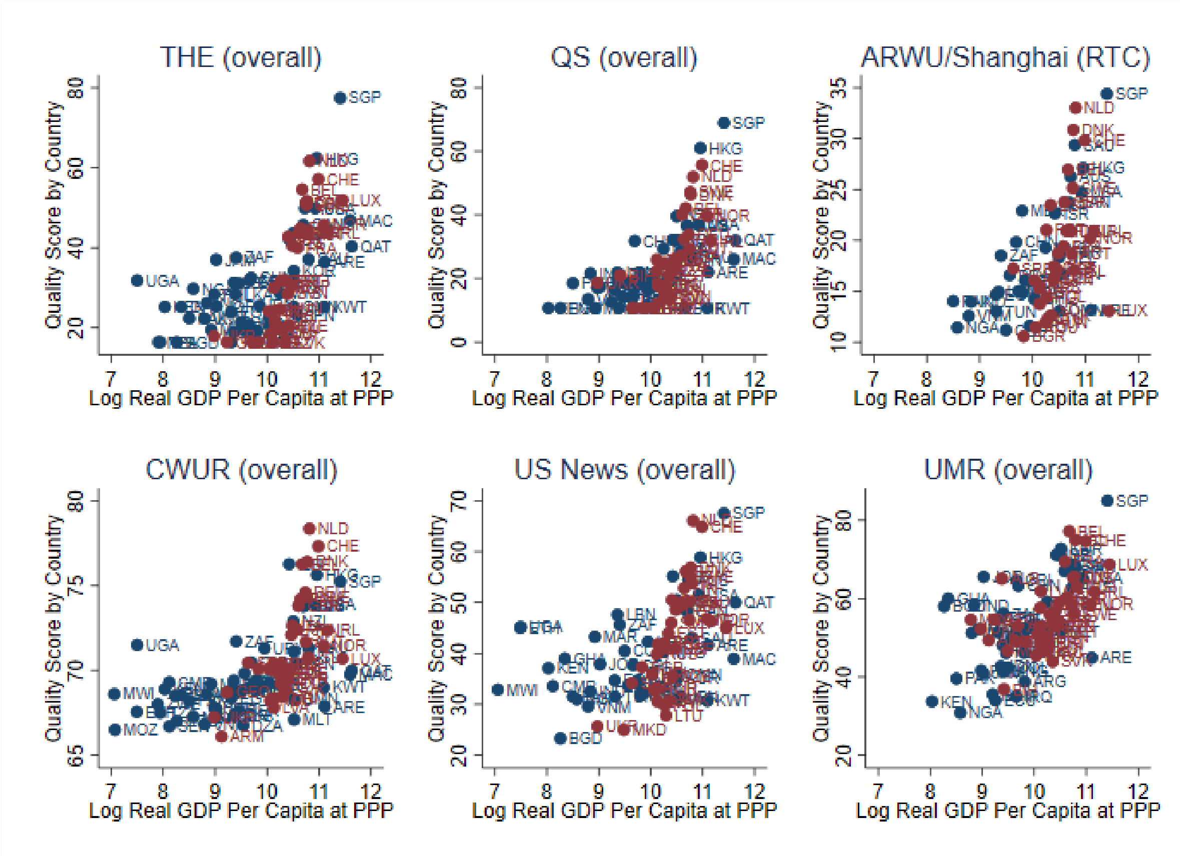
Table 3 – Partial correlation across country averages (n=54)

	Ov. THE	Ov. QS	RTC ARWU	Ov. CWUR	Ov. US News	Ov. UMR
Overall THE	1					
Overall QS	0.9044	1				
RTC ARWU	0.8514	0.8587	1			
Overall CWUR	0.8741	0.8443	0.8461	1		
Overall US News	0.9272	0.8220	0.7975	0.8961	1	
Overall UMR	0.7453	0.7711	0.6977	0.7122	0.6387	1

	RTC THE	RTC QS	RTC ARWU	Ov. CWUR	Ov. US News	RTC UMR
RTC THE	1					
RTC QS	0.8833	1				
RTC ARWU	0.8436	0.8533	1			
Overall CWUR	0.8819	0.8427	0.8461	1		
Overall US News	0.9144	0.7962	0.7975	0.8961	1	
RTC UMR	0.7354	0.7231	0.7210	0.7125	0.6138	1

A positive correlation also exists between the quality scores and the income level of countries (see Figure 1). Singapore is ranked as the country with the highest quality score in the THE, QS and ARWU rankings, while for the CWUR ranking the highest ranked country is the Netherlands.

Figure 1 – University rankings (quality score) and income level



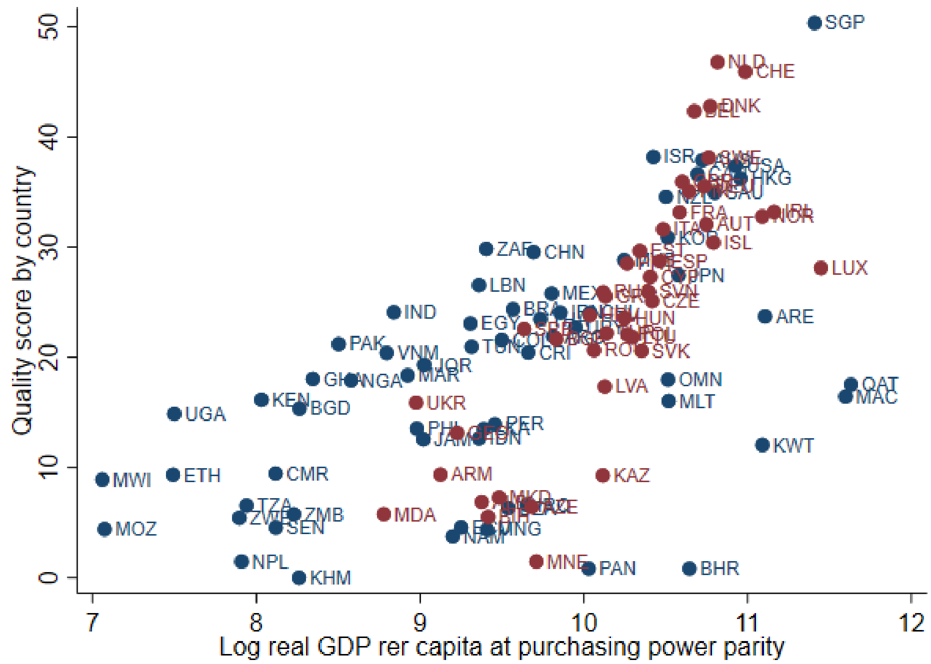
Note: in red are marked the countries of Europe and Central Asia

To create an aggregate quality score that combines the information from the six rankings, we first code as 0 the score for a country that is not present in the ranking (except for the CWUR ranking, for which we use a value of 60, given that the minimum score recorded in that ranking is 66.5). The scores for each ranking are then normalized to have a mean of 0 and a standard deviation of 1. The overall score is used for the THE, QS, CWUR, U.S. News, and U-Multirank rankings; the RTC score is used for the ARWU. The simple average of the six standardized scores is then rescaled to a 0–100 range for presentational purposes.

This procedure ranks countries in terms of the average quality of its universities, ignoring the distribution of students across universities. Given that this information is not available at a global scale, the simple average is used.

Figure 2 plots the values of the aggregate quality score by country and income level. Only countries that are present in at least one of the six rankings are included.[2] The correlation between income level and the aggregate quality score is particularly steep for Europe and Central Asia.

Figure 2. Correlation between aggregate quality score of universities and country income level



Note: Only countries present in at least one of the six rankings are included. Red points indicate countries in Europe and Central Asia.

Estimation of the quality-adjustment factor

To estimate the productivity effect of university quality (parameters β and m in equation 7), we rely on a cohort-college-level data set for 294 U.S. colleges. Focusing on the U.S. data allows us to control for parental income, one of the key drivers of individual income. The data set comes from the *Mobility Report Cards* constructed by Chetty and others (2017), which combines college and administrative data that link the parental and post-college earnings of about 28.1 million students born between 1980 and 1991 for 2,463 colleges. The data set consists of cohort-college observations—that is, observations of the average characteristics of students born in a given year who studied at a given college. For each observation, the data set includes the students' average annual earnings in 2014 and the average parental earnings when the cohort was age 15–19. The data set also includes a series of college-level variables, such as the average

[2] In that countries have a value of zero in the quality score Q_c, the quality adjustment factor QA_c has a value of m: having a tertiary degree from these countries has an intrinsic value of m but no *additional* quality premium.

attendance costs, instructional expenditure, and percentage of students in each type of major. We match this data set with the six university rankings. Among U.S. higher education institutions, 294 are present in at least one of the rankings, and 108 are present in all four.

The simple OLS regression estimated is the following:

$$\log(earnings)^{2014}_{b,g,c} = \alpha_g + \beta_g Q_c + \gamma_{1,g}\log(pearnings)_{b,g,c} + \gamma_{2,g} age_b + \gamma_{3,g} pct\_STEM_c + \varepsilon_{b,g,c} \quad (8)$$

where the dependent variable is the annual average log earnings in 2014 of the cohort born in year b of gender g that went to college c. The main regressor of interest is Q, the quality measure based on the six rankings for college c. Coefficient β is the productivity effect of quality; it is used as the quality-adjustment factor in equation (7) which feeds into the ECA-HCI. Other regressors are the log parental earnings of the cohort born in year b of gender g that went to college c when the individuals were 15–19; the age of cohort b in 2014; and percentage of STEM majors in college c in year 2000 (included to control for the STEM wage premium). Standard errors are clustered at the college level.

Table 4 provides the results for the aggregate quality score derived from the combination of the six rankings, shown for the sample of universities that are present in at least one of the rankings (323 universities in total) and for the common sample of 98 universities that are present in all the rankings. Table 5 summarizes the values of β and m (the implied productivity of a "zero-quality" institution) that arise from the results of the OLS estimations of equation (8), focusing only on values that refer to both genders. Full results are available in Table A.1 in the appendix.

Table 4. Ordinary least squares estimates of aggregate quality scores of universities

	Log annual earnings in 2014					
	Full sample			Common sample		
	Both genders	Men	Women	Both genders	Men	Women
Aggregate quality score	0.0024***	0.0031***	0.0016***	0.0044***	0.0052***	0.0036***
	(0.004)	(0.0004)	(0.0004)	(0.0009)	(0.0010)	(0.0008)
Log parental earnings	0.2986***	0.3142***	0.2646***	0.3202***	0.3597***	0.2543***
	(0.0136)	(0.0150)	(0.0134)	(0.0248)	(0.0283)	(0.0225)
Age	0.1074***	0.1237***	0.0894***	0.1157***	0.1295***	0.0979***
	(0.0013)	(0.0014)	(0.0013)	(0.0023)	(0.0024)	(0.0022)
STEM majors in	0.0058***	0.0053***	0.0049***	0.0046***	0.0043***	0.0032***
college (0–100)	(0.0005)	(0.0005)	(0.0006)	(0.0008)	(0.0008)	(0.0010)
(percent)						
Constant	3.8250***	3.2798***	4.6636***	3.2758***	2.4979***	4.5139***
	(0.1679)	(0.1881)	(0.1606)	(0.3061)	(0.3469)	(0.2707)
Observations	3,784	3,689	3,738	1,159	1,159	1,156
Number of colleges	323	315	321	98	98	98

Note: The common sample is composed of universities that are present in all six rankings. Clustered standard errors at the college level are in parentheses. STEM = science, technology, engineering, and mathematics.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5. Parameters of the quality-adjustment factor used to assess universities

	THE		QS		ARWU	CWUR	U.S. News	U-Multirank		Aggregate quality score (overall)	
	Overall	RTC	Overall	RTC	RTC	Overall	Overall	Overall	RTC	All sample	Common
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
β	0.0032	0.0031	0.0027	0.0024	0.0045	0.0073	0.0019	0.0040	0.0032	**0.0024**	0.0044
m	0.726	0.733	0.763	0.787	0.638	0.747	0.826	0.668	0.728	**0.787**	0.647

Note: ARWU = Academic Ranking of World Universities; CWUR = Center for World University Rankings; QS = Quacquarelly Symonds; RTC = research, teaching, and citations; THE = Times Higher Education.

