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RESEARCH ARTICLE

Cognitive ability and economic growth: how much happiness is optimal?

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Abstract

The cognitive human capital approach assumes that cognitive abilities (CA) enable societies to be innovative and competitive and to achieve higher productivity and prosperity. However, does happiness enhance the effect of CA on economic growth? Our study views happiness as an intrinsic motivator that helps workers be more productive and get the most out of their CA. Regression analyzes using two different measures for CA showed strong evidence that CA generated economic growth from 1960 to 2017, even though it interacted negatively with happiness. These results were found to be robust after controlling for endogeneity bias using instrumental variable for happiness. In addition, the threshold regression analyses revealed significant evidence that the relationships between CAs and growth vary according to happiness levels. Two prominent ranges of threshold were established: γ_1 = 4.75–4.96 and γ_2 = 6.16–6.43 on the 0 to 10 happiness scale. Accordingly, the effects of CA were smallest in very unhappy countries (happiness $< \gamma_1$), strongest in fairly happy societies (happiness of $\gamma_1 - \gamma_2$), and moderately strong among the happiest countries (happiness $\geq \gamma_2$). In summary, the pursuit of highest productivity growth seems to require an optimal level of happiness, where moderate level of happiness (likely indicative of existence of higher motivation with little emotional distress) could inspire and drive people to fully utilize their cognitive capital and achieve high economic growth.

Keywords Cognitive ability · Economic growth · Happiness · Human motivation · Savanna-IQ interaction hypothesis

JEL Classification J24 · E71 · O47 · B52

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1 Introduction

Economic growth is one of the most important and stimulating areas of research in science. Since the mid-twentieth century, many researchers have focused on studying the factors that contribute to economic growth. One result is that investment in physical capital is not sufficient to guarantee long-term economic growth. The development of wealth in recent decades seems to be mainly due to the use of cognitive human capital (i.e., cognitive ability or intelligence and knowledge) to develop new technologies and more efficient production methods. Cognitive human capital is necessary for innovation as technological progress or more effective organizations and for adapting technology from other countries (e.g., Hanushek and Woessmann 2015; Jones 2016; Lucas 1988; Mincer 1958; Rindermann 2018; Romer 1990).

Since the Industrial Revolution, societies have evolved rapidly, and Schumpeterian creative destruction has steadily dismantled traditional practices focused on mere expansion. This process was rapid and intense, quite different from what the human species originally evolved for: a rather incomplex life as hunter-gatherers on the Savanna for more than 100,000 years, accounting for more than 90 percent of human life history (Lee and Daly 1999). The Savanna Principle states that modern societies face unique challenges because humans evolved to adapt to an original Savanna environment—an ecosystem fundamentally different from that of urban and industrial civilizations in modern times (Kanazawa 2004; Kanazawa and Li 2018; Li and Kanazawa 2016).

In small hunter-gatherer and tribal communities, survival was based on muscular legs, handling tools such as spears, and rather simple thought processes. The brains of early humans were designed to feed in the wild and raise offspring under harsh and dangerous conditions. For example, at a concrete-objective level, cognitive skills were used to develop stone-tipped spears into effective weapons and tools for hunting and fishing (e.g., Milks et al. 2019). In contrast, life in today's world depends more on rapid technological progress, on abstract monetary units and interaction processes with distant partners enabled by high cognitive abilities. Highly intelligent people are associated with the creation of modern, complex and evolutionarily novel environments that are later adopted by people of more average intelligence (Gottfredson 2007; Kanazawa 2004). Modern societies are not only becoming more complex, but also more heterogeneous, as differences in wealth and income and between societies become increasingly visible through television and the internet.

In within society comparisons, higher income goes along with more happiness (Easterlin 1974). In addition, happiness or satisfaction motivates workers to be more engaged at work. Resources appear to be used more efficiently and competences more enhanced, all resulting in higher productivity (Frey 2018; Piekałkiewicz 2017). However, do happier nations achieve higher economic growth? Do happiness and cognitive skills together contribute to wealth, i.e., do cognitive skills lead to more wealth and thus to more happiness, which in turn leads to more economic growth? However, growing inequalities, and especially the possibility of observing such inequalities within and between modern societies, can have a negative impact on happiness: There are always some people or nations who, on average, are richer, or more beautiful, or in some other way better off than you are (Buss 2000). The rich person as a visible neighbor makes you feel poor yourself. Moreover, the greater complexity and abstractness of daily life in modern societies may have a detrimental effect on happiness. Finally, the effect of cognitive ability on economic growth may depend on the level of happiness: Happier societies lead to greater well-being, which can improve the exercise of their existing skills in general, and cognitive ability in particular, further increasing national productivity. At the same time, however, it could also be that the lower the level of happiness, the more "urgent" it can be to improve one's living conditions, and an important means of doing this would be the use of cognitive ability.

In light of these theoretical considerations, the present study analyzed the role of happiness in regulating the impact of human capital, particularly cognitive ability (CA), on economic growth at the cross-country level. This study addressed happiness as an intrinsic motivator and positive psychological state of workers on a national scale.

2 A closer look on happiness, cognitive ability and productivity

2.1 Happiness and motivation at work

Maslow (1970/1954) and Goldstein (1947) emphasized that individuals tend to realize their own abilities in life as fully as possible. They developed the concept of self-actualization, asserting that an individual is regulated and driven by the motivation arising from their propensity to actualize themselves as much as possible in line with their potential. Abraham Maslow's hierarchy of needs emphasizes that the realization of human potential occurs only when all basic and psychological needs are met. If these needs are not met, individuals will experience stress and are therefore unable to focus their motivation on realizing their innate potential and thus unable to thrive.

In organizations, the effectiveness of skilled laborers is reduced if they are not motivated to perform their jobs (Delaney and Huselid 1996). Workers' motivation can be defined as "psychological forces that determine the direction of a person's behavior in an organization, a person's level of effort and a person's level of persistence" (Jones et al. 2000). Accordingly, individuals with intrinsic motivation have an innate propensity to seek challenge and innovate, to develop and practice their skills, to explore, and to learn new things (Ryan and Deci 2000). Consequently, motivated workers are more likely to perform tasks or jobs with a strong sense of interest and enjoyment. Perhaps in this way people's satisfaction or happiness is related to organizational behavior and productivity levels.

Psychological and emotional health is a key element for societies to thrive and develop, to realize their full potential and thereby live productively (Schultz 1977). In a similar way, happiness is usually seen as a positive and desirable goal. The happy worker hypothesis states that happy workers perform better at work than unhappy workers (Wright and Cropanzano 2004). Employees with higher psychological well-being or positive emotional experiences at work are highly connected to their work and their company (Shuck and Reio 2014). They are more engaged in the workplace and value what the organization does (Johnson et al. 2018). Happy employees manage resources efficiently and follow company rules and procedures (Hosie et al. 2012). Satisfied workers perform better because positive emotions induce prosocial organizational behaviors (also known as organizational citizenship behaviors) that promote effective organizational functioning (Koys 2001). Bellet et al. (2020) found that happiness is a source of intrinsic motivation that positively impacts a worker's social skills, such as interpersonal relationships, persuasiveness and negotiation skills. Consequently, happy people are more empathetic, respectful, and helpful and form successful social interactions with their peers in any organization (Barsade and Gibson 2007).

Bellet et al. (2020), for example, studied sales staff from 11 call centers in the United Kingdom for six months and discovered a strong causal effect of staff satisfaction on sales. The result was that employees worked more efficiently and were 13% more productive, i.e., made more calls per hour and more successful sales per day, when they were happier. Furthermore, Oswald et al. (2015) showed that positive shocks to happiness could increase individuals' efforts at their tasks, resulting in relevant increases in productivity of up to 12%. These findings are consistent with the assumption that people with positive psychological well-being would exert themselves and "go the extra mile." Accordingly, other researchers have argued that while monetary motivators are costly efforts, psychological motivators and non-monetary rewards are efficient in motivating workers to perform challenging tasks (e.g., DellaVigna and Pope 2017; Gneezy and Rustichini 2000). Extrinsic motivations like rewards are weak short-term reinforcers that become negative reinforcers and hidden costs once withdrawn (Bénabou and Tirole 2003).

In a study in Finland, Böckerman and Ilmakunnas (2012) found that an increase in average job satisfaction increased productivity (measured in terms of value added per hour worked) in the manufacturing sector from 1996 to 2001. Similarly, Bryson et al. (2017), using nationally representative data in the UK from 2004 to 2011 from most of the country's economic sectors, discovered a significant impact of job satisfaction on job performance. In addition, there was no significant association between the level of work-related affective well-being and worker performance. This result indicates that overall satisfaction or happiness is more critical to improving productivity compared to job-specific emotional experiences.

Studies have discussed the direction of causality between psychological well-being and productivity. To determine the impact of happiness on productivity, empirical studies have looked at the possibility of reverse causality between productivity and a worker's well-being. Various methods were used to constrain potential reverse causality, which was found to run in reverse, i.e., from a worker's happiness to productivity (e.g., Bellet et al. 2020; Böckerman and Ilmakunnas 2012; Bryson, et al. 2017; DiMaria et al. 2020; Harter et al. 2010).