To estimate the ECA-HCI, we use the values estimated from the use of the aggregate quality score in the extended sample (Table 5, column 10). These values can be understood as a conservative estimate of the productivity effects of quality, as the estimates from the sample of universities present in the six rankings (Table 5, column 11) imply a larger effect. The parameters are derived from the implied differences in the wages of graduates of a low-quality university compared with those of a high-quality university in the United States. This implied wage differential may be even higher when comparing a low-quality university in a given country with a high-quality university in another country. Interpretation of the results emerging from the use of this quality-adjustment factor needs to take these limitations into account.

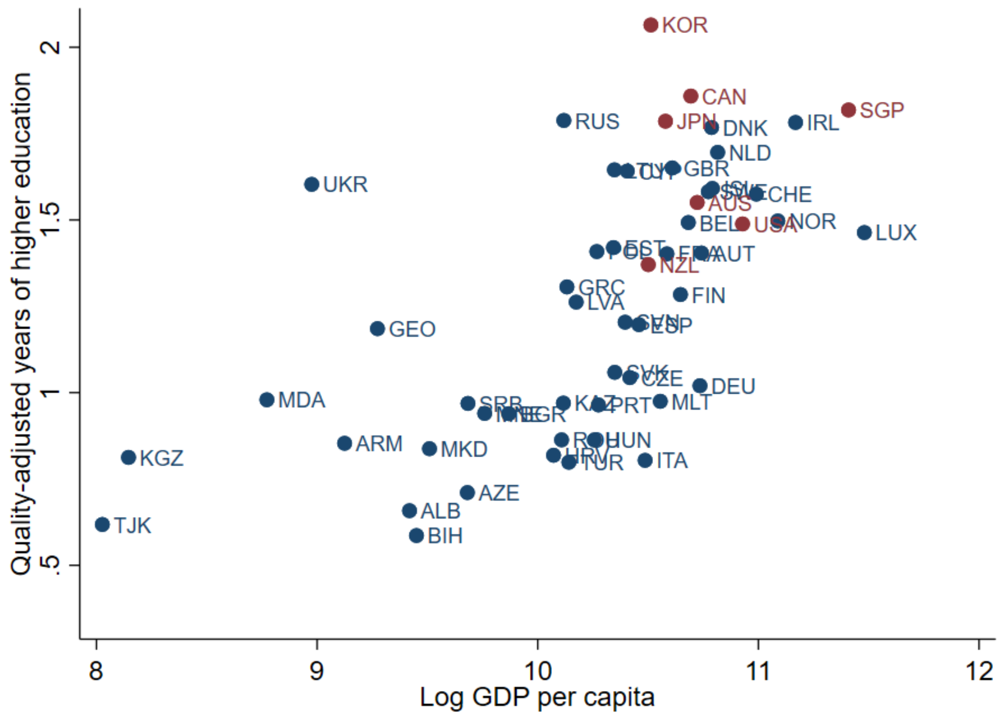
3.3 Quality-adjusted years of higher education

Based on the estimates of the previous paragraphs, the detailed calculation formula for the quality-adjusted years of higher education (*QAYH*) is as follows:

$$QAYH_c = Tertiary\ attainment_c^{age\ 30-34} \times 3.5 \times 0.787 \times e^{0.0024 \times Q_c} \quad (8)$$

where Q is the aggregate quality score for higher education for country c. There is also positive association between quality-adjusted years of higher education and income level (see Figure 3).

Figure 3 – Quality-adjusted years of higher education and income level



Note: Countries in blue are in Europe and Central Asia. Countries in red are high income countries from other regions.

3.4 Contribution of education to relative productivity in the ECA-HCI

To calculate the education component of the ECA-HCI, we need to establish the returns to one additional year of tertiary education. We rely on the evidence presented by Montenegro and Patrinos (2014), who suggest that an average return of an additional year of tertiary education is 0.152. For basic education, as stated before, we will rely on the same productivity parameter as the original HCI – a value of 0.08 for any additional year of basic education. The benchmarks for full education are set at 14 years of basic education and 3.5 years of higher education. Country and subregion estimates are presented in table 6.

Figure 4 plots the education component of the ECA-HCI. The distance between a given value and 1 indicates the productivity lost as a result of the average level of education falling short of the benchmark There is a positive association between a country's income level and the contribution of education to relative productivity, although the association is looser at lower income levels.

Figure 4. Contribution of education to relative productivity (ECA-HCI)

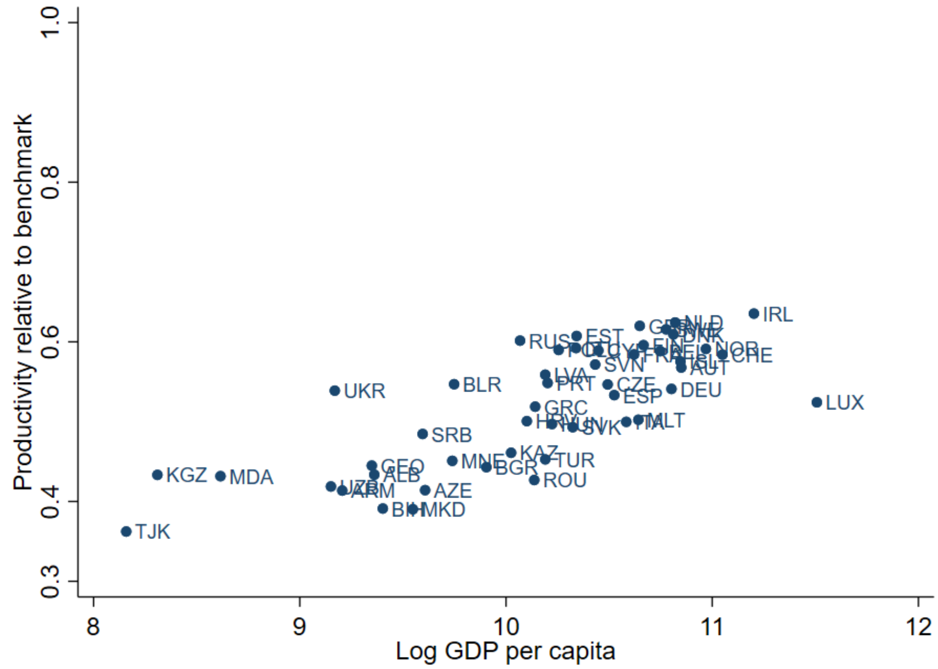


Table 6 Education component of the Europe and Central Asia extension of the Human Capital Index (ECA-HCI)

Subregion/country	*Learning-adjusted years of basic education*	*Share of population 30–34 with tertiary degree*	*Aggregate higher education quality score*	*Quality-adjusted years of higher education*	*Education component, ECA-HCI*	*Education component, HCI*
Central Asia	**8.8**	**0.213**	**2.5**	**0.59**	**0.424**	**0.659**
Kazakhstan	9.1	0.344	9.3	0.97	0.461	0.677
Kyrgyz Republic	8.7	0.295		0.81	0.433	0.652
Tajikistan	6.8	0.224		0.62	0.362	0.561
Uzbekistan	9.1	0.121		0.34	0.419	0.678
Central Europe and Baltic countries	**10.4**	**0.392**	**22.3**	**1.14**	**0.526**	**0.750**
Bulgaria	8.7	0.324	21.6	0.94	0.443	0.654
Croatia	10.4	0.281	23.8	0.82	0.501	0.753
Czech Republic	11.1	0.357	25.1	1.04	0.547	0.794
Estonia	11.7	0.480	29.7	1.42	0.607	0.833
Hungary	10.3	0.296	23.5	0.86	0.497	0.742
Latvia	11.0	0.440	17.3	1.26	0.559	0.785
Lithuania	11.0	0.567	21.8	1.65	0.592	0.785
Poland	11.4	0.485	22.1	1.41	0.590	0.811
Romania	8.4	0.298	20.6	0.86	0.427	0.637
Slovak Republic	9.8	0.366	20.6	1.06	0.493	0.715
Slovenia	11.4	0.411	25.9	1.20	0.572	0.810

Eastern Europe	**9.9**	**0.525**	**16.3**	**1.50**	**0.534**	**0.723**
Belarus	10.8	0.421	22.1	1.22	0.547	0.773
Moldova	8.3	0.351	5.8	0.98	0.432	0.633
Ukraine	9.9	0.560	15.9	1.60	0.539	0.719
Northern Europe	**11.4**	**0.512**	**37.3**	**1.54**	**0.605**	**0.814**
Denmark	11.1	0.579	42.8	1.77	0.609	0.793
Finland	11.7	0.428	35.1	1.28	0.596	0.835
Iceland	10.7	0.537	30.4	1.59	0.575	0.769
Norway	11.2	0.502	32.8	1.50	0.591	0.801
Sweden	11.6	0.524	38.1	1.58	0.616	0.824
Russian Federation	**10.9**	**0.610**	**25.9**	**1.79**	**0.601**	**0.780**
South Caucasus	**8.2**	**0.299**	**8.5**	**0.84**	**0.421**	**0.630**
Armenia	8.0	0.303	9.4	0.85	0.414	0.619
Azerbaijan	8.3	0.254[a]	6.4	0.71	0.414	0.633
Georgia	8.3	0.417	13.1	1.19	0.445	0.632
Southern Europe	**10.5**	**0.341**	**29.8**	**1.01**	**0.518**	**0.756**
Cyprus	10.9	0.558	27.3	1.64	0.589	0.781
Greece	10.0	0.446	25.5	1.30	0.519	0.724
Italy	10.5	0.271	31.6	0.80	0.500	0.753
Malta	10.2	0.341	16.0	0.98	0.502	0.737
Portugal	11.3	0.327	28.5	0.96	0.548	0.806
Spain	10.5	0.406	28.7	1.20	0.533	0.757
Turkey	**9.2**	**0.275**	**22.2**	**0.80**	**0.453**	**0.683**
Western Balkans	**8.8**	**0.285**	**13.3**	**0.81**	**0.442**	**0.664**
Albania	9.0	0.235	6.9	0.66	0.434	0.668
Bosnia and Herzegovina	7.8	0.210	5.5	0.59	0.391	0.609
Kosovo	7.9					0.612
Montenegro	8.9	0.340	1.5	0.94	0.451	0.665
North Macedonia	7.3	0.299	7.3	0.84	0.390	0.585
Serbia	9.8	0.333	22.6	0.97	0.485	0.712
Western Europe	**11.3**	**0.459**	**36.2**	**1.38**	**0.583**	**0.803**
Austria	10.9	0.472	32.1	1.40	0.568	0.781
Belgium	11.2	0.489	42.3	1.49	0.588	0.798
France	11.3	0.470	33.1	1.40	0.584	0.804
Germany	11.0	0.340	35.5	1.02	0.541	0.789
Ireland	11.6	0.597	33.2	1.78	0.635	0.825
Luxembourg	9.8	0.497	28.1	1.46	0.524	0.714
Netherlands	11.5	0.550	46.8	1.70	0.624	0.821
Switzerland	10.9	0.512[b]	45.9	1.58	0.584	0.782
United Kingdom	11.5	0.550	35.9	1.65	0.620	0.821
ECA (country average)	**10.1**	**0.403**	**23.0**	**1.18**	**0.520**	**0.736**
ECA (population-weighted average)	**10.4**	**0.424**	**26.2**	**1.25**	**0.539**	**0.755**

Sources: Attainment data were calculated from the *European* Union Statistics on Income and Living Conditions and household surveys. Learning-adjusted years of basic education (LAYS) were obtained from the HCI database.
Note: For the average standardized quality score for higher education, the quality scores from each of the six university rankings (the Times Higher Education, the Quacquarelly Symonds, Academic Ranking of World Universities, the Center for World University Rankings, the U.S. News Global Universities Ranking, and U-Multirank) are first standardized to a global mean of 0 and a standard deviation of 1 and then averaged for every country. For presentational purposes, this value is then rescaled to range from 0 to 100. A value of 0 for the quality measure implies that no university in that country appears in any of the six university rankings. The education component of the original HCI was updated with PISA 2018 results or the latest available data. HCI = Human Capital Index; ECA-HCI = Europe and Central Asia extension of the HCI.
— Not available.
a. Based on population age 25 and older.
b. Based on population 25–34.

4. Health Component

The health component of the HCI seeks to measure the productivity losses associated with poor health that a child born today will face later in life as an adult. The original HCI calculates this component based on two variables: the child stunting rate and the adult survival rate (the chance that a 15-year-old survives to age 60). These variables are understood to be good proxies for unobserved latent health status in a global context. Their effects on productivity are measured by the returns to adult height.

The ECA-HCI takes a different approach. It starts by assuming that good health means the absence of disease and bad health means the presence of disease. To measure latent health status, the ECA-HCI focuses on the factors that may cause disease. A low prevalence of these risk factors implies a lower disease burden; a high prevalence could imply a higher disease burden. The risk factors that are relevant as indirect measures of latent health status depend on the types of disease prevalent in each context. Smith and Nguyen (2013) show that in Europe and Central Asia, cardiovascular disease, followed by external causes (mainly alcohol-related road traffic injuries), explains most of the differences in adult life expectancy. Data from the COVID-19 pandemic also show that people with underlying cardiovascular conditions have a higher mortality rate than people without them (Wu and McGoogan 2020; Zhou and others 2020). In view of these findings, the ECA-HCI uses the prevalence of three health risk factors associated with cardiovascular disease: obesity, tobacco smoking, and heavy alcohol consumption. The higher the prevalence of these risk factors, the higher the probability of disease and the worse the health status. The prevalence of these risk factors increases the probability of suffering from noncommunicable diseases and increases the mortality and morbidity consequences of some infectious diseases like COVID-19. The health benchmark in the ECA-HCI with which countries are compared is zero prevalence of obesity, smoking, and heavy drinking.

The impact on productivity of specific health conditions is difficult to estimate. There is more evidence on the productivity effects associated with the risk factors behind such health conditions. The literature has quantified the effects on productivity of obesity, tobacco smoking, and heavy drinking, making it possible to incorporate their prevalence directly into the ECA-HCI without the intermediating factor of adult height, as in the original version of the index.

Focusing only on risk factors has its limitations, however. Between risk factors and morbidity lies a mediating institutional factor: health care systems. The capacity of health care systems to manage the consequences of increased risk factors—and the diseases associated with them—ultimately determines whether that increased risk ends in increased morbidity and, eventually, mortality. Good health care systems strongly alleviate the morbidity and mortality consequences of the increased prevalence of risk factors.

To account for the effects of health care systems, the model uses a health outcome measure as a proxy for latent health status—the child stunting and adult survival rates used in the original HCI. The health component of the ECA-HCI uses the average of a risk factor–based proxy of health status and an outcome-based proxy. The productivity effects of child stunting and adult survival rates are retained, as in the original HCI. The health component of the ECA-HCI has the following basic formulation:

$$ECA - HCI_{Health} = e^{\frac{\gamma_{RF}(RF-RF^*)+\gamma_O(O-O^*)}{2}} \tag{9}$$

where γ_{RF} is the productivity effect associated to the prevalence of risk factors RF; RF^* is the benchmark rate of zero prevalence of risk factors; and γ_O is the productivity effect of health outcomes O, with the benchmark of "full" health outcomes being O^*. For risk factors, the ECA-HCI uses the share of non-obese adults (*NOB*), the share of nonsmokers among adults (*NSM*), and the share of adults not reporting heavy drinking (*NAL*). The productivity effects of these risk factors (γ_{OB}, γ_{SM}, γ_{AL}) are assumed to be additive.[3] For health outcomes, the ECA-HCI uses the adult survival rate (*ASR*) and the share of children not stunted (*NSTNT*). As in the original HCI, these rates are intended to proxy the same variable: latent health status. Their productivity effects (γ_{ASR}, γ_{STNT}) are therefore averaged. The equation for the health component is the following:

$$ECA - HCI_{Health} = e^{\frac{[\gamma_{OB}(NOB-1)+\gamma_{SM}(NSM-1)+\gamma_{AL}(NAL-1)]+[\gamma_{ASR}(ASR-1)+\gamma_{STNT}(NSTNT-1)]/2}{2}} \tag{10}$$

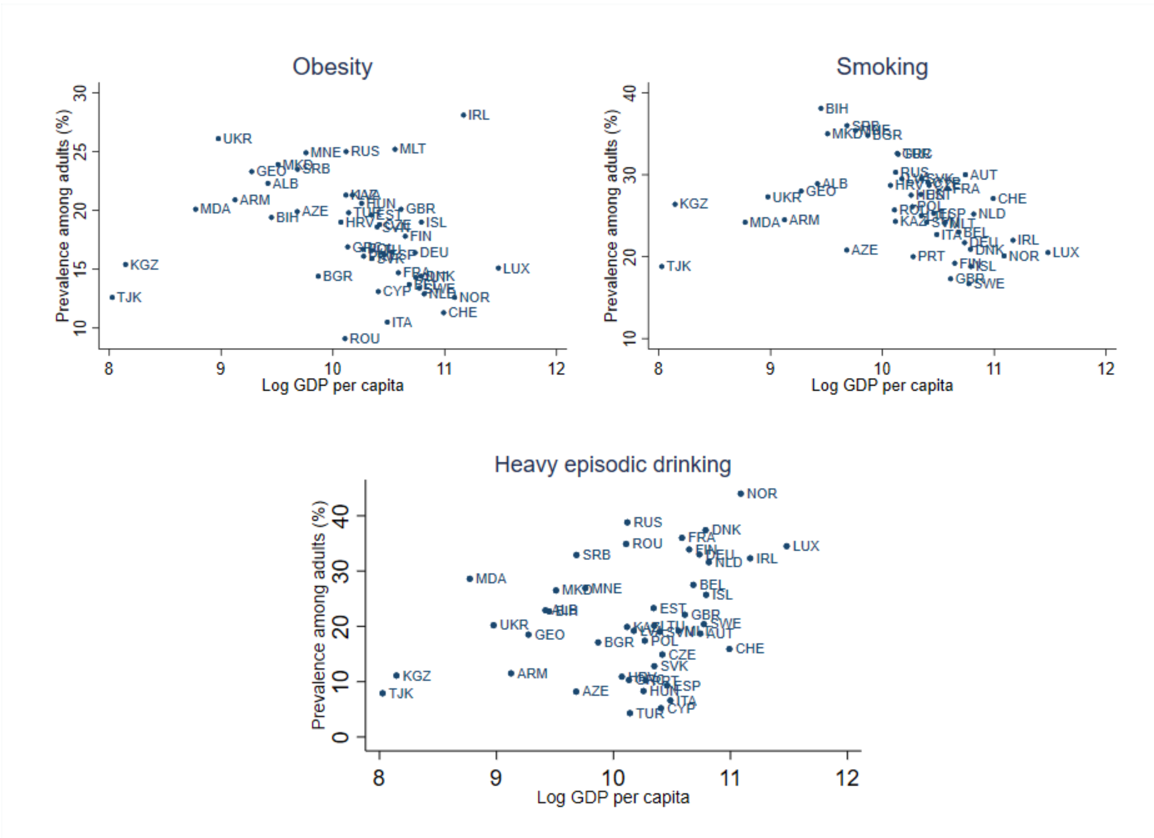
The values of γ_{STNT} and γ_{ASR}, the productivity effects associated with child stunting the adult survival rate, are kept as in the original HCI. They are derived from the correlation of these rates with adult height, for which the literature provides reliable microeconometric estimations of productivity. These values are assumed to be 0.35 for γ_{STNT} and 0.65 for γ_{ASR}. Adult survival rates are widely available; child stunting rates

[3] Perfectly additive productivity effects imply that the productivity effect of smoking and obesity (combined) is simply the summation of the productivity effect of smoking and the productivity effect of obesity. This figure can be understood as an upper-bound estimation of the combined productivity effects of risk factors.

are available only for a few countries in the region. For countries for which estimates of child stunting are not available, only the adult survival rate is used to estimate the outcome-based productivity proxy.

A literature review was carried out to obtain estimates of the productivity effects of the prevalence of the risk factors (see appendix B). The median values for all the average effects found was chosen as the parameter for use in the ECA-HCI. These values are 0.0993 for obesity (γ_{OB}), 0.096 for smoking (γ_{SM}), and 0.1995 for heavy drinking (γ_{AL}). These values represent the negative productivity effects associated with each risk factor. The prevalence of the three health risk factors among the adult population across Europe and Central Asia is plotted in figure 5 in comparison with country income levels.

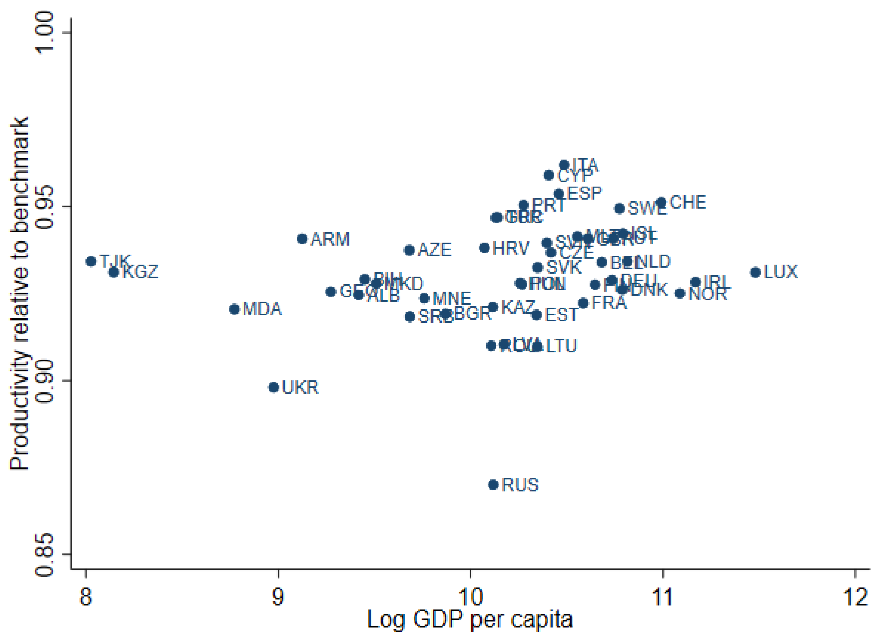
Figure 5 – Prevalence of health risk factors among adult population



Sources: European Health Interview Survey 2014 and World Health Organization.

Country and subregional estimates of the health component are presented in table 7. Figure 6 plots the values of the health component with respect to countries' income level. In contrast to the education component, there is no clear correlation between income and the contribution of health status to relative productivity.

Figure 6. Contribution of health to relative productivity in Europe and Central Asia



Note: Productivity figures are from the Europe and Central Asia extension of the Human Capital Index (ECA-HCI).