The role of well-being in increasing economic performance has also been studied at the cross-country level. DiMaria et al. (2020) found that happiness led to efficiency gains in productivity in 20 European countries between 2004 and 2010. They added that well-being should be treated as a productivity factor rather than as a positive consequence of high income resulting from high productivity. Krekel et al. (2019) conducted a meta-analysis of 339 research studies on the well-being of approximately 1.9 million workers and the performance of more than 80,000 business units across 49 industries in the US and outside the US. In particular, a strong positive association was found between employee satisfaction with their company and their level of productivity and customer loyalty, while satisfaction was strongly negatively associated with employee turnover. These results indicated that employee well-being, often measured in terms of happiness or satisfaction, is significantly related to productivity at the company and country levels.

2.2 Cognitive ability as a robust determinant of productivity

"Intelligence" can be briefly and comprehensively defined as the ability to think (Rindermann 2018). This concept may be too narrow, as it does not include knowledge. The concept of "cognitive ability" encompasses both intelligence (as the ability to think), knowledge (knowledge of true and relevant content), and competent-intelligent use of knowledge. In economics, the term "skill" is more common. By "skill," however, is meant a narrower ability, but neither intelligence nor cognitive ability is narrow.

Cognitive ability is related to the complexity of job tasks and occupational status (Gottfredson 2018; Nyborg and Jensen 2001). In statistical analyses of job performance, cognitive abilities show the highest predictive validity. Depending on job performance criteria and applied correction formula for low reliability and variance restriction, the relationships range between $r/\beta/\rho = 0.23$ and 0.64 (Salgado et al. 2003; Schmidt 2012). This is true for different countries including developing countries (Meisenberg et al. 2006). Cognitive ability improves job performance through on-the-job learning, as cognitively competent workers acquire faster and more knowledge. Job requirements are cognitively demanding, e.g., understanding instructions, assignments, and safety hazards; prioritizing tasks; making decisions; dealing with people; processing, integrating, and evaluating information to solve problems, as in accountants, business people, doctors, engineers, managers, scientists, etc. (Rindermann 2018). Especially in modernity and with more complex jobs, learning is a prerequisite to becoming an effective worker. In addition, intelligent people are more successful at calculating risk and diversifying portfolios in their personal investing (e.g., Grinblatt et al. 2015). These individuals also usually prefer to work more patiently together as a team, preferring large and long-term benefits rather than small and immediate gains (see overview of Jones 2016).

The role of cognitive ability in productivity can be extended from the micro level to the country level. National intelligence or cognitive ability estimates based on psychometric intelligence tests or student assessment tests (e.g., PISA and TIMSS[1]) successfully predict income, economic growth and wealth (Angrist et al. 2021; Burhan et al. 2017; Hanushek and Woessmann 2015; Lim et al. 2018; Lynn & Becker 2019; Rindermann 2018).

Various research approaches have attempted to test whether the relationship between cognitive ability and wealth is due to a causal influence of ability. For cognitive

[1] The Programme for International Student Assessment (PISA) is coordinated by the Organization for Economic Co-operation and Development (OECD) for measuring fifteen-year-old school students' scholastic performance on mathematics, science, and reading, while the Trends in International Mathematics and Science Study (TIMSS) is established by the International Association for the Evaluation of Educational Achievement (IEA) to measure the level of students' mathematics and science knowledge in grades 4 and 8. There are many other regional or global studies of student assessment.

ability, Lynn data or alternative student assessment study results were used. For wealth, income, GDP/c, economic growth and assets were used as indicators. Methods applied were, for instance, regression analyses. Jones and Schneider (2006, p. 71) used 1330 regressions and concluded that “IQ is statistically significant in 99.8%” of their analyses predicting economic growth. Rindermann and Becker (2018) examined whether a historical increase in IQ within countries has led to later economic growth. This design can exclude national differences being associated with human capital and growth (e.g., in culture, economic freedom and politics) which may bias the results. The results showed substantial correlations between growth in IQ and GDP, with the highest values for economic growth lagged by 5 to 15 years ($r=0.25$ to 0.44 resp. 0.46 to 0.77). The outcome supports the theory that cognitive ability contributes to prosperity.

Studies have found a weak relationship between common measures of schooling (e.g., years of schooling) and wealth, as schooling variables are typically gross inputs and crude measures of human capital (e.g., Hanushek and Woessmann 2011; Weede 2004). Looking more closely at the mechanisms of how cognitive ability can lead to higher growth, one can consider the individual-level effects that can be aggregated at the country-level, e.g., better learning of work tasks, fewer errors, dealing with complexity (see above). However, there are also institutional effects as better universities, better governance, more rule of law, more human rights, being a “good country,” faster technological progress and absorption (diffusion) from foreign countries and improved educational systems (e.g., Burhan et al. 2018; Jones 2012; Rindermann and Carl 2018, 2020). Finally, cognitive ability seems to have with ability increasing effects: effects of cognitive ability on various productivity measures increase nonlinearly at higher levels of ability, indicating that higher ability levels disproportionately boost a nation’s productivity (Coyle et al. 2018).

2.3 The Easterlin Paradox and genetics of happiness

Although higher economic growth brings more prosperity, various studies have shown that an increase in wealth does little to increase human happiness. In 1974, economist Richard Easterlin found that average happiness in the USA had remained virtually unchanged for decades despite continuous economic growth (Easterlin 1974). The Easterlin paradox specified that “at a point in time both among and within nations, happiness varies directly with income, but over time, happiness does not increase when a country’s income increases” (Easterlin et al. 2010, p. 22,463).

Moreover, at the macro-level, there is increasing evidence that the relationship between income and emotional well-being declines above a certain income level. For example, Oswald (1997) found that economic progress contributes little to happiness in industrialized countries, with life satisfaction declining in many European countries and average levels of job satisfaction remaining the same in the United States and the United Kingdom. Happiness research has found that money generates happiness through the fulfillment of needs and material desires. However, happiness adjustment in the population occurs at a certain higher level of income. This situation is called *income satiation*, where income beyond the saturation point no longer contributes to happiness (see Jebb et al. 2018; Kahneman and Deaton 2010). The stability in happiness levels in nations was also summarized by Veenhoven (2014).

The long-term stability of happiness is consistent with studies showing that a person's affective state and mood are also determined by genetic factors (Bartels 2015). Genes influence a person's personality and can provide an affective reserve needed during stress and recovery. Similarly, recent studies at the global level have found that differences in genetic factors have a significant impact on national differences in happiness levels. For instance, Minkov and Bond (2017) mentioned that national percentages of very happy individuals highly correlate with the national prevalence of the "rs324420 A" allele in the FAAH gene, essential in enhancing sensory pleasure and reducing pain. In a similar vein, Proto and Oswald (2017) stated that societies with high average happiness levels have a low frequency of the short allele version of the 5-HTTLPR polymorphism associated with neuroticism, harm avoidance, negative affect, and clinical depression. These results show that factors that are robust to change also contribute to subjective well-being, and thus a rather stable international pattern of happiness can emerge.

3 Empirical strategy

3.1 Threshold regression

For this study, data on the average economic growth rates of 57 years from 1960 to 2017 were used. The linear regression model has the following form:

$$\begin{aligned}\text{Growth}_i = \beta_0 + \beta_1\text{CA}_i + \beta_2\text{Happiness}_i + \beta_3\text{Institution}_i \\ + \beta_4\text{CA}_i * \text{Happiness}_i + \delta_1 W_{1i} + \cdots + \delta_4 W_{4i} + u_i\end{aligned}$$

Growth is the growth rate (%) of GDP per capita in purchasing power parity (PPP, at constant 2011 international USD) for country *i*. The data on *Growth* were obtained from the Penn World Table (PWT) 9.1 (Feenstra et al. 2015). β_0 and u_i are generic constant and error terms. *W*'s represents a vector of conditional information set of control variables, including GDP/c_{1960} as the initial GDP per capita (log-transformed) for the year 1960, I/GDP the investment as a percentage (%) of annual GDP, and the population growth rate (%). These three control variables are commonly used in growth regression analyses (e.g., Barro 1991; Mankiw et al. 1992). In the current study, data were retrieved from the PWT 9.1, where I/GDP and population growth have their annual values averaged from 1960 to 2017.

The fourth component of *W*'s denotes a dummy variable (0, 1) indicating membership in the Organization of Petroleum Exporting Countries (OPEC). On average, oil-exporting countries reflect high income relative to human capital levels, as annual GDP reflects current resource extraction rather than labor efficiency (Barro 1991; Mankiw et al. 1992). Therefore, control proved essential for OPEC countries, as cognitive ability in those economies may not be as critical to long-term economic growth as in non-OPEC regions.,[2][3]

Institution refers to two measures of institutional quality, namely the degrees of economic freedom and of rule of law, each of which was inserted separately into the regression. Data on economic freedom were obtained from the Fraser Institute's online database (Gwartney et al. 2020) approximately between 1960 and 2017. Economic freedom is defined as "the ability of individuals to make their own economic decisions without interference or limitations by government or government's protection of anti-market behavior in favor of powerful groups and these group's abuse of this power to limit market choices of other" (McMahon 2014, p. 1795). Economic freedom is one very classical determinant of economic growth and more generally of the welfare of nations (e.g., Coyle et al. 2016; Hayek 2011/1960).[4] The second measure of institutional quality is the rule of law, annual data is from the World Bank's Worldwide Governance Indicators (WGI) (2021). Similar to economic freedom, the rule of law is crucial for economic growth and development, it is also part of the concept of "being a good country." Rodrik et al. (2004), for instance, found that the rule of law 'trumped' all other development indicators in determining income levels around the world. The positive impact of the rule of law on economic growth occurs through the containment of violence, the protection of property rights, institutional controls of the government, and the control of private expropriation and corruption (Haggard and Tiede 2011).