Table 7 Health component of the Europe and Central Asia extension of the Human Capital Index (ECA-HCI)

Subregion/country	*Obese adult population (%)*	*Heavy episodic drinkers (%)*	*Current smokers (%)*	*Adult survival rate*	*Children under 5 not stunted (%)*	*Health component, ECA-HCI*	*Health component, HCI*
Central Asia	**16.6**	**11.5**	**17.8**	**0.859**	**88.9**	**0.941**	**0.937**
Kazakhstan	21.3	19.9	24.3	0.845	92.0	0.928	0.937
Kyrgyz Republic	15.4	11.1	26.4	0.849	88.2	0.936	0.933
Tajikistan	12.6	7.9	18.8	0.871	82.5	0.942	0.930
Uzbekistan	15.3	7.9	12.3	0.866	89.2	0.949	0.939
Central Europe and Baltic Countries	**15.9**	**19.3**	**27.3**	**0.890**	–	**0.928**	**0.933**
Bulgaria	14.4	17.1	34.8	0.866	93.0	0.934	0.946
Croatia	19.0	10.9	28.7	0.917	–	0.941	0.948
Czech Republic	18.8	14.9	28.7	0.922	–	0.939	0.951
Estonia	19.6	23.3	27.6	0.897	–	0.924	0.936
Hungary	20.6	8.3	27.5	0.880	–	0.932	0.925
Latvia	21.3	19.2	29.5	0.844	–	0.910	0.904
Lithuania	16.6	20.1	25.0	0.844	–	0.913	0.903

Poland	16.7	17.4	26.1	0.894	–	0.930	0.934
Romania	9.1	34.9	25.7	0.878	–	0.913	0.924
Slovak Republic	15.9	12.8	29.5	0.898	–	0.934	0.936
Slovenia	18.6	19.0	24.2	0.935	–	0.941	0.959
Eastern Europe	**25.8**	**22.0**	**26.9**	**0.822**	–	**0.901**	**0.893**
Belarus	26.6	28.2	26.2	0.853	93.6	0.903	0.909
Moldova	20.1	28.6	24.2	0.836	–	0.921	0.937
Ukraine	26.1	20.2	27.3	0.815	–	0.899	0.886
Northern Europe	**14.4**	**31.5**	**18.8**	**0.941**	–	**0.936**	**0.962**
Denmark	14.4	37.4	20.9	0.932	–	0.926	0.957
Finland	17.8	33.9	19.2	0.930	–	0.928	0.956
Iceland	19.0	25.7	18.8	0.955	–	0.943	0.971
Norway	12.6	44.0	20.1	0.945	–	0.925	0.965
Sweden	13.4	20.4	16.7	0.950	–	0.950	0.968
Russian Federation	**25.0**	**38.8**	**30.3**	**0.804**	–	**0.879**	**0.880**
South Caucasus	**20.8**	**11.1**	**23.1**	**0.876**	–	**0.934**	**0.930**
Armenia	20.9	11.5	24.5	0.886	90.6	0.941	0.948
Azerbaijan	19.9	8.2	20.8	0.882	82.2	0.939	0.933
Georgia	23.3	18.5	28.0	0.853	–	0.913	0.909
Southern Europe	**13.6**	**8.2**	**24.3**	**0.947**	–	**0.957**	**0.966**
Cyprus	13.1	5.2	29.1	0.952	–	0.960	0.969
Greece	16.9	10.3	32.6	0.933	–	0.945	0.957
Italy	10.5	6.6	22.7	0.953	–	0.963	0.970
Malta	25.2	19.2	24.1	0.951	–	0.943	0.969
Portugal	16.1	10.2	20.0	0.933	–	0.952	0.957
Spain	16.2	9.3	25.3	0.946	–	0.954	0.966
Turkey	**19.8**	**4.3**	**32.5**	**0.911**	**94.0**	**0.952**	**0.961**
Western Balkans	**22.5**	**27.9**	**35.0**	**0.906**	**92.4**	**0.925**	**0.957**
Albania	22.3	22.9	28.9	0.929	88.7	0.933	0.958
Bosnia and Herzegovina	19.4	22.7	38.1	0.914	91.1	0.930	0.957
Kosovo	–	–	–	0.906	–	–	0.941
Montenegro	24.9	26.9	35.4	0.906	90.6	0.923	0.954
North Macedonia	23.9	26.5	35.0	0.909	95.1	0.928	0.962
Serbia	23.5	32.9	36.0	0.893	94.0	0.919	0.956
Western Europe	**16.5**	**29.7**	**23.0**	**0.933**	–	**0.932**	**0.957**
Austria	14.3	18.7	30.0	0.937	–	0.941	0.960
Belgium	13.7	27.5	23.0	0.931	–	0.935	0.956
Germany	14.7	36.0	28.3	0.926	–	0.922	0.953
France	16.4	33.0	21.7	0.931	–	0.929	0.956
Ireland	28.1	32.3	22.0	0.944	–	0.928	0.964
Luxembourg	15.1	34.5	20.5	0.942	–	0.932	0.963
Netherlands	12.9	31.6	25.2	0.946	–	0.935	0.966
Switzerland	11.3	15.9	27.1	0.954	–	0.952	0.970

United Kingdom	20.1	22.1	17.3	0.933	–	0.940	0.958
ECA (country average)	**18.0**	**21.1**	**25.9**	**0.904**	**90.3**	**0.932**	**0.945**
ECA (population-weighted average)	**18.4**	**22.5**	**25.6**	**0.894**	**91.4**	**0.927**	**0.938**

Source: Data on obesity, smoking, and alcohol consumption are from the European Health Interview Survey, Health Equity and Financial Protection Indicators, and the World Health Organization. The ECA average for the share of children not stunted is calculated based on countries for which data are available only.
Note: HCI = Human Capital Index; ECA-HCI = Europe and Central Asia extension of the HCI.

— Not available.

a. Includes consumption of smokeless tobacco.

5. Estimation of the ECA-HCI

The ECA-HCI is the product of three components:

$$ECA - HCI = Survival \times Education \times Health$$

The three components are defined as follows:

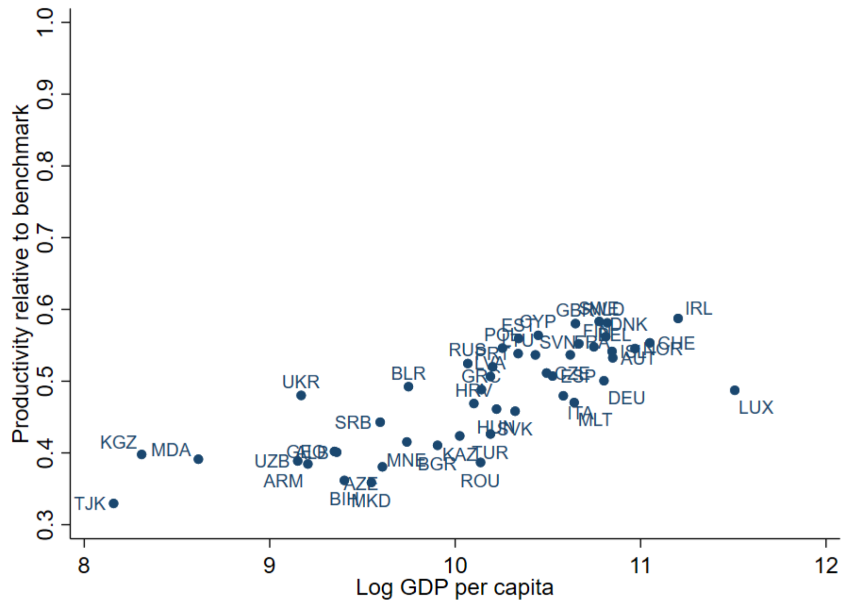
$$Survival \equiv \frac{1 - Under\ 5\ Mortality\ rate}{1}$$

$$Education \equiv e^{0.08(LAYS-14)+0.152(QAYH-3.5)}$$

$$Health \equiv e^{\frac{[0.0993(NOB-1)+0.096(NSM-1)+0.1995(NAL-1)]+[0.65(ASR-1)+0.35(NSTNT-1)]/2}{2}}.$$

The estimates of the ECA-HCI in table 8 show that countries in the region can achieve large increases in their long-run productivity if they reduce the distance between the expected educational attainment and adult health status of children born today and the benchmarks of complete education and full health. The average country for which the ECA-HCI is calculated has a value of 0.481, meaning that children born today in the average country in the region will be almost half as productive as they would have had they reached the benchmark of complete education and full health (14 years of basic education; 3.5 years of higher education; no obesity, tobacco smoking, or heavy drinking; no statistically significant child stunting; and 100 percent adult survival rate to age 60). The correlation between income levels and the ECA-HCI is positive, as it is for the original HCI (figure 7).

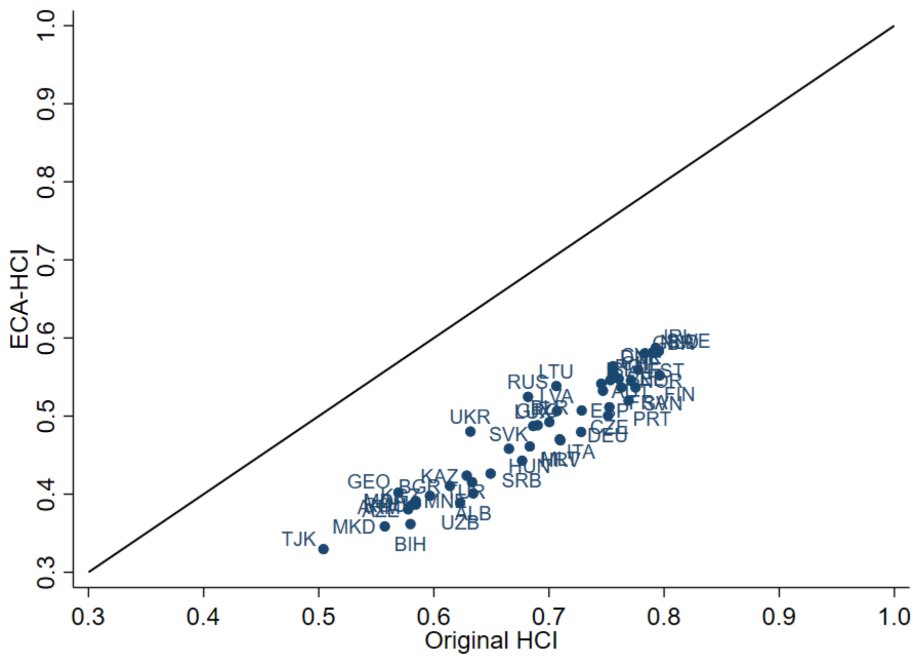
Figure 7. Estimates of ECA-HCI and country income levels



Note: Figures are based on the Europe and Central Asia extension of the Human Capital Index extension of (ECA-HCI).

The value of the ECA-HCI is consistently below that of the original HCI, because the full education benchmark of the ECA-HCI includes higher education. However, there is considerable correlation between the two values (figure 8), although some re-ranking occurs. Like the original HCI, the ECA-HCI is measured with some imprecision, so small differences across countries do not represent meaningful differences in education and health environments.

Figure 8. Correlation between the original HCI and ECA-HCI



Note: Figures are based on the Europe and Central Asia extension of the Human Capital Index extension of (ECA-HCI) and the HCI 2020 Update.

Table 8 Full estimates of the Europe and Central Asia extension of the Human Capital Index (ECA-HCI)

Subregion/country	*Probability of survival to age 5*	*Education component*	*Health component*	*ECA-HCI*	*HCI*
Central Asia	**0.980**	**0.424**	**0.941**	**0.391**	**0.606**
Kazakhstan	0.990	0.461	0.928	0.424	0.629
Kyrgyz Republic	0.981	0.433	0.936	0.398	0.597
Tajikistan	0.965	0.362	0.942	0.330	0.504
Uzbekistan	0.979	0.419	0.949	0.389	0.623
Central Europe and Baltic countries	**0.995**	**0.526**	**0.928**	**0.486**	**0.697**
Bulgaria	0.993	0.443	0.934	0.411	0.614
Croatia	0.995	0.501	0.941	0.469	0.710
Czech Republic	0.997	0.547	0.939	0.511	0.752
Estonia	0.997	0.607	0.924	0.559	0.777
Hungary	0.996	0.497	0.932	0.461	0.683
Latvia	0.996	0.559	0.910	0.506	0.707
Lithuania	0.996	0.592	0.913	0.538	0.706
Poland	0.996	0.590	0.930	0.546	0.753
Romania	0.993	0.427	0.913	0.387	0.584
Slovak Republic	0.994	0.493	0.934	0.458	0.665

Slovenia	0.998	0.572	0.941	0.537	0.775
Eastern Europe	**0.992**	**0.534**	**0.901**	**0.477**	**0.640**
Belarus	0.997	0.547	0.903	0.492	0.700
Moldova	0.984	0.432	0.921	0.391	0.584
Ukraine	0.991	0.539	0.899	0.480	0.631
Northern Europe	**0.997**	**0.605**	**0.936**	**0.564**	**0.781**
Denmark	0.996	0.609	0.926	0.562	0.755
Finland	0.998	0.596	0.928	0.552	0.796
Iceland	0.998	0.575	0.943	0.541	0.745
Norway	0.997	0.591	0.925	0.545	0.771
Sweden	0.997	0.616	0.950	0.583	0.795
Russian Federation	**0.993**	**0.601**	**0.879**	**0.525**	**0.681**
South Caucasus	**0.983**	**0.421**	**0.934**	**0.386**	**0.576**
Armenia	0.988	0.414	0.941	0.385	0.579
Azerbaijan	0.978	0.414	0.939	0.381	0.578
Georgia	0.990	0.445	0.913	0.402	0.569
Southern Europe	**0.997**	**0.518**	**0.957**	**0.494**	**0.728**
Cyprus	0.998	0.589	0.960	0.564	0.756
Greece	0.996	0.519	0.945	0.488	0.690
Italy	0.997	0.500	0.963	0.480	0.728
Malta	0.993	0.502	0.943	0.470	0.709
Portugal	0.996	0.548	0.952	0.520	0.769
Spain	0.997	0.533	0.954	0.507	0.728
Turkey	**0.989**	**0.453**	**0.952**	**0.426**	**0.649**
Western Balkans	**0.993**	**0.442**	**0.925**	**0.406**	**0.631**
Albania	0.991	0.434	0.933	0.401	0.634
Bosnia and Herzegovina	0.994	0.391	0.930	0.362	0.580
Kosovo	0.985				0.567
Montenegro	0.997	0.451	0.923	0.415	0.633
North Macedonia	0.990	0.390	0.928	0.359	0.557
Serbia	0.994	0.485	0.919	0.443	0.677
Western Europe	**0.996**	**0.583**	**0.932**	**0.541**	**0.765**
Austria	0.996	0.568	0.941	0.533	0.747
Belgium	0.996	0.588	0.935	0.548	0.760
France	0.996	0.584	0.922	0.537	0.763
Germany	0.996	0.541	0.929	0.501	0.751
Ireland	0.996	0.635	0.928	0.587	0.793
Luxembourg	0.998	0.524	0.932	0.487	0.686
Netherlands	0.996	0.624	0.935	0.581	0.790
Switzerland	0.996	0.584	0.952	0.553	0.756
United Kingdom	0.996	0.620	0.940	0.580	0.783
Simple average	**0.993**	**0.520**	**0.932**	**0.481**	**0.691**
Population-weighted average	**0.993**	**0.539**	**0.927**	**0.496**	**0.704**

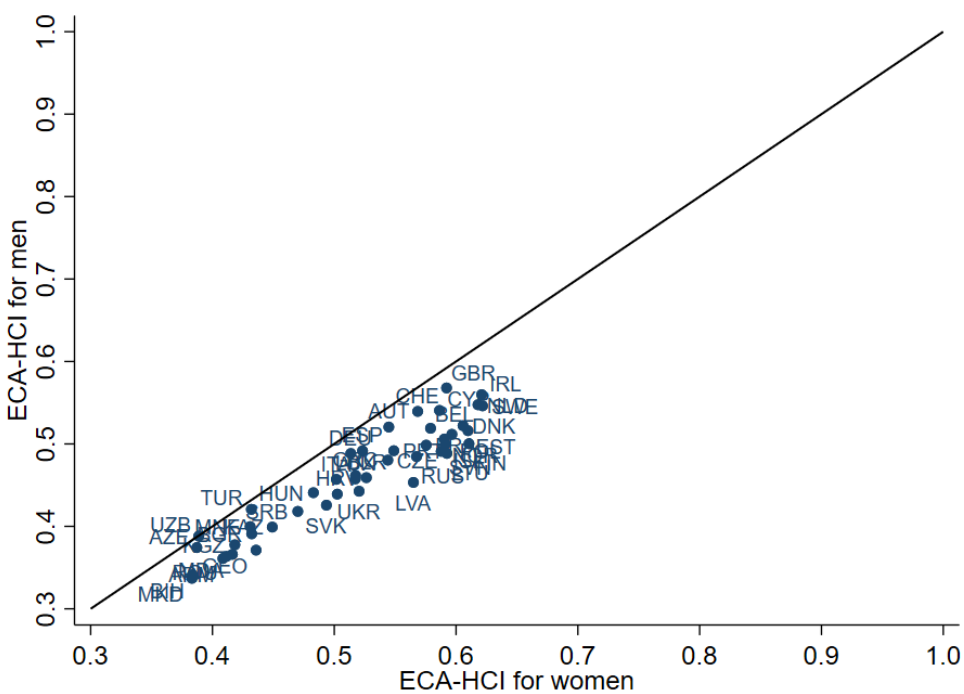
Source: Authors' calculations.
Note: HCI = Human Capital Index; ECA-HCI = Europe and Central Asia extension of the Human Capital Index.

Gender disaggregation of ECA-HCI

Like the original HCI, the ECA-HCI can be disaggregated by gender. The values of learning-adjusted years of schooling can be disaggregated by gender in terms of quantity (expected years of basic education) and quality (test score performance); the values of QAYH can be disaggregated by gender in quantity (expected years of higher education) but not by quality, as there is no gender variation in the quality measure used for higher education (university rankings). The prevalence of adult risk factors (obesity, smoking, and heavy drinking) is available for men and women for almost all countries in the region.

The results can be disaggregated by gender for 38 countries (table 9). For the average country, the value of the ECA-HCI is 0.459 for men and 0.517 for women. In all countries, the value is lower for men than women (figure 9). The gender gap is largest in Finland and Latvia (about 11 percentage points) and smallest in Uzbekistan and Turkey (1 percentage point or below).

Figure 9. Gender-disaggregated values of ECA-HCI



Note: Figures are based on the Europe and Central Asia extension of the Human Capital Index extension of (ECA-HCI).

Table 9 Gender-disaggregated estimates of the Europe and Central Asia extension of the Human Capital Index (ECA-HCI)

	Probability of survival to age 5		*Education component*		*Health component*		*ECA-HCI*	
Subregion/country	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*
Central Asia	**0.978**	**0.983**	**0.433**	**0.434**	**0.920**	**0.961**	**0.390**	**0.411**
Kazakhstan	0.989	0.991	0.449	0.474	0.900	0.956	0.399	0.449
Kyrgyz Republic	0.979	0.983	0.424	0.442	0.909	0.962	0.378	0.418
Tajikistan	0.961	0.969	–	–	–	–	–	–
Uzbekistan	0.976	0.982	0.426	0.411	0.933	0.964	0.388	0.389
Central Europe and Baltic countries	**0.995**	**0.995**	**0.503**	**0.549**	**0.909**	**0.957**	**0.456**	**0.524**
Bulgaria	0.992	0.994	0.431	0.457	0.914	0.953	0.391	0.432
Croatia	0.995	0.996	0.479	0.525	0.921	0.961	0.439	0.502
Czech Republic	0.996	0.997	0.523	0.570	0.921	0.957	0.480	0.544
Estonia	0.997	0.998	0.579	0.641	0.894	0.954	0.516	0.610
Hungary	0.995	0.996	0.487	0.509	0.910	0.953	0.441	0.483
Latvia	0.996	0.996	0.521	0.600	0.873	0.945	0.453	0.565
Lithuania	0.996	0.996	0.562	0.625	0.873	0.952	0.488	0.592
Poland	0.995	0.996	0.557	0.622	0.923	0.964	0.512	0.597
Romania	0.992	0.993	0.418	0.436	0.877	0.949	0.364	0.411
Slovak Republic	0.994	0.995	0.470	0.518	0.911	0.958	0.426	0.494
Slovenia	0.998	0.998	0.533	0.614	0.923	0.959	0.491	0.588
Eastern Europe	**0.991**	**0.993**	**0.517**	**0.551**	**0.860**	**0.942**	**0.441**	**0.515**
Belarus	0.996	0.997	0.534	0.560	0.863	0.943	0.459	0.526
Moldova	0.982	0.986	0.419	0.443	0.888	0.953	0.366	0.416
Ukraine	0.990	0.992	0.521	0.558	0.857	0.940	0.443	0.520
Northern Europe	**0.997**	**0.997**	**0.570**	**0.643**	**0.921**	**0.950**	**0.523**	**0.610**
Denmark	0.995	0.996	0.575	0.647	0.912	0.940	0.522	0.606
Finland	0.998	0.998	0.553	0.644	0.907	0.949	0.500	0.611
Iceland	0.998	0.998	0.536	0.621	0.934	0.953	0.500	0.591
Norway	0.997	0.998	0.557	0.630	0.911	0.939	0.506	0.590
Sweden	0.997	0.998	0.584	0.648	0.939	0.962	0.546	0.622
Russian Federation	**0.992**	**0.994**	**0.582**	**0.623**	**0.840**	**0.917**	**0.485**	**0.568**
South Caucasus	**0.981**	**0.985**	**0.417**	**0.426**	**0.908**	**0.958**	**0.371**	**0.402**
Armenia	0.986	0.989	0.401	0.427	0.912	0.967	0.361	0.409
Azerbaijan	0.976	0.981	0.416	0.412	0.921	0.957	0.374	0.387
Georgia	0.989	0.991	0.431	0.461	0.871	0.954	0.371	0.436
Southern Europe	**0.997**	**0.997**	**0.503**	**0.534**	**0.945**	**0.968**	**0.473**	**0.515**
Cyprus	0.997	0.998	0.574	0.604	0.944	0.974	0.541	0.586
Greece	0.995	0.996	0.499	0.540	0.929	0.961	0.462	0.517

Italy	0.997	0.997	0.481	0.519	0.953	0.969	0.457	0.502
Malta	0.992	0.994	0.478	0.530	0.930	0.956	0.441	0.504
Portugal	0.996	0.997	0.529	0.568	0.933	0.969	0.492	0.549
Spain	0.997	0.997	0.524	0.542	0.942	0.967	0.492	0.523
Turkey	**0.989**	**0.990**	**0.453**	**0.452**	**0.939**	**0.965**	**0.421**	**0.432**
Western Balkans	**0.993**	**0.994**	**0.429**	**0.460**	**0.904**	**0.947**	**0.385**	**0.432**
Albania	0.991	0.992	–	–	0.910	0.957	–	–
Bosnia and Herzegovina	0.994	0.995	0.378	0.405	0.910	0.951	0.341	0.384
Kosovo	0.983	0.988	–	–	–	–	–	–
Montenegro	0.997	0.998	0.443	0.458	0.904	0.943	0.400	0.431
North Macedonia	0.989	0.991	0.375	0.407	0.909	0.949	0.337	0.383
Serbia	0.994	0.995	0.469	0.502	0.897	0.941	0.418	0.470
Western Europe	**0.996**	**0.996**	**0.571**	**0.595**	**0.914**	**0.949**	**0.520**	**0.563**
Austria	0.996	0.997	0.564	0.572	0.927	0.956	0.520	0.545
Belgium	0.996	0.997	0.567	0.611	0.919	0.950	0.519	0.579
France	0.996	0.996	0.558	0.610	0.897	0.948	0.499	0.576
Germany	0.996	0.997	0.537	0.545	0.913	0.945	0.488	0.514
Ireland	0.996	0.997	0.613	0.655	0.917	0.951	0.560	0.621
Luxembourg	0.997	0.998	0.501	0.547	0.916	0.948	0.458	0.517
Netherlands	0.996	0.997	0.601	0.649	0.916	0.955	0.548	0.618
Switzerland	0.996	0.996	0.575	0.593	0.942	0.962	0.539	0.568
United Kingdom	0.995	0.996	0.615	0.625	0.927	0.952	0.568	0.592
Simple average	**0.993**	**0.994**	**0.507**	**0.545**	**0.910**	**0.954**	**0.459**	**0.517**
Population-weighted average	**0.993**	**0.994**	**0.527**	**0.556**	**0.905**	**0.950**	**0.473**	**0.524**

Source: Authors' calculations.
Note: – Not available.