CA_i is the average level of cognitive ability (CA) for each country *I*. Two measures of CA were employed. The first measure comes from Lynn and Vanhanen (2012), who collected average national IQ scores in 157 countries worldwide (IQ). The 2012 dataset is an improved version of previous datasets and provides values for a larger number of countries and a more reliable estimation. The second measure of CA used was the dataset from Altinok et al. (2014). Altinok et al. compared competencies across countries based on student performance on PISA and TIMSS in reading, mathematics, and science. The final cognitive scores were named Indicator of Quality of Student

[2] This study attempted to incorporate regional dummies for East Asia and sub-Saharan Africa as the regions implied higher and lower economic growth rates, respectively. However, without suppressing the IQ significance level ($p < .01$), including these dummies extremely elevated the variance inflation factor (VIF) of IQ from ~ 4 to ~ 16 for regressions with and without interaction term ($N = 94$). These regional dummies were highly correlated with national IQ, for instance, at $r = -.76$ for the sub-Saharan Africa. This negative connection proved stronger than the IQ-GDP/c_{1960} ($r = .61$) in Table 2 and the correlations between sub-Saharan Africa (dummy) and other vital variables: GDP/c_{1960} ($r = -.54$) and population growth rate ($r = .55$). Furthermore, IQ was strongly associated with the East Asian dummy ($r = .43$) as the six East Asian countries in Table 1 denoted the highest IQs among all the nations. Predictably, the regional dummies reflected long-term stable patterns of development (e.g., Hart 2007; Murray 2003; Rindermann 2018). Therefore, this study omitted these regional dummies from the regression because the sample-splitting (or threshold effect) could be highly sensitive to their impacts.

[3] Not presented in Table 2, the correlations between OPEC dummy and other main variables were insignificant except for the association with economic freedom ($r = -.27$; $p < .01$), rule of law ($r = -.32$; $p < .01$), and population growth ($r = .19$; $p < .10$).

[4] Murphy (2016) has provided empirical evidence that Fraser's economic freedom is more powerful than other measures of institutional quality provided by Heritage Foundation, Freedom House, Polity IV, and Worldwide Governance Indicators (WGI) to predict the level of human development in different countries.

Table 1 List of countries with top- and bottom-10 rankings for selected variables

	Economic growth rate (%) 1960–2017		National intelligence (IQ)		Indicator of Quality of Student Achievement (IQSA)*		Happiness (Scale 0 to 10)	
10 countries at highest ranking	1. South Korea	5.76	1. Singapore	107.1	1. South Korea	6.20	1. Denmark	7.70
	2. Botswana	5.67	2. China	105.8	2. Singapore	6.19	2. Norway	7.56
	3. Taiwan	5.53	3. Hong Kong	105.7	3. Japan	6.14	3. Switzerland	7.54
	4. China	5.17	4. South Korea	104.6	4. Hong Kong	6.05	4. Finland	7.52
	5. Singapore	5.07	5. Taiwan	104.6	5. Finland	6.05	5. Netherlands	7.47
	6. Thailand	4.81	6. Japan	104.2	6. Netherlands	5.91	6. Canada	7.44
	7. Malta	4.80	7. Finland	100.9	7. Belgium	5.90	7. Iceland	7.41
	8. Hong Kong	4.42	8. Netherlands	100.4	8. United Kingdom	5.90	8. Sweden	7.37
	9. Romania	4.27	9. Canada	100.4	9. Canada	5.86	9. New Zealand	7.32
	10. Malaysia	4.06	10. Switzerland	100.2	10. Germany	5.82	10. Australia	7.31
10 countries at lowest ranking	85. Guinea	.721	85. Mozambique	69.5	74. Togo	3.44	85. Malawi	4.15
	86. Cameroon	.713	86. Ethiopia	68.5	75. Zambia	3.38	86. Gambia	4.12
	87. Zambia	.573	87. Congo (Dem. Rep.)	68.0	76. Ghana	3.28	87. Botswana	4.10
	88. Jamaica	.503	88. Lesotho	66.5	77. Senegal	3.18	88. Zimbabwe	4.06
	89. Senegal	.197	89. Guinea	66.5	78. South Africa	3.10	89. Syria	4.02
	90. Venezuela	.098	90. Sierra Leone	64.0	79. Congo (Dem. Rep.)	3.01	90. Madagascar	3.93
	91. Gambia	− .033	91. Cameroon	64.0	80. Mali	2.84	91. Guinea	3.86
	92. Madagascar	− .722	92. Cent. African Rep	64.0	81. Benin	2.69	92. Tanzania	3.72
	93. Cent. African Rep	− 1.12	93. Gambia	62.0	82. Niger	2.56	93. Rwanda	3.70
	94. Congo (Dem. Rep.)	− 1.61	94. Malawi	60.1	83. Mauritania	2.11	94. Cent. African Rep	3.51
Mean	2.21		85.44		4.62		5.62	
Median	2.11		85.70		4.46		5.55	
Std. Dev	1.41		12.03		1.00		1.16	

*IQSA scale divided by 100

Table 2 Correlation matrix for main variables ($N = 76$)

		Economic growth	GDP/c_{1960}	I/GDP	Population growth	Economic freedom	Rule of law	IQ	IQSA	Happiness
1	Economic growth	1								
2	GDP/c_{1960}	−.300***	1							
3	Investment rate (I/GDP)	.357***	.423***	1						
4	Population growth	−.343***	−.507***	−.440***	1					
5	Economic freedom	.299***	.591***	.466***	−.581***	1				
6	Rule of law	.342***	.595***	.585***	−.697***	.842***	1			
7	IQ (psychometric)	.429***	.609***	.605***	−.710***	.692***	.751***	1		
8	IQSA (student achievement)	.380***	.619***	.612***	−.728***	.737***	.811***	.932***	1	
9	Happiness	.092	.784***	.469***	−.627***	.716***	.716***	.745***	.755***	1

Significance level: ***$p < .01$; **$p < .05$, *$p < .10$

Achievement (IQSA). In general, psychometric intelligence tests and student achievement tests are considered different measures. However, analyses of the content of tasks and the cognitive processes involved in solving such tasks show a strong similarity between psychometric and student achievement tasks (Rindermann and Baumeister 2015). Moreover, correlations between psychometric intelligence and achievement test scores are high at both the individual and national levels (e.g., Kaufman et al. 2012).

In this study, *Happiness* represents the national average happiness score, with data taken from the World Happiness Report (WHR) 2020 (Helliwell et al. 2020) and averaged for the period 2006 to 2017. The WHR used data from the Gallup World Poll (GWP) and calculated the national average of responses to the following question: "Please imagine a ladder with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you, and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?" This study assumes that the fluctuations in the level of happiness in the countries are comparatively small, e.g., due to genetic and long-term stable cultural influences (see literature overview in Sect. 2.3). This assumed stability allows happiness measured over the period 2006–2017 to explain the economic growth from 1960 to 2017.

Finally, *CA*Happiness* is the interaction between the national average levels of CA and happiness. In this study, social happiness levels were hypothesized to influence the effects of CA and productivity. Specifically, it was hypothesized that the effects of CA on productivity differ between, for example, two different levels of happiness as follows:

$$\text{Growth}_i = \alpha X_i + \beta_2 \text{Happiness}_i + \begin{cases} \beta_{1\text{A}} \text{CA}_i, \textit{Happiness} < \gamma \\ \beta_{1\text{B}} \text{CA}_i, \textit{Happiness} \geq \gamma \end{cases}$$

In this equation, X represents all control variables. *Happiness* acts as the threshold variable. The above model allows the impact of cognitive capital on economic growth to take two different values depending on whether the happiness level is higher or lower than the threshold value, γ. The impact of CA on economic growth is β_1 and β_2 for societies of low and high happiness levels, correspondingly. The constant and error terms are not shown for simplicity.

The threshold regression analysis followed procedures from the structural break test by Bai and Perron (2003) to determine significant happiness thresholds. This technique divides the country sample into different groups with varying degrees of relationship between CA and economic growth based on happiness levels. In particular, the procedure involves two main steps: determining the value of $\hat{\gamma}$ and the slope parameters of α and β. Estimates of $\hat{\gamma}$ was established by probing the threshold model with all potential values of γ, whereby $\hat{\gamma}$ was the minimizer of the residual sum of squares calculated across all potential γ-values. Next, estimates of the slope parameters were ensued as $\hat{\alpha}(\hat{\gamma})$ and $\hat{\beta}(\hat{\gamma})$ once $\hat{\gamma}$ was identified. The second step involved determining the significance of the threshold parameter γ, set at $p<0.05$ level. In fact, γ is non-significant under the null hypothesis. Furthermore, the significance of the threshold parameter $\hat{\gamma}$ was estimated using 10% trimming percentage to trim high leverage points.