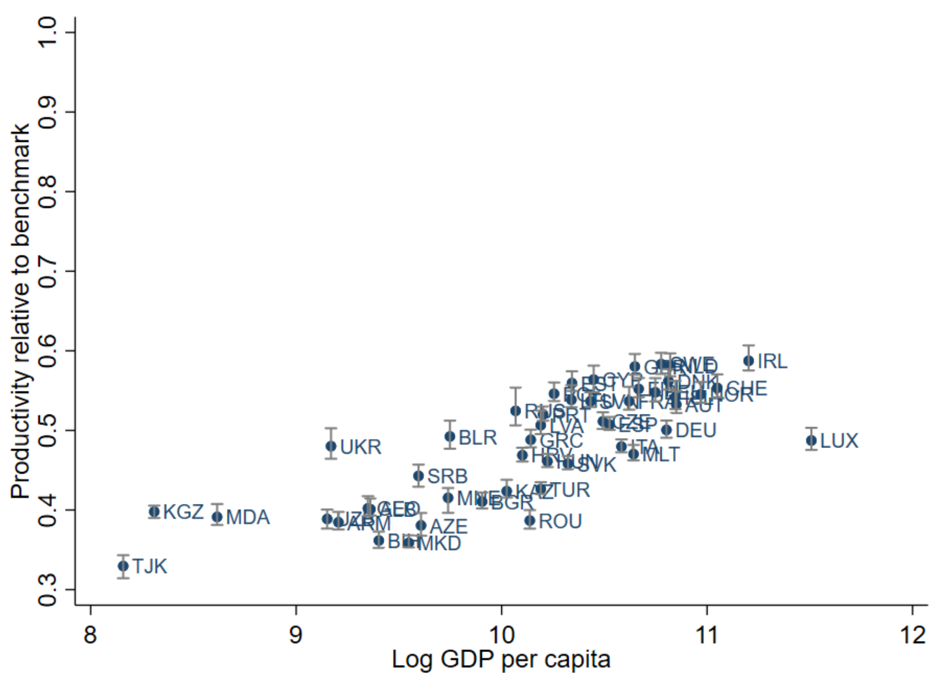
Uncertainty intervals of ECA-HCI

The components of the ECA-HCI are measured with some error; just as in the original HCI, an uncertainty interval can be calculated to provide a measure of the precision of the estimates. This uncertainty interval is not a statistical estimation but rather a calculation of the ECA-HCI under worst- or best-case scenarios. The worst-case scenario indicates that all the components take the lower-bound values; the best-case scenario indicates that all the components take the upper-bound values. As Kraay (2019) points out, this approach is conservative, equivalent to assuming that the measurement error is highly correlated across components. The variables for which lower- and upper-bound values are available are the probability of survival to age five; quality-adjustment factors for basic education (harmonized learning outcomes) and higher education (aggregate quality score); the prevalence of adult health risk factors (obesity, smoking, and heavy drinking); the adult survival rate; and the share of stunted children.

For the probability of survival to age five, harmonized learning outcomes, the adult survival rate, and the share of stunted children, we use the same bounds as in the original HCI (for details, see Kraay 2019). For the aggregate quality score for higher education, we use as bounds the maximum and minimum values for each country across the six university rankings (after rescaling the CWUR ranking to 0–100). For the adult health risk factors, the determination of the bounds depends on the data source. For countries whose values are sourced from the European Health Interview Survey, the bounds represent the limits of the 95 percent confidence interval, as detailed in the European Health Interview Survey round 2 quality report (Eurostat, 2018). For countries whose values are sourced from the World Health Organization, the bounds are that institution's low and high estimates.

The ECA-HCI values range from 0.31 to 0.60 (see table 10). The median size of the uncertainty intervals is about 0.025—very similar to that of the original HCI (0.030). For some countries with less precise component data, the interval can range up to 0.076. Figure 10 plots the uncertainty intervals of the ECA-HCI.

Figure 10. Uncertainty intervals for ECA-HCI



Note: ECA-HCI estimate in blue. Grey lines indicate the upper and lower bounds estimates.

Table 10 Uncertainty intervals for the Europe and Central Asia extension of the Human Capital Index (ECA-HCI)

Subregion/country	*ECA-HCI*	*Lower bound*	*Upper bound*	*Countries within the uncertainty interval*
Central Asia	**0.391**	**0.380**	**0.403**	
Kazakhstan	0.424	0.416	0.438	TUR
Kyrgyz Republic	0.398	0.390	0.405	ALB, GEO, MDA
Tajikistan	0.330	0.314	0.343	
Uzbekistan	0.389	0.377	0.401	ARM, AZE, KGZ, MDA, ROU
Central Europe and Baltic countries	**0.486**	**0.477**	**0.499**	
Bulgaria	0.411	0.402	0.422	GEO, MNE
Croatia	0.469	0.461	0.478	HUN, MLT
Czech Republic	0.511	0.502	0.523	ESP, LVA, PRT
Estonia	0.559	0.550	0.574	CHE, CYP, DNK, FIN
Hungary	0.461	0.454	0.471	HRV, MLT, SVK
Latvia	0.506	0.495	0.525	CZE, DEU, ESP, PRT, RUS
Lithuania	0.538	0.529	0.557	AUT, BEL, CHE, FIN, FRA, ISL, NOR, POL, SVN
Poland	0.546	0.537	0.560	BEL, CHE, EST, FIN, ISL, LTU, NOR
Romania	0.387	0.377	0.400	ARM, AZE, KGZ, MDA, UZB
Slovak Republic	0.458	0.451	0.468	HUN
Slovenia	0.537	0.529	0.548	AUT, BEL, FRA, ISL, LTU, NOR, POL
Eastern Europe	**0.477**	**0.461**	**0.498**	
Belarus	0.492	0.477	0.512	CZE, DEU, ESP, GRC, ITA, LUX, LVA, UKR
Moldova	0.391	0.381	0.408	ALB, ARM, GEO, KGZ, ROU, UZB
Ukraine	0.480	0.464	0.503	BLR, DEU, GRC, HRV, ITA, LUX, MLT
Northern Europe	**0.564**	**0.553**	**0.579**	
Denmark	0.562	0.551	0.577	CHE, CYP, EST, FIN
Finland	0.552	0.542	0.566	BEL, CHE, CYP, DNK, EST, NOR, POL
Iceland	0.541	0.527	0.562	AUT, BEL, CHE, DNK, EST, FIN, FRA, LTU, NOR, POL, SVN
Norway	0.545	0.535	0.561	BEL, CHE, EST, FIN, FRA, ISL, LTU, POL, SVN
Sweden	0.583	0.571	0.597	GBR, IRL, NLD
Russian Federation	**0.525**	**0.506**	**0.554**	AUT, BEL, CHE, CZE, ESP, FIN, FRA, ISL, LTU, LVA, NOR, POL, PRT, SVN
South Caucasus	**0.386**	**0.375**	**0.401**	
Armenia	0.385	0.376	0.398	AZE, MDA, ROU, UZB
Azerbaijan	0.381	0.368	0.396	ARM, MDA, ROU, UZB
Georgia	0.402	0.392	0.417	ALB, BGR, KGZ, MNE
Southern Europe	**0.494**	**0.487**	**0.504**	
Cyprus	0.564	0.548	0.581	CHE, DNK, EST, FIN, GBR, NLD
Greece	0.488	0.479	0.501	BLR, DEU, ITA, LUX, UKR
Italy	0.480	0.473	0.489	GRC, LUX, UKR
Malta	0.470	0.462	0.482	HRV, ITA, UKR

Portugal	0.520	0.512	0.530	RUS
Spain	0.507	0.501	0.517	CZE, DEU, LVA
Turkey	**0.426**	**0.420**	**0.435**	KAZ
Western Balkans	**0.406**	**0.395**	**0.419**	
Albania	0.401	0.393	0.414	BGR, GEO, KGZ
Bosnia and Herzegovina	0.362	0.352	0.373	MKD
Kosovo				
Montenegro	0.415	0.396	0.428	ALB, BGR, GEO, KAZ, KGZ, TUR
North Macedonia	0.359	0.353	0.368	BIH
Serbia	0.443	0.429	0.457	
Western Europe	**0.541**	**0.530**	**0.556**	
Austria	0.533	0.522	0.549	BEL, FRA, ISL, LTU, NOR, POL, RUS, SVN
Belgium	0.548	0.536	0.566	CHE, CYP, DNK, EST, FIN, FRA, ISL, LTU, NOR, POL, SVN
France	0.537	0.526	0.555	AUT, BEL, CHE, FIN, ISL, LTU, NOR, POL, SVN
Germany	0.501	0.491	0.512	BLR, CZE, ESP, LVA
Ireland	0.587	0.575	0.607	GBR, NLD, SWE
Luxembourg	0.487	0.475	0.503	BLR, DEU, GRC, ITA, UKR
Netherlands	0.581	0.568	0.597	GBR, IRL, SWE
Switzerland	0.553	0.542	0.570	BEL, CYP, DNK, EST, FIN, NOR, POL
United Kingdom	0.580	0.570	0.596	IRL, NLD, SWE
Simple average	**0.481**	**0.471**	**0.496**	
Population-weighted average	**0.496**	**0.484**	**0.511**	

Source: Authors' calculations.

6. Concluding Remarks

This paper provides an extension of the Human Capital Index that makes it more relevant for the education and health challenges faced by countries in Europe and Central Asia. Specifically, the extension incorporates two elements that are particularly important for the region. First, there is an additional focus on quality adjusted years of tertiary education, in addition to basic education. Second, health status is captured by including risk factors such as obesity, smoking and heavy alcohol consumption, all of which are prevalent in the region. This exercise highlights the importance of investing in tertiary education for many countries in the region, as well as the importance of preventing risk factors for noncommunicable and infectious diseases in the aging societies of the region.

As in any cross-country benchmarking exercise, there are limitations. When analyzing the contribution to productivity from higher education, the ECA-HCI does not distinguish between types of disciplines and the measure of quality can be imprecise. Moreover, data on tertiary attainment are missing for some countries. In terms of the health component, the contribution of adult health risk factors to productivity is based on estimates from the literature which can be imprecise. In any case, the ECA-HCI is not to be interpreted as a measure of welfare but as a reference for policy makers on the productivity gains that can be expected from investing in the different aspects of human capital in Europe and Central Asia. Despite these caveats, the extension of the Human Capital Index presented in this paper could be useful for all middle-income countries where investments in improving tertiary education and limiting health risk factors are likely to be priorities.

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Table A.1 – Productivity effect of university quality

Panel a

Ranking	THE (Overall)			THE (RTC)			QS (Overall)			QS (RTC)		
	Dependent variable: log annual earnings in 2014											
	Both	Males	Females	Both	Males	Females	Both	Males	Females	Both	Males	Females
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Quality score (0-100)	0.0032***	0.0039***	0.0026***	0.0031***	0.0039***	0.0026***	0.0027***	0.0033***	0.0021***	0.0024***	0.0029***	0.0018***
	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0006)
Log parental earnings	0.3222***	0.3526***	0.2650***	0.3194***	0.3489***	0.2628***	0.3035***	0.3327***	0.2466***	0.3076***	0.3365***	0.2507***
	(0.0221)	(0.0246)	(0.0216)	(0.0221)	(0.0247)	(0.0215)	(0.0235)	(0.0262)	(0.0235)	(0.0242)	(0.0271)	(0.0245)
Age	0.1097***	0.1242***	0.0919***	0.1097***	0.1242***	0.0919***	0.1120***	0.1270***	0.0934***	0.1121***	0.1271***	0.0935***
	(0.0018)	(0.0019)	(0.0017)	(0.0018)	(0.0018)	(0.0017)	(0.0018)	(0.0020)	(0.0019)	(0.0019)	(0.0020)	(0.0019)
% of STEM majors in college (0-100)	0.0056***	0.0053***	0.0046***	0.0057***	0.0054***	0.0046***	0.0057***	0.0051***	0.0047***	0.0058***	0.0053***	0.0049***
	(0.0005)	(0.0005)	(0.0007)	(0.0005)	(0.0005)	(0.0007)	(0.0005)	(0.0005)	(0.0007)	(0.0005)	(0.0005)	(0.0007)
Constant	3.3955***	2.6932***	4.5220***	3.4290***	2.7378***	4.5480***	3.6132***	2.9394***	4.7470***	3.5621***	2.8922***	4.6973***
	(0.2640)	(0.2862)	(0.2509)	(0.2642)	(0.2972)	(0.2499)	(0.2910)	(0.3235)	(0.2896)	(0.3005)	(0.3342)	(0.3019)
Observations	1,823	1,823	1,816	1,823	1,823	1,816	1,708	1,696	1,705	1,708	1,696	1,705
Number of colleges	154	154	154	154	154	154	145	144	145	145	144	145

Panel b

Ranking	ARWU (RTC)			CWUR (Overall)			U-Multirank (overall)			U-Multirank (RTC)		
	Dependent variable: log annual earnings in 2014											
	Both	Males	Females	Both	Males	Females	Both	Males	Females	Both	Males	Females
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Quality score (0-100)	0.0045***	0.0056***	0.0035***	0.0073***	0.0102***	0.0045***	0.0040***	0.0047***	0.0031***	0.0032***	0.0035***	0.0028***
	(0.0007)	(0.0008)	(0.0008)	(0.0013)	(0.0013)	(0.0013)	(0.0007)	(0.0008)	(0.0008)	(0.0006)	(0.0006)	(0.0007)
Log parental earnings	0.3255***	0.3546***	0.2730***	0.3255***	0.3190***	0.2641***	0.3204***	0.3498***	0.2675***	0.3131***	0.3421***	0.2605***
	(0.0187)	(0.0216)	(0.0183)	(0.0187)	(0.0147)	(0.0143)	(0.0196)	(0.0230)	(0.0171)	(0.0202)	(0.0239)	(0.0172)
Age	0.1105***	0.1252***	0.0921***	0.1078***	0.1240***	0.0894***	0.1141***	0.1297***	0.0951***	0.1139***	0.1295***	0.0949***
	(0.0019)	(0.0021)	(0.0019)	(0.0013)	(0.0015)	(0.0013)	(0.0019)	(0.0021)	(0.0018)	(0.0019)	(0.0021)	(0.0018)
% of STEM majors in college (0-100)	0.0059***	0.0054***	0.0053***	0.0057***	0.0052***	0.0047***	0.0055***	0.0053***	0.0040***	0.0060***	0.0059***	0.0043***
	(0.0006)	(0.0005)	(0.0007)	(0.0005)	(0.0005)	(0.0006)	(0.0008)	(0.0008)	(0.0009)	(0.0008)	(0.0008)	(0.0009)
Constant	3.3484***	2.6820***	4.4156***	3.2907***	2.5193***	4.3775***	3.1628***	2.4354***	4.3134***	3.2624***	2.5575***	4.3854***
	(0.2291)	(0.2655)	(0.2207)	(0.1774)	(0.2655)	(0.1701)	(0.2649)	(0.3107)	(0.2224)	(0.2690)	(0.3193)	(0.2204)
Observations	1,869	1,868	1,865	3,302	3,252	3,278	2,006	1,972	1,985	2,006	1,972	1,985

Number of colleges	158	158	158	279	275	278	170	167	169	170	167	169

Note: The common sample is composed of universities which are present in all the six rankings. Clustered standard errors at the college level in parentheses. Significance: * p<0.10, ** p<0.05, *** p<0.01.

Panel c

	Dependent variable: log annual earnings in 2014								
Ranking	US News (overall)			Aggregate Quality Score			Agg. Q. Score (common sample)		
	Both	Males	Females	Both	Males	Females	Both	Males	Females
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Quality score (0-100)	0.0019***	0.0027***	0.0013**	0.0024***	0.0031***	0.0016***	0.0044***	0.0052***	0.0036***
	(0.0006)	(0.0006)	(0.0006)	(0.004)	(0.0004)	(0.0004)	(0.0009)	(0.0010)	(0.0008)
Log parental earnings	0.3440***	0.3701***	0.2934***	0.2986***	0.3142***	0.2646***	0.3202***	0.3597***	0.2543***
	(0.0206)	(0.0236)	(0.0202)	(0.0136)	(0.0150)	(0.0134)	(0.0248)	(0.0283)	(0.0225)
Age	0.1074***	0.1228***	0.0891***	0.1074***	0.1237***	0.0894***	0.1157***	0.1295***	0.0979***
	(0.0016)	(0.0018)	(0.0016)	(0.0013)	(0.0014)	(0.0013)	(0.0023)	(0.0024)	(0.0022)
% of STEM majors in college (0-100)	0.0059***	0.0059***	0.0050***	0.0058***	0.0053***	0.0049***	0.0046***	0.0043***	0.0032***
	(0.0004)	(0.0004)	(0.0006)	(0.0005)	(0.0005)	(0.0006)	(0.0008)	(0.0008)	(0.0010)
Constant	3.2374***	2.565***	4.2977***	3.8250***	3.2798***	4.6636***	3.2758***	2.4979***	4.5139***
	(0.2415)	(0.28001	(0.2293)	(0.1679)	(0.1881)	(0.1606)	(0.3061)	(0.3469)	(0.2707)
Observations	2,363	2,363	2,360	3,784	3,689	3,738	1,159	1,159	1,156
Number of colleges	199	199	199	323	315	321	98	98	98

Note: The common sample is composed of universities which are present in all the six rankings. Clustered standard errors at the college level in parentheses. Significance: * p<0.10, ** p<0.05, *** p<0.01.

Appendix A. Skill-based adjustment of higher education

Quality adjustment of higher education can be performed by measuring the quality of inputs (educational institutions) or the quality of outputs (academic proficiency of graduates from higher education). Quality adjustment using university rankings corresponds to the former approach. Quality adjustment using the skills of university graduates corresponds to the latter approach.

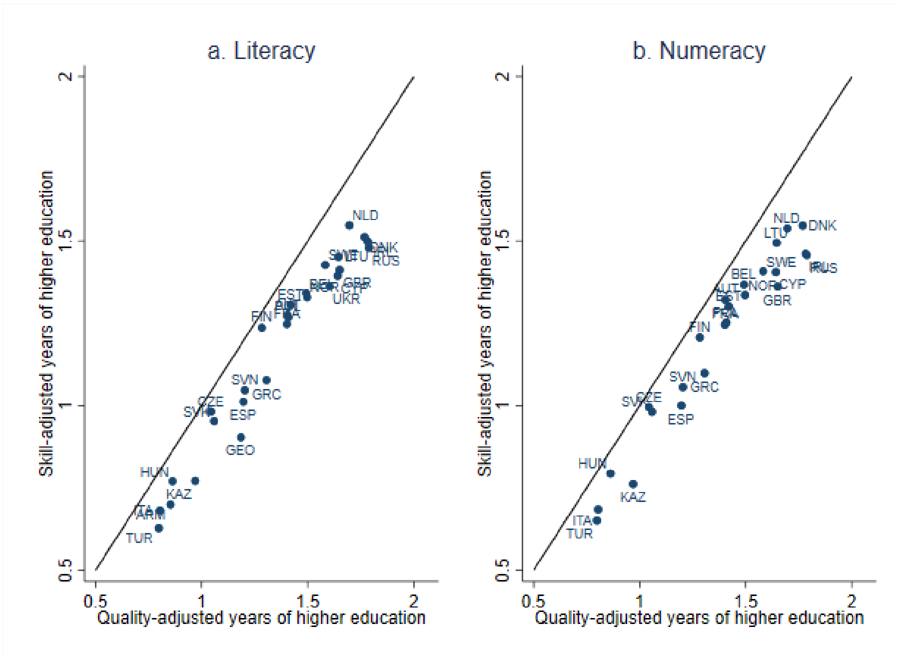
Adult skill proficiency is multidimensional. This analysis focuses on two dimensions that are measured by the Program for the International Assessment of Adult Competencies (PIAAC) survey: literacy proficiency and numeracy proficiency. The PIAAC survey, run by the Organisation for Economic Co-operation and Development, has been carried out in 40 countries, of which 24 are in Europe and Central Asia. The Skills Towards Employment survey, which is run by the World Bank, measures literacy proficiency on a scale equivalent to the PIAAC in three additional countries in Europe and Central Asia. The literacy and numeracy proficiencies are measured on a 0–500 scale; any value greater than 376 is considered highly proficient. The benchmark for full proficiency is set at 400, which exceeds the value reported at the 90th percentile of the score distribution of the average adult population in all countries. Each skill type is weighted equally.

The quality-adjustment measure used is the proficiency in both types of skills of individuals 30–34 who completed a tertiary degree in each country. This demographic group was chosen to match the group for which attainment rates of tertiary degrees are used. The skill-adjusted years of higher education (SAYH) is then derived using the following formula:

$$SAYH_c = Tertiary\ attainment_c^{age\ 30-34} \times 3.5 \times \left(\frac{Literacy_c^{age\ 30-34}}{400} + \frac{Numeracy_c^{age\ 30-34}}{400}\right)\frac{1}{2}$$

The correlation between the SAYH and the QAYH is very high. It is similar for literacy (figure A.1, panel a) and numeracy (figure A.1, panel b) skills. Adjusting the quality of higher education based on adult skill proficiency (SAYH) or university rankings (QAYH) seems to yield similar results.