Because of the small sample size, the number of thresholds allowed was set to two, which divided the countries into three different levels of happiness. The approach facilitated this study to estimate the threshold parameter $\hat{\gamma}$ at its best with up to 25% trimming as a robustness test. Thus, this study identified the threshold effect and the statistical significance of $\beta_{1\mathrm{A}}$, $\beta_{1\mathrm{B}}$ and $\beta_{1\mathrm{C}}$ for the three different country groups, specifically countries with low, medium, and high happiness levels. Therefore, the linear model is reconfigured as follows:

$$\mathrm{Growth}_i = \beta_2 \mathrm{Happiness}_i + \beta_3 \mathrm{Institution}_i + \delta_1 W_{1i} + \dots + \delta_4 W_{4i} + \begin{cases} \beta_{1\mathrm{A}} \mathrm{CA}_i, \mathit{Happiness} < \gamma_1 \\ \beta_{1\mathrm{B}} \mathrm{CA}_i, \gamma_1 \le \mathit{Happiness} < \gamma_2 \\ \beta_{1\mathrm{C}} \mathrm{CA}_i, \mathit{Happiness} \ge \gamma_2 \end{cases}$$

3.2 Endogeneity and instrumental variable (IV) estimation

Endogeneity means a correlation between an independent (causal) variable and another unknown or known error variable. For example, there is a correlation between sex (independent, predictor, causal variable) and weight (dependent, criterion variable that should be explained or variation in it), but also between sex and height. Thus, the explanation that male sex leads to overweight or obesity is incorrect. Sex leads to different body size, which leads to different weight. In the case of a relationship between happiness, growth and wealth, it could be that it is not happiness (via happier and more productive workers) that leads to economic growth and wealth, but that wealth leads to more happiness (reverse causation). Despite the veracity of the Easterlin paradox and happiness level stability, many studies have suggested that wealth plays a significant role in happiness, at least in the short run using cross-sectional data (e.g., Helliwell et al. 2020; Sabri et al. 2021). Therefore, although happiness could increase workforce productivity, it could also be endogenous to economic growth in the long run. Therefore, it is imperative to control for these potential reverse causalities so that the regression estimates are not at risk of simultaneous equation bias. Moreover, happiness and economic growth may be correlated with unobserved variables that were not included in the regression, leading to omitted variable bias.

Apart from that, prominent cross-national studies on IQ-economic growth suggested that reverse causality was not a critical problem. For example, Jones and Schneider (2010) pointed out that the IQ of oil-exporting Middle Eastern countries has been at the level of the world average IQ since the 1950s (about 85 compared to a British mean of 100), despite their exceptionally high income. Thus, acquiring wealth over several decades would not optimize the level of cognitive capital. Similarly, Weede and Kämpf (2002) suggested that endogeneity issues (the feedback of wealth or economic growth on IQ) should be viewed as a century-long rather than a decade-long problem, with the exception of mass immigration and emigration between countries.[5] Moreover, country level data on cognitive ability presented by Lynn and Vanhanen (2012) and Altinok et al. (2014), as employed in this study, were already fine-tuned to predict long-term trend of economic development at cross-national level.

The endogeneity problem could be mitigated by the use of IV technique. Since happiness is endogenous in the model, the selection of instrumental variables (instruments) should be based on the fact that the instrumental variables are related to economic growth only through their association with happiness, while they should not be directly related to economic growth. Having at least one instrument for an endogenous happiness variable is very crucial. Following the WHR of Helliwell et al. (2020, p. 16), social support is highly relevant for happiness. Therefore, this study used the degree of social support as the instrument for happiness because it is expected not to be directly correlated with national productivity. The quality of social relationships people have in their family and surrounding community influences happiness. Although societies are gratified with material prosperity, the high quality of social connectivity provides them with social support and bonding, resulting in happiness (Hori and Kamo 2018; Myers and Diener 2018). In a recent economic study, Bruni et al. (2019) found that micro-dimensions of social capital such as individual social support, kinship and friendship relationships, reciprocity and high-quality social or family relationships help build an institutionalized collaborative culture that promotes happiness. Therefore, the economic development of the last few decades might have improved the social net or welfare in the societies of the different countries.

The data come from responses to the Gallup World Poll (GWP), where social support refers to the country's average level of social support based on the binary response (either zero or one) to the question, "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?" Theoretically, this variable does not correlate directly with economic growth and is likely to affect it only through their impact on happiness.

Next, this study proceeded with the design of the IV method after the selection of the instrument. The two-stage least squares (2SLS) was estimated in two-step procedure, as suggested by Stock and Watson (2020, pp. 437–440). First, the potentially endogenous variable, happiness was regressed against its instrument, specifically the social support (*Support*) and all exogenous regressors that originated from the main *Growth* equation:

$$\text{Happiness}_i = \pi_0 + \pi_1 \text{Support}_i + \pi_2 \text{CA}_i + \pi_3 \text{Institution}_i + \lambda_1 W_{1i} + \cdots + \lambda_4 W_{4i} + v_i$$

Because the number of instrument (i.e., *Support*) equals the number of endogenous regressor (i.e., *Happiness*), therefore the coefficient is said to be 'exactly identified'. The first stage regression computed the predicted values of happiness as follows:

[5] On the other hand, mass migration can be termed "great migration" like Indo-European migrations and "forced migration" like the Atlantic slave trade. Both are considered very influential in the course of history. Mass migration differs from individual, small-scale and seasonal migration, which can occur on a regular basis.

$$\widehat{\text{Happiness}}_i = \hat{\pi}_0 + \hat{\pi}_1\text{Support}_i + \hat{\pi}_2\text{CA}_i + \hat{\pi}_3\text{Institution}_i + \hat{\lambda}_1 W_{1i} + \cdots + \hat{\lambda}_4 W_{4i}$$

Subsequently, the fitted values were applied as predictor variables in the second stage regression, summarized as follows:

$$\text{Growth}_i = \beta_0 + \beta_1\text{CA}_i + \beta_2\widehat{\text{Happiness}}_i + \beta_3\text{Institution}_i + \delta_1 W_{1i} + \cdots + \delta_4 W_{4i} + u_i$$

Considering the main aim of this study to determine the threshold effect of happiness on the relationship between CA and economic growth, hence the *Growth* model was transformed into a general threshold regression model:

$$\text{Growth}_i = \delta_1 W_{1i} + \cdots + \delta_4 W_{4i} + \beta_2\widehat{\text{Happiness}}_i + \beta_3\text{Institution}_i + \begin{cases} \beta_{1\text{A}}\text{CA}_i, \widehat{\text{Happiness}} < \gamma_1 \\ \beta_{1\text{B}}\text{CA}_i, \gamma_1 \le \widehat{\text{Happiness}} < \gamma_2 \\ \beta_{1\text{C}}\text{CA}_i, \widehat{\text{Happiness}} \ge \gamma_2 \end{cases}$$

For visual simplicity, the constant and error terms are not shown in the model. Earlier, this study specified two distinct variables for cognitive ability (CA), particularly IQ and IQSA, and two different variables for institutional quality (*Institution*), namely the economic freedom and the rule of law (henceforth labeled as *EconomicFreedom* and *RuleOfLaw*, respectively). Consequently, *Happiness* (IV) and *Growth* were predicted by different combinations of *CA* and *Institution* variables through 2SLS method. From this, one might expect that threshold effect and the statistical significance of $\beta_{1\text{A}}$, $\beta_{1\text{B}}$ and $\beta_{1\text{C}}$ may vary. Therefore, the threshold regression model was adapted into four variations as follows:

$$\text{Growth}_i = \delta_1 W_{1i} + \cdots + \delta_4 W_{4i} + \beta_2\widehat{\text{Happiness}}_i + \beta_3\text{EconomicFreedom}_i + \begin{cases} \beta_{1\text{A}}\text{IQ}_i, \widehat{\text{Happiness}} < \gamma_1 \\ \beta_{1\text{B}}\text{IQ}_i, \gamma_1 \le \widehat{\text{Happiness}} < \gamma_2 \\ \beta_{1\text{C}}\text{IQ}_i, \widehat{\text{Happiness}} \ge \gamma_2 \end{cases}$$

$$\text{Growth}_i = \delta_1 W_{1i} + \cdots + \delta_4 W_{4i} + \beta_2\widehat{\text{Happiness}}_i + \beta_3\text{RuleOfLaw}_i + \begin{cases} \beta_{1\text{A}}\text{IQ}_i, \widehat{\text{Happiness}} < \gamma_1 \\ \beta_{1\text{B}}\text{IQ}_i, \gamma_1 \le \widehat{\text{Happiness}} < \gamma_2 \\ \beta_{1\text{C}}\text{IQ}_i, \widehat{\text{Happiness}} \ge \gamma_2 \end{cases}$$

$$\text{Growth}_i = \delta_1 W_{1i} + \cdots + \delta_4 W_{4i} + \beta_2\widehat{\text{Happiness}}_i + \beta_3\text{EconomicFreedom}_i + \begin{cases} \beta_{1\text{A}}\text{IQSA}_i, \widehat{\text{Happiness}} < \gamma_1 \\ \beta_{1\text{B}}\text{IQSA}_i, \gamma_1 \le \widehat{\text{Happiness}} < \gamma_2 \\ \beta_{1\text{C}}\text{IQSA}_i, \widehat{\text{Happiness}} \ge \gamma_2 \end{cases}$$

$$\text{Growth}_i = \delta_1 W_{1i} + \cdots + \delta_4 W_{4i} + \beta_2\widehat{\text{Happiness}}_i + \beta_3\text{RuleOfLaw}_i + \begin{cases} \beta_{1\text{A}}\text{IQSA}_i, \widehat{\text{Happiness}} < \gamma_1 \\ \beta_{1\text{B}}\text{IQSA}_i, \gamma_1 \le \widehat{\text{Happiness}} < \gamma_2 \\ \beta_{1\text{C}}\text{IQSA}_i, \widehat{\text{Happiness}} \ge \gamma_2 \end{cases}$$

4 Results

Table 1 shows the list of countries that rank in the top and bottom ten based on economic growth, happiness, and two CA measures: IQ (Lynn's estimates of cognitive ability based on psychometric intelligence tests) and IQSA (estimates of cognitive ability based on student performance). The higher average economic growth rates in the period 1960 to 2017 were mainly achieved by East Asian countries, while several sub-Saharan African countries (with the exception of Botswana) had weak economic performance for almost six decades. Scandinavian and other European countries were more cognitively competent and happier. East Asian countries led on both CA indices. Sub-Saharan African countries had low scores on both CA and happiness.

The correlations between the variables are shown in Table 2, with growth showing a strong and positive relationship with the two CA measures ($r=0.43$ and 0.38). In contrast, the correlation between growth and happiness was very low ($r=0.09$). Results also showed that high population growth was negatively associated with all levels of socioeconomic development ($r=-0.37$ to -0.76). Happiness was highly associated with psychometric IQ ($r=0.75$), student achievement IQSA ($r=0.76$), and 1960 GDP per capita ($r=0.78$), implying that happier societies are more prosperous and intelligent and vice versa. Finally, an extremely high correlation ($r=0.93$) was found between IQ and IQSA, indicating that the two variables overlap empirically in measuring cognitive ability.

To illustrate the relationship between cognitive ability and economic growth, Figs. 1 and 2 plot the partial associations between growth and CAs, net of the values predicted by GDP/c_{1960}. Partial correlations of $r=0.82$ and $r=0.74$ were found for IQ-growth and IQSA-growth, respectively, likely indicating strong and positive effects of CAs on economic growth between 1960 and 2017.

Tables 3 and 4 summarize the results of the regression analyses for the entire country sample. In this study, the OLS method found positive and negative signs for investment as a percentage (%) of annual GDP (I/GDP) and population growth, indicating that economies with a higher investment ratio and lower population growth have higher economic growth rates. The negative sign of GDP/c_{1960} implies the beta-convergence of the long-term economic growth process, in which poor economies have grown faster than rich economies since 1960 (advantages of backwardness). In this study, the model included two indicators of cognitive human capital (i.e., students' psychometric IQ and IQSA). Developing countries are likely to benefit from their relative backwardness by learning the production methods and technologies of developed countries at lower cost and therefore experiencing faster GDP growth than advanced economies. Convergence rates were estimated to be higher (Table 3: $|\beta_{GDP/c1960}|>|-2.912|$; Table 4: $|\beta_{GDP/c1960}|>|-2.737|$) when cognitive ability was included in the growth regression because human capital partly determines the steady-state level of GDP per capita in countries in the long run.

Model 3 of Tables 3 and 4 shows that happiness was positive and highly significant ($p<0.01$) toward economic growth before CA was being included in the regression. When IQ and IQSA variables were entered into the regression (Model 4), the happiness-growth relationships were still positive but became marginally significant

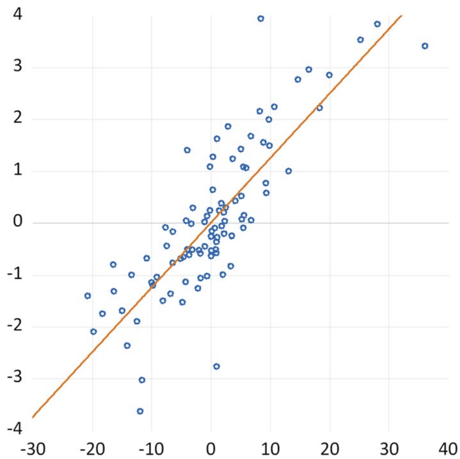

Fig. 1 Partial association ($r = .824$; $N = 94$) between psychometric IQ and economic growth. y-axis = economic growth, net of GDP/c_{1960} effect. x-axis = IQ, net of GDP/c_{1960} effect

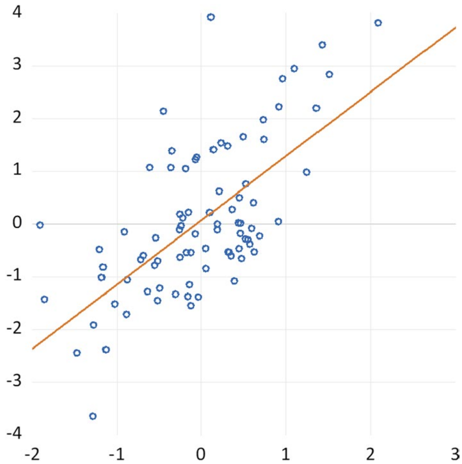

Fig. 2 Partial association ($r = .739$; $N = 83$) between student IQSA and economic growth. y-axis = economic growth, net of GDP/c_{1960} effect. x-axis = IQSA, net of GDP/c_{1960} effect

($p < 0.10$). Psychometric IQ and students' IQSA have stable and large effects on growth (being exceptionally significant at $p < 0.01$), even when happiness, economic freedom, and rule of law are present in the model. Columns 4A and 6A of Tables 3 and 4 show across variables comparable standardized effects. CA ($\beta = 0.58$ and 0.46) showed the largest effect after 1960 GDP. Its effects are larger than the effects of economic freedom ($\beta = 0.28$ and 0.31) and rule of law ($\beta = 0.31$ and 0.34). GDP per capita 1960 shows a suppressor effect (i.e., $\beta > r$, $\beta = -1.08$ to -1.10). GDP is highly correlated with all other variables in the equation (see Table 2). The main implication of this effect is that wealth reduces growth and poverty increases it—the benefits of backwardness. The R^2s of Table 3 was higher than that of Table 4. Psychometric IQ appears to be a better indicator of CA than student IQSA, but country samples also differed (sample sizes for psychometric IQ were 11 countries larger; see list in Table 11). In comparison between Tables 3 and 4, the standardized effects of psychometric IQ (Table 3; models 4A and 6A; $\beta = 0.58$) were larger than that of (educational) IQSA (Table 4; models 4A and 6A;

Table 3 Regression analysis using IQ (psychometric) predicting economic growth

	Dependent variable: economic growth rate (%) 1960–2017								
	(1)	(2)	(3)	(4)	(4A)	(5)	(6)	(6A)	(7)
GDP/c_{1960}	−2.912*** ***(−9.374)	−3.209*** (−13.050)	−3.569*** (−8.914)	−3.492*** (−10.539)	−1.089*** (−10.539)	−3.392*** (−10.811)	−3.458*** (−10.182)	−1.079*** (−10.182)	−3.369*** (−11.010)
Investment rate (I/GDP)	.071*** (5.176)	.042*** (3.325)	.065*** (4.871)	.042*** (3.306)	.249*** (3.306)	.049*** (3.755)	.034** (2.500)	.201** (2.500)	.034** (2.586)
Population growth	−.599*** (−4.655)	−.281*** (−2.704)	−.486*** (−4.088)	−.258** (−2.606)	−.164** (−2.606)	−.292*** (−3.075)	−.186* (−1.758)	−.118* (−1.758)	−.172 (−1.588)
Economic freedom	.759*** (4.389)	.485*** (3.574)	.568*** (3.263)	.421*** (3.308)	.283*** (3.308)	.445*** (3.503)			
Rule of law							.411*** (2.689)	.309*** (2.689)	.787*** (4.966)
OPEC membership	.571 (1.605)	.526* (1.817)	.612* (1.819)	.550* (1.885)	.103* (1.885)	.355 (1.181)	.651** (2.235)	.122** (2.235)	.680*** (2.745)
IQ (psychometric)		.075*** (6.837)		.068*** (5.910)	.579*** (5.910)	.165*** (4.995)	.067*** (5.741)	.575*** (5.741)	.244*** (6.768)
Happiness			.524*** (3.472)	.248* (1.738)	.205* (1.738)	.194*** (3.469)	.292* (1.811)	.240* (1.811)	3.324*** (5.536)
Interaction CA × Happiness						−.020*** (−3.093)			−.037*** (−5.100)
N	94	94	94	94	94	94	94	94	94
Adj. R^2	.619	.752	.663	.759	.759	.779	.754	.754	.813

Main entries are unstandardized regression coefficients estimated using White–Hinkley heteroskedasticity correction. Models labeled as ‘A’ present standardized estimates. Robust t-statistics are in parentheses. Constant terms are not shown. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

Table 4 Regression analysis using IQSA (student achievement) predicting economic growth

	Dependent variable: economic growth rate (%) 1960–2017								
	(1)	(2)	(3)	(4)	(4A)	(5)	(6)	(6A)	(7)
GDP/c_{1960}	−2.737***	−3.007***	−3.291***	−3.335***	−1.081***	−3.147***	−3.395***	−1.101***	−3.266***
	(−8.181)	(−9.346)	(−8.116)	(−8.549)	(−8.549)	(−8.292)	(−8.110)	(−8.110)	(−8.594)
Investment rate (I/GDP)	.053***	.035**	.050***	.035**	.202**	.044***	.027*	.154*	.026*
	(3.463)	(2.444)	(3.282)	(2.375)	(2.375)	(2.804)	(1.794)	(1.794)	(1.769)
Population growth	−.646***	−.370***	−.552***	−.340***	−.229***	−.381***	−.261**	−.176**	−.225*
	(−4.671)	(−3.409)	(−4.309)	(−3.333)	(−3.333)	(−3.850)	(−2.405)	(−2.405)	(−1.774)
Economic freedom	.768***	.519***	.616***	.449***	.310***	.510***			
	(4.640)	(3.162)	(3.300)	(2.650)	(2.650)	(3.342)			
Rule of law							.435**	.337**	.990***
							(2.306)	(2.306)	(5.421)
OPEC membership	.821*	.871**	.924*	.932**	.179**	.579	1.076**	.207**	.984**
	(1.807)	(2.366)	(1.904)	(2.310)	(2.310)	(1.294)	(2.615)	(2.615)	(2.615)
IQSA (student achievement)		.707***		.628***	.462***	2.263***	.626***	.460***	3.396***
		(3.879)		(3.380)	(3.380)	(4.184)	(3.305)	(3.305)	(6.021)
Happiness			.411***	.266*	.231*	1.685***	.338**	.295**	2.851***
			(2.686)	(1.735)	(1.735)	(3.714)	(2.183)	(2.183)	(6.459)
Interaction						−.318***			−.568***
CA × Happiness						(−3.337)			(−5.646)
N	83	83	83	83	83	83	83	83	83
Adj. R^2	.584	.653	.611	.661	.661	.706	.654	.654	.766

Main entries are unstandardized regression coefficients estimated using White–Hinkley heteroskedasticity correction. Models labeled as ‘A’ present standardized estimates. Robust *t*-statistics are in parentheses. Constant terms are not shown. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

$\beta = 0.46$). To test this, this study performed additional regression analyses based on the corresponding models 4A and 6A, including only countries ($N = 76$) for which both IQ and IQSA data were available. In our calculations, not shown in the table, it was again found that the standardized coefficients and adjusted R^2 were larger for psychometric IQ ($\beta = 0.56$ to 0.57; $R^2 = 0.75$ to 0.76) than for IQSA ($\beta = 0.40$ to 0.41; $R^2 = 0.69$ to 0.71). The results are consistent with the relationships between CA and economic growth presented in Figs. 1, 2. Moreover, Models 5 and 7 of Tables 3 and 4 show that the interaction term has a strong negative impact ($p < 0.01$) on growth. In addition, economic freedom and rule of law was consistently significant for economic growth, indicating that enhanced quality of institution is essential for long-run economic growth. The OPEC membership dummy was significantly positive in several models, providing evidence that oil-exporting countries, despite their relatively lower levels of human capital, had outperformed due to their resource wealth (see Barro 1991; Jones and Schneider 2010).

Table 5 presents the results of the economic growth analysis using IV for happiness. The preliminary analyses for IV estimations are presented in Appendix A as Tables 9, 10. Although happiness showed high correlation with social support (instrument), the correlations between social support and the error terms of the explanatory equation (i.e., the growth regression conditional on the other covariate) were not significant even at the $p < 0.20$ level (Table 9). Thus, these results show that the presence of instruments does not violate the *exclusion restriction* condition. Controlling for other exogenous growth factors, the social support had significantly predicted happiness with high *F*-statistic values (Table 10). Therefore, the instrument was relevant in addressing the potential problem of endogeneity or reverse causality. As shown in Table 5, the effect of happiness (IV) was positively significant in several models. The psychometric IQ was stronger ($p < 0.01$) than IQSA in predicting growth. Besides, the highly significant interaction terms, which were negative ($p < 0.01$), corroborated that the impact of cognitive capitals on economic growth had decreased at a higher level of happiness.

In addition, the effect of cognitive human capital on economic growth was estimated using the threshold regression method. Because the number of countries is small, the number of happiness thresholds was set to two in the first instance, yielding up to three different levels of cognitive ability effects on growth. Threshold regressions were run with a trim percentage of 10%, and the happiness threshold was determined with a confidence level of $p < 0.05$. This procedure has generated four threshold regressions with different combinations of exogenous *Growth* predictors (i.e., IQ, IQSA, economic freedom and rule of law). The results presented in Table 6 show the identified threshold for happiness (scale of 1–10). The direct effect of happiness was only significant in Model 1, but only at 10% significance level. All regressions had produced one threshold only. The results are mixed. Model 1 presents that the happiness threshold is $\gamma = 6.37$, where the effects of IQ were significant at 1% level for high and low happiness levels, although the coefficient declined significantly in happier countries ($\beta = 0.060 \rightarrow 0.052$). Model 2 shows that the IQ-economic growth relationship was moderately significant ($\beta = 0.034$; $p < 0.05$) when happiness is lower than $\gamma = 4.96$, while according to Models 3 and 4, IQSA was non-significant ($p > 0.10$) when happiness is lower than $\gamma = 4.75$ or 4.79. Thus, for Models 2 to 4, the positive impacts of CA were the strongest for IQ ($\beta = 0.049$; $p < 0.01$) and IQSA ($\beta = 0.51$–0.60; $p < 0.01$)

Table 5 Controlling for endogeneity using instrumental variable (IV)

	Dependent variable: economic growth rate (%) 1960–2017											
	(1)	(1A)	(2)	(3)	(3A)	(4)	(5)	(5A)	(6)	(7)	(7A)	(8)
GDP/c_{1960}	− 3.958*** (− 7.240)	− 1.235*** (− 7.240)	− 3.650*** (− 7.847)	−4.056*** (− 7.880)	− 1.265*** (− 7.880)	− 3.618*** *(− 9.149)	− 3.809*** (− 6.942)	− 1.235*** (− 6.942)	− 3.250*** (− 5.697)	− 3.937*** (− 7.181)	− 1.277*** (− 7.181)	− 3.294*** (− 6.257)
Investment rate (I/GDP)	.042*** (3.394)	.248*** (3.394)	.047*** (3.792)	.035** (2.590)	.208** (2.590)	.032** (2.363)	.035** (2.563)	.201** (2.563)	.042*** (2.907)	.027* (1.902)	.154* (1.902)	.025* (1.699)
Population growth	− .220* (− 1.939)	− .140* (− 1.939)	− .308*** (− 2.909)	− .154 (− 1.385)	− .098 (− 1.385)	− .225** (− 2.126)	− .298** (− 2.380)	− .200** (− 2.380)	− .425*** (− 3.597)	− .221* (− 1.712)	− .148* (− 1.712)	− .321** (− 2.527)
Economic freedom	.315** (2.109)	.212** (2.109)	.434*** (2.909)				.347* (1.865)	.240* (1.865)	.545*** (3.174)			
Rule of law				.315** (2.066)	.236** (2.066)	.702*** (4.297)				.388** (2.056)	.301** (2.056)	.875*** (4.878)
OPEC membership	.589* (1.959)	.110* (1.959)	.444 (1.436)	.704** (2.373)	.132** (2.373)	.746** (2.854)	1.020** (2.613)	.196** (2.613)	.636 (1.595)	1.209*** (3.101)	.232*** (3.101)	.991*** (3.200)
IQ (psychometric)	.056*** (3.618)	.477*** (3.618)	.164*** (4.334)	.052*** (3.477)	.445*** (3.477)	.224*** (5.742)						
IQSA (student achievement)							.514** (2.403)	.378** (2.403)	2.428*** (3.382)	.478** (2.198)	.351** (2.198)	3.175*** (4.078)
Happiness (IV)	.658* (1.724)	.492* (1.724)	2.100*** (3.555)	.780** (2.308)	.584** (2.308)	3.164*** (6.067)	.650* (1.824)	.518* (1.824)	1.835*** (3.347)	.744** (2.367)	.592** (2.367)	2.535*** (4.643)
Interaction CA × Happiness			− .020*** (− 3.077)			− .033*** (− 5.025)			− .349*** (− 3.040)			− .509*** (− 4.107)
N	94	94	94	94	94	94	83	83	83	83	83	83
Adj. R^2	.761	.761	.783	.760	.760	.809	.668	.668	.719	.663	.663	.751

Main entries are unstandardized regression coefficients estimated using White–Hinkley heteroskedasticity correction. Models labeled as 'A' present standardized estimates. Robust t-statistics are in parentheses. Constant terms are not shown. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

Table 6 Discrete threshold regression analysis predicting the economic growth

	Dependent variable: economic growth rate (%) 1960–2017							
	(1)		(2)		(3)		(4)	
Happiness (IV) threshold estimate, γ	IQ (psychometric)		IQ (psychometric)		IQSA (student achievement)		IQSA (student achievement)	
	$\gamma = 6.366$		$\gamma = 4.958$		$\gamma = 4.745$		$\gamma = 4.785$	
Happiness (IV) regime	Happiness (IV) < 6.366	Happiness (IV) ≥ 6.366	Happiness (IV) < 4.958	Happiness (IV) ≥ 4.958	Happiness (IV) < 4.745	Happiness (IV) ≥ 4.745	Happiness (IV) < 4.785	Happiness (IV) ≥ 4.785
Cognitive ability (CA)	.060*** (3.930)	.052*** (3.452)	.034** (2.328)	.049*** (3.413)	.225 (1.146)	.603*** (3.239)	.088 (.437)	.512*** (2.746)
GDP/c_{1960}	−3.684*** (−6.937)		−3.883*** (−6.939)		−3.703*** (−8.395)		−3.795*** (−9.260)	
Investment rate (I/GDP)	.041*** (3.086)		.027** (2.229)		.042*** (3.397)		.030** (2.508)	
Population growth	−.317*** (−2.861)		−.096 (−.849)		−.317*** (−2.805)		−.207* (−1.753)	
Economic freedom	.402*** (2.685)				.230 (1.536)			
Rule of law			.556*** (3.621)				.457*** (3.134)	
OPEC membership	.487 (1.544)		.738** (2.195)		.464 (1.297)		.705** (2.091)	
Happiness (IV)	.654* (1.815)		.250 (.598)		.230 (.681)		.206 (.698)	
No. of countries, N	68	26	29	65	17	66	18	65
Adj. R^2	.781		.805		.745		.767	

Threshold estimates are significant at 5% level. Main entries are unstandardized coefficients estimated using White–Hinkley heteroskedasticity correction. Robust *t*-statistics are in parentheses and calculated with 10% trimming percentage. Constant terms are not shown. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

after the happiness exceeded these thresholds $\gamma=4.75$ to 4.96. The R^2 of the threshold regressions were estimated higher compared to OLS (Table 5), suggesting that the overall effect of the independent variables on economic growth was improved by the discrete threshold regression. Moreover, an interesting finding is that IQ was a better growth predictor compared to IQSA, since IQ works significantly in both very happy and very unhappy conditions demonstrated in Table 6.

Following Barro (1991), the robustness of the direct effects of economic growth predictors was determined by weighting countries by their respective population sizes. Each country (row) was multiplied by the square root of its total population. The reason for this correction is that small or less populous countries tend to be more atypical, that is, in terms of the well-being of citizens compared to large populations. For this analysis, annual total population data (World Bank 2020) were averaged for the period 1960–2017. Results presented in Table 7 are based on the similar Models 1–4 of Table 6. After the regressions were weighted by population size, the threshold values become slightly different for IQ (Models 1 and 2: $\gamma=6.37$ and 6.16) and IQSA (Models 3 and 4: $\gamma=4.79$, 6.36 and 6.38. Although Model 4 produced two significant happiness thresholds, the pattern of CA-economic growth relationships are almost the same with other models in Tables 6 and 7). Standardized estimates for Tables 6 and 7 are presented in Appendix A as Tables 12, 13. Altogether, summing up the finding from Tables 6 and 7, it can be established that there were two obvious ranges of high and low thresholds for happiness, specifically $\gamma_1=4.75$ to 4.96 and $\gamma_2=6.16$ to 6.38. It was observed that the growth effects of cognitive capital were the largest and highly significant ($p<0.01$) when countries are in the states of happiness of between these two thresholds (γ_1–γ_2), with the largest *t*-statistics. The CA-economic growth relationships were moderately large for countries with happiness greater than γ_2, and the smallest (or weakest) effects of CA were found in countries with happiness below the thresholds of γ_1.

Further robustness checks were conducted using different trimming percentages of 5%, 15%, 20%, and 25%, which are summarized in Table 8. There is an additionally different threshold of $\gamma=6.43$ for IQSA especially the regression with 25% trimming percentage. Therefore, altogether, this study consistently corroborated that low- and high-happiness thresholds stretch within the ranges of $\gamma_1=4.75$ to 4.96 and $\gamma_2=6.16$ to 6.43, respectively. Importantly, the results presented in Table 8 exhibit the similar pattern of CA-*Growth* relationship as in Tables 6 and 7.

5 Discussion

This study examined the role of happiness in regulating the impact of human capital, particularly cognitive human capital, on economic growth at a cross-country level. It is well established in the literature that happiness acts as an intrinsic motivator and positive psychological state that causes workers to be more engaged in their jobs and organizations, and inspires them to fully realize their human capital potential to achieve higher

Table 7 Discrete threshold regression weighted by the country's population size

	Dependent variable: economic growth rate (%) 1960–2017								
	(1)		(2)		(3)		(4)		
Happiness (IV) threshold estimate, γ	IQ (psychometric)		IQ (psychometric)		IQSA (student achievement)		IQSA (student achievement)		
	$\gamma = 6.366$		$\gamma = 6.161$		$\gamma = 6.362$		$\gamma_1 = 4.785$, $\gamma_2 = 6.379$		
Happiness (IV) regime	Happiness (IV) < 6.366	Happiness (IV) ≥ 6.366	Happiness (IV) < 6.161	Happiness (IV) ≥ 6.161	Happiness (IV) < 6.362	Happiness (IV) ≥ 6.362	Happiness (IV) < 4.785	4.785 ≤ Happiness (IV) < 6.379	Happiness (IV) ≥ 6.379
Cognitive ability (CA)	.068*** (4.933)	.057*** (4.134)	.063*** (4.932)	.049*** (3.709)	.994*** (3.761)	.694** (2.613)	.509** (2.226)	.775*** (3.595)	.521** (2.229)
GDP/c_{1960}	−2.914*** (−6.325)		−2.985*** (−7.489)		−3.016*** (−5.551)		−2.956*** (−6.519)		
Investment rate (I/GDP)	.029* (1.673)		.012 (.611)		.028 (1.223)		.027 (1.439)		
Population growth	−.464*** (−3.063)		−.316* (−1.862)		−.592*** (−3.112)		−.459** (−2.646)		
Economic freedom	.481*** (3.238)				.448*** (2.788)				
Rule of law			.738*** (4.066)				.711*** (4.586)		
OPEC membership	.472** (2.174)		.797*** (3.876)		.478** (2.238)		.498* (1.960)		
Happiness (IV)	.243 (.833)		.430* (1.874)		.284 (.852)		−.063 (−.180)		
No. of countries, *N*	68	26	64	30	58	25	18	41	24
Adj. R^2	.835		.852		.826		.873		

Threshold estimates are significant at 5% level. Main entries are unstandardized coefficients estimated using White–Hinkley heteroskedasticity correction. Regressions were weighted by the square-root of total population of relevant countries. Robust *t*-statistics are in parentheses and calculated with 10% trimming percentage. Constant terms are not shown. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

Table 8 Further robustness checks using different trimming percentages

			Dependent variable: economic growth rate (%) 1960–2017							
			Method: discrete threshold regression				Method: discrete threshold regression weighted by the square-root of total population			
Control variables include economic freedom			IQ (psychometric)				IQ (psychometric)			
	Trimming percentage		5%	15%	20%	25%	5%	15%	20%	25%
	Threshold estimate, γ		6.366	6.366	6.366	6.366	6.366	6.366	6.366	6.366
	Cognitive ability (CA)									
		Happiness (IV) < γ	.060***	.060***	.060***	.060***	.068***	.068***	.068***	.068***
		Happiness (IV) ≥ γ	.052***	.052***	.052***	.052***	.057***	.057***	.057***	.057***
	No. of countries, $N=94$									
		Low happiness	68	68	68	68	68	68	68	68
		High happiness	26	26	26	26	26	26	26	26
			IQSA (student achievement)				IQSA (student achievement)			
	Trimming percentage		5%	15%	20%	25%	5%	15%	20%	25%
	Threshold estimate, γ		4.745	4.745	4.745	6.362	6.362	6.362	6.362	6.362
	Cognitive ability (CA)									
		Happiness (IV) < γ	.223	.223	.223	.657***	.994***	.994***	.994***	.080***
		Happiness (IV) ≥ γ	.603***	.603***	.603***	.452**	.694**	.694**	.694**	.069***
	No. of countries, $N=83$									
		Low happiness	17	17	17	58	58	58	58	58
		High happiness	66	66	66	25	25	25	25	25

Table 8 (continued)

			Dependent variable: economic growth rate (%) 1960–2017							
			Method: discrete threshold regression				Method: discrete threshold regression weighted by the square-root of total population			
Control variables include the rule of law			IQ (psychometric)				IQ (psychometric)			
	Trimming percentage		5%	15%	20%	25%	5%	15%	20%	25%
	Threshold estimate, γ		4.958	4.958	4.958	4.958	6.161	6.161	6.161	6.161
	Cognitive ability (CA)									
		Happiness (IV) $<\gamma$	.034**	.034**	.034**	.034**	.063***	.063***	.063***	.063***
		Happiness (IV) $\geq\gamma$	.049***	.049***	.049***	.049***	.049***	.049***	.049***	.049***
	No. of countries, $N=94$									
		Low happiness	29	29	29	29	64	64	64	64
		High happiness	65	65	65	65	30	30	30	30
			IQSA (student achievement)				IQSA (student achievement)			
	Trimming percentage		5%	15%	20%	25%	5%	15%	20%	25%
	Threshold estimate, γ		4.785	4.785	4.785	6.429	$\gamma_1=4.785$ $\gamma_2=6.379$	$\gamma_1=4.785$ $\gamma_2=6.379$	$\gamma_1=4.785$ $\gamma_2=6.379$	6.379
	Cognitive ability (CA)									
		Happiness (IV) $<\gamma_1$	.088	.088	.088	.474**	.509**	.509**	.509**	.829***
		$\gamma_1\leq$ Happiness (IV) $<\gamma_2$	–	–	–	–	.775***	.775***	.775***	–

Table 8 (continued)

		Dependent variable: economic growth rate (%) 1960–2017							
		Method: discrete threshold regression				Method: discrete threshold regression weighted by the square-root of total population			
	Happiness (IV) ≥ γ_2	.512***	.512***	.512***	.196	.521**	.521**	.521**	.482*
No. of countries, $N = 83$									
	Low happiness	18	18	18	61	18	18	18	59
	Medium happiness	–	–	–	–	41	41	41	–
	High happiness	65	65	65	22	24	24	24	24

Regressions estimated using White–Hinkley heteroskedasticity correction. Threshold estimates are significant at 5% level. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

productivity. This idea suggests that in societies with higher happiness levels, cognitive ability may have a greater impact on economic growth than in less happy societies.

Regression analyses were performed with cognitive ability (CA as measured by psychometric IQ tests or student achievement tests) and instrumental variable (IV) estimates for happiness to determine their effect for growth in the presence of their interaction effect (CA x happiness). However, the empirical results contradicted the previous hypothesis, as the regressions contained significantly negative interaction terms. These results were supported by the results of threshold regression of five different trimming percentages. Two ranges of happiness threshold were identified: $\gamma_1=4.75–4.96$ and $\gamma_2=6.16–6.43$ based on wellbeing scale of 1 to 10. Accordingly, CA requires a sufficient level of happiness ($\geq\gamma_1$) for it to function optimally on generating economic growth. The effects of CA toward growth are the strongest among societies of medium level of happiness (i.e., between γ_1 and γ_2) and significantly weaker at higher levels of happiness ($\geq\gamma_2$). These findings were corroborated by the population size-weighted threshold regressions that served as robustness tests to determine the significance of CA effects and happiness thresholds. Again, it can be summarized that IQ was a stronger growth predictor compared to IQSA. IQ rather than IQSA functions more significantly in both very happy and very unhappy environments.

Countries at all levels of economic development were equally represented in this study. Interestingly, the psychometric IQ and student achievement datasets overlap for only 76 countries, leaving no overlapping single analyses for 25 countries (Appendix: Table 11). Because the two datasets differed in their populations or sample characteristics, the conclusions about the happiness threshold and the interaction between CA and happiness are stronger. Throughout the regression analyses, the standardized effect of IQ was consistently larger than that of IQSA on economic growth. This at least underlines the quality of the IQ data. Uncorrected student assessment data may be biased due to national differences in enrollment rates, student ages, and sampling methods (Rindermann 2018). The highly significant cognitive ability x happiness interactions proved that happiness plays a significant role in regulating the effects of cognitive ability on growth. However, cognitive ability has stronger direct effects than happiness. This is because economics primarily requires cognitive ability, while positive affectivity or intrinsic motivation (as indicated by happiness) acts as an additional promoter of productivity growth.

The Savanna-IQ Interaction Hypothesis postulates that highly intelligent people are more resourceful than less intelligent individuals in understanding and coping with evolutionarily novel situations that did not exist in their ancestral environment. Early humans relied on athletic and motoric skills and simple cognitive abilities and survived by foraging, fishing, hunting, and gathering. In contrast, in modern societies, a high level of cognitive ability, of intelligence and knowledge and its intelligent use, is essential to drive technological innovation in order to compete globally and achieve greater prosperity.

The results of this study indicated that a sufficient level of luck is required for CA to function fully in national productivity. The impact of cognitive ability on economic growth increased significantly after the countries surpassed the happiness level of $\gamma_1=4.75–4.96$ applied at the cross-country level. This corresponds to Maslow's hierarchy of needs. Therefore, considering happiness as an indicator of psychological well-being, an adequate level of happiness is crucial for societies to focus their motivation on exerting their human capital (IQ and IQSA) on productivity growth. It may be that in most African countries, societies at the bottom of the happiness rankings (see Table 1) have not had the opportunity to make optimal use of their cognitive abilities to achieve high productivity. In addition, it can be pointed out that increased happiness is not only associated with positive psychological well-being and greater motivation among workers, but also stimulates the country's economic dynamism. Along the same lines, Inglehart (2018/1990) claimed that higher levels of happiness imply improvement in social capital such as trust in people and institutions, which according to Whiteley (2000) and Shad et al. (2018) is very important for economic growth and also promotes international cooperation in financial markets. Therefore, although the direct effect of happiness on economic growth was marginally significant, a sufficient level of happiness ($\geq \gamma_1$) in the societies is crucial for CA to be exercised at full capacity to generate high productivity.

The CA effects decreased significantly after happiness levels rose above a certain threshold, i.e., $\gamma_2 = 6.16$–6.43. These results show that cognitive abilities have a stronger impact on productivity growth in societies with moderate happiness than in societies with the highest happiness. Thus, this study proves that very happy or very satisfied societies are less likely to use their full cognitive potential to generate additional productivity growth. This phenomenon is consistent with Maslow's self-actualization theory, which states that people are motivated to take action and pursue their efforts to fulfill their desires. However, once these needs are satisfied, they no longer serve as motivators for people. Subsequent satisfaction of basic needs would gradually shift the focus to non-material goals such as self-expression, autonomy, sense of belonging, and intellectual and aesthetic satisfaction (Inglehart 1977). Therefore, higher levels of satisfaction experienced in a materialistic society could reduce the pursuit of further income growth, as shown in this study, in which the effect of cognitive ability on productivity growth decreased at very high levels of happiness.

In general, people with higher cognitive abilities are more productive and successful in modern economic societies. Nonetheless, less happy or dissatisfied lives are to some extent conducive to societies making more efforts to harness their human capital potential for higher productivity. Negative emotions are functional for humans as they help them solve adaptive problems of life. For example, evolutionary psychologist David Buss (2000, p. 17) noted that while negative experiences can be distressing and reduce an individual's quality of life, they motivate actions aimed at eliminating "the interference or to avoid subsequent interfering events." This assumption is consistent with the study of Oishi et al. (2007), who confirmed that moderate levels of happiness are ideal for life goals that require analytical skills and self-improvement motivation, such as job performance and wealth accumulation. Some level of dissatisfaction is necessary to motivate people to perform better and take corrective action to achieve their life goals.

The current study outlined that the pursuit of ever-higher economic growth could be challenging and grueling for all societies for decades to come. In order to achieve the highest economic growth in the long term, the labor force must acquire new technical skills and produce technological innovations faster to become the most efficient country in its production each year. Proponents of the modern economy have always emphasized ever-increasing economic growth, with the expectation that greater material wealth would improve the quality of life and bring greater happiness to society. At the same time, modern social structures have spread motivational beliefs that lead people to make the greatest efforts in life to achieve barely attainable goals (Nesse 2004).

Nettle (2005, p. 14) had summarized that “What we are programmed for by evolution is not happiness itself, but a set of beliefs about the kinds of things that will bring happiness, and a disposition to pursue them.” Evolutionary theory has emphasized that the human brain is designed for constant striving, not for increasing happiness (e.g., Grinde 2002; Nettle 2005, p. 43). The ultimate objective is to increase the frequency of genes in a population. The human brain functions as a survival and reproductive tool, creating emotions to support behaviors that ensure the survival of human generations. In addition to the role of cognitive abilities in coping with evolutionary problems, humans have evolved psychological mechanisms to induce subjective stress or unhappiness, when necessary and helpful, to solve adaptation problems. If the corresponding needs are satisfied, however, the motivational boost provided by these systems, which would, nevertheless, be necessary for the daily struggle for long-term economic growth, fails to materialize. Learning, education, getting up early, long trips to schools and work, many hours of effort, etc. are not all fun. The regulatory system of the human brain is not evolutionarily designed to cope with enduring efforts to achieve long-term and sustained economic growth in a world of already achieved prosperity. A pursuit of happiness through ever further accumulation of wealth could lead to unhappiness, or some form of suffering or hardship is required as a push factor for societies to realize their cognitive potential during the long-term process of economic growth.

A continuous increase in economic growth requires an optimal level of happiness. A ‘satisficing’ level of happiness with a little emotional stress boosts human evolutionary behavior to fully exploit cognitive abilities and further increase productivity for decades. This approach may explain why societies with a moderate level of happiness can use more of their given cognitive potential and achieve even higher productivity than those ‘very happy’ or ‘very unhappy’ societies with similar levels of cognitive human capital. Importantly, the overall conclusions of this study indicate that achieving the greatest happiness, rather than the highest income, has always been society’s ultimate aspiration and goal.

Appendix A

See Tables 9, 10, 11, 