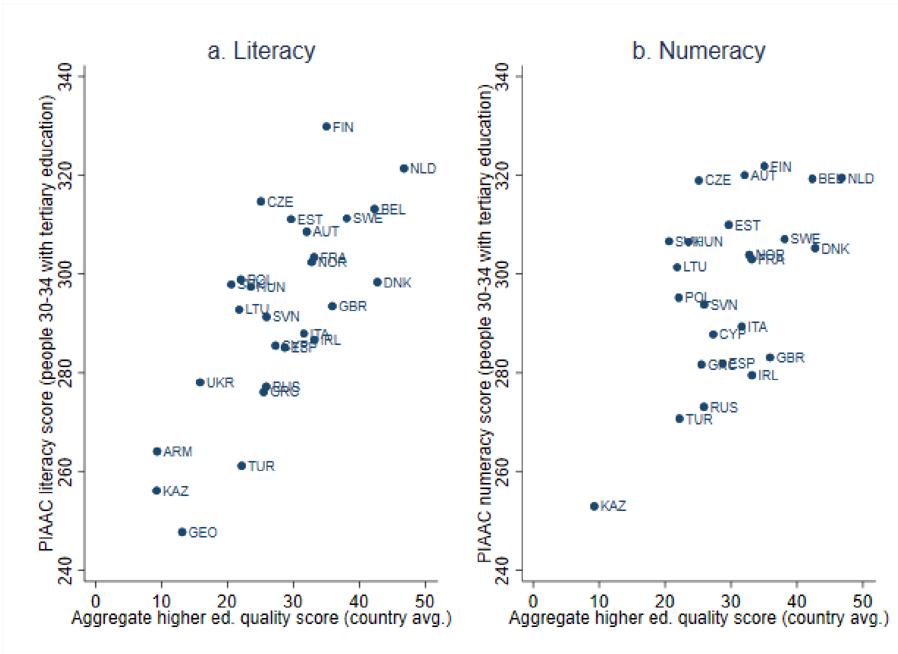
Figure A.1 Correlation between skill-adjusted and quality-adjusted years of higher education for literacy and numeracy skills



Source: Authors’ calculations.

This finding is not surprising, given that there is a high correlation between adult skill proficiency and the average score of a country's universities in the six university rankings (figure A.2).

Figure A.2 Correlation between skill proficiency and university ranking quality score for literacy and numeracy skills



Note: The standardized quality score for higher education is calculated in the following way: The quality scores from each of the six university rankings (the Times Higher Education, the Quacquarelly Symonds, the Academic Ranking of World Universities, the Center for World University Rankings, the U.S. News U.S. Global Universities Ranking, and U-Multirank) are first standardized to a global mean of 0 and a standard deviation of 1 and then averaged for every country. This value is then rescaled to range from 0 to 100 for presentational purposes. PIAAC = Programme for the International Assessment of Adult Competencies.

Appendix B. Estimates of the Effect of Adult Health Risk Factors on Productivity

This appendix reports conditional estimates on log earnings. The characteristics controlled for may differ across papers, but they always include age, gender, and education.

Table B.1 Review of studies on effect of obesity on productivity

	Estimate				
Paper	*Low*	*High*	*Average*	*Comment*	*Source in paper*
Averett and Korenman (1996)	–0.03	–0.15	–0.09	Coefficients compare obese people (BMI > 30) and people of ideal weight (BMI 20–25). Low estimate is for men, 1988 sample; high estimate is for women, 1981 sample.	Table 4
Cawley, Grabka, and Lillard (2005)	0	–0.1986	–0.0993	Coefficients compare obese people (BMI > 30) and people of ideal weight (BMI 20–25). Low estimate is for men in the United States (not significantly different from zero); high estimate is for women in the United States.	Table 2
Lundborg and others (2007)	–0.058	–0.074	–0.066	Coefficients compare obese people (BMI > 30) and non-obese people (BMI < 30); high estimate includes health status as control.	Table 9
Brunello and D'Hombres (2007)	–0.04	–0.105	–0.0725	Regression is linear specification with BMI as independent variable. Coefficients are multiplied by 5 to simulate a change from BMI 25 to BMI 30. Low estimate is for women, controlling for occupation and sector; high estimate is for men, not controlling for occupation and sector.	Table 3
Kline and Tobias (2008)	–0.0685	–0.153	–0.1108	Regression is nonlinear specification with BMI as independent variable. Low estimate corresponds to expected change between BMI 25 and BMI 30 for women; high estimate corresponds to same change for men.	Table IV
Lundborg, Nysted, and Rooth (2010)	–0.072	–0.153	–0.1125	Coefficients compare obese people (BMI > 30) and people of ideal weight (BMI 20–25). Low estimate is for specification controlling for noncognitive skills; high estimate is for specification not controlling for any skill.	Table 4.1, columns C, D, E
Bockerman and others (2019)	0	–0.355	–0.1775	Regression is linear specification with BMI as independent variable. Coefficients are multiplied by 5 to simulate a change from BMI 25 to BMI 30. Low estimate corresponds to genetic instrumental variable 97 SNP (not significantly different from zero). High	Table 1

		estimate corresponds to genetic instrumental variable 32 SNP.
Median	–0.0993	

J. Viinikainen, T. Lehtimäki, S. Rovio, I. Seppälä, J. Pejkonen, and O. Raitakari. 2019. “The Effect of Weight on Labor Market Outcomes: An Application of Genetic Instrumental Variables.” *Health Economics* 28: 65–77.

Brunello, G., and B. D’Hombres. 2007. “Does Body Weight Affect Wages? Evidence from Europe.” *Economics & Human Biology* 5 (1): 1–19.

Cawley, J., M. Grabka, and D. Lillard. 2005. "A Comparison of the Relationship between Obesity and Earnings in the U.S. and Germany." *Schmollers Jahrbuch: Journal of Applied Social Science Studies / Zeitschrift für Wirtschafts–und Sozialwissenschaften* 125 (1): 119–29.

Kline, B., and J. Tobias. 2008. “The Wages of BMI: Bayesian Analysis of a Skewed Treatment–Response Model with Nonparametric Endogeneity.” *Journal of Applied Econometrics* 23: 767–93.

Lundborg, P., K. Bolin, S. Hojgard, and B. Lindgren. 2007. “Obesity and Occupational Attainment Among the 50+ of Europe.” *Advances on Health Economics and Health Services Research* 17: 219–51.

Lundborg, P., P. Nysted, and D.–O. Rooth. 2010. “No Country for Fat Men? Obesity, Earnings, Skills and Health among 450,000 Swedish Men.” IZA Discussion Paper No. 4775, Institute of Labor Economics, Bonn.

Table B.2 Review of studies on effect of smoking on productivity

Paper	Estimate Low	High	Average	Comments	Source in paper
Levine, Gustafson, and Velenchik (1997)	–0.04	–0.08	–0.06	Coefficients compare smokers (more than 1 cigarette a day) and nonsmokers. Low estimate is for 1984; high estimate is for 1991.	Table 4
Van Ours (2004)	–0.085	–0.119	–0.102	Coefficients compare smokers and nonsmokers. Low estimate is for average smokers; high estimate is for twice average smokers.	Table 10
Auld (2005)	–0.083	–0.268	–0.1755	Coefficients compare smokers and nonsmokers. Low estimate treats smoking as exogenous; high estimate treats smoking as endogenous.	Table 2
Grafova and Stafford (2009)	–0.076	–0.102	–0.089	Coefficient compare persistent smokers and people who never smoked. Low estimate is for 1986; high estimate is for 2001.	Table 7
Lokshin and Beegle (2011)	–0.19	–0.23	–0.21	Coefficient corresponds to (causal) difference in earnings of current smokers and nonsmokers. Low estimate is for LIV specification; high estimate is for 2SLS specification.	Table 2 and page 227
Bondzie (2016)	–0.043	–0.069	–0.056	Matching estimates of differences between smokers and nonsmokers. Low estimate corresponds to kernel ATT; high estimate corresponds to nearest neighbor ATT.	Table 5
Median			–0.096		

References for Table B.2

Auld, C. 2005. “Smoking, Drinking and Income.” *Journal of Human Resources* 40 (2): 505–18.

Bondzie, E. A. 2016. “Effect of Smoking and Other Economic Variables on Wages in the Euro Area.” MPRA Paper No. 69230, University of Munich, Germany.

Grafova, I., and F. P. Stafford. 2009. “The Wage Effects of Personal Smoking History.” *Industrial and Labor Relations Review* 62 (3): 381–93.

Levine, P. B., T. A. Gustafson, and A. D. Velenchik. 1997. "More Bad News for Smokers? The Effect of Cigarette Smoking on Wages." *Industrial and Labor Relations Review* 50 (3): 493–509.

Lokshin, M., and K. Beegle. 2011. “Foregone Earnings from Smoking: Evidence for a Developing Country.” *Research in Labor Economics* 33: 209–38.

Van Ours, J. 2004. “A Pint a Day Raises a Man’s Pay; but Smoking Blows That Gain Away.” *Journal of Health Economics* 23 (5): 863–86.

Table B.3 Review of studies on effect of heavy drinking on productivity

Paper	*Low*	*High*	*Average*	*Comments*	*Source in paper*
	Estimate				
Mullahy and Sindelar (1993)	–0.163	–0.176	–0.1695	Coefficients compare people diagnosed with alcoholism and people not diagnosed with alcoholism. Low estimate is for people ever diagnosed with alcoholism; high estimate is for people diagnosed with alcoholism in past year.	Table 3, all obs.
Hamilton and Hamilton (1997)	–0.254	–0.758	–0.506	Coefficients correspond to decomposition of wage differences attributed to differences in returns to characteristics of heavy drinkers (people who consume eight or more drinks on one or more days in the previous week) and nondrinkers. Low estimate is for wider definition of heavy drinker.	Table 4 and page 148
Zarkin and others (1998)	0.082	–0.021	0.0305	Coefficients compare heavy drinkers (people who consumed more than 94 drinks in past 30 days for men, 48 drinks for women) and nondrinkers. Low estimate is for men; high estimate is for women.	Table 2
Barrett (2002)	–0.08	–0.19	–0.135	Low estimate compares heavy drinkers (people who consumed eight or more drinks on one or more days the previous week) and nondrinkers. High estimate is for heavy drinkers versus moderate drinkers.	Table 4
Sloan and Grossman (2011)	0	–0.459	–0.2295	Coefficient compares heavy drinkers (people who consume more than 12 drinks a week) and nondrinkers. Low estimate is for whites and women (not significantly different from zero); high estimate is for black men.	Table 2
Bockerman, Hyytinen, and Maczulskij (2017)	–0.18	–0.424	–0.302	Coefficient corresponds compares heavy drinkers (men who consume more than 280 grams of alcohol a week and women who consume more than 190) and moderate drinkers (men who consume less than 280 grams of alcohol a week and women who consume less than 190). Low estimate is for twin differences in monozygotic twins; high estimate is for twin differences in dizygotic twins.	Table V
Median			–0.1995		

References for Table B.3

Barrett, G. 2002. "The Effect of Alcohol Consumption on Earnings." *Economic Record* 78 (1): 79–96.

Bockerman, P., A. Hyytinen, and T. Maczulskij. 2017. "Alcohol Consumption and Long–Term Labor Market Outcomes." *Health Economics* 26: 275–91.

Hamilton, V., and B. H. Hamilton. 1997. "Alcohol and Earnings: Does Drinking Yield a Wage Premium?" *Canadian Journal of Economics* 30 (1): 135–51.

Mullahy, J., and J. L. Sindelar. 1993. "Alcoholism, Work and Income." *Journal of Labor Economics* 11: 494–519.

Sloan, F. A., and D. S. Grossman. 2011. "Alcohol Consumption in Early Adulthood and Schooling Completed and Labor Market Outcomes at Midlife by Race and Gender." *American Journal of Public Health* 101 (11): 2093–2101.

Zarkin, G. A., M. T. French, T. Mroz, and J. W. Bray. 1998. "Alcohol Use and Wages: New Results from the National Household Survey on Drug Abuse." *Journal of Health Economics* 17: 53–68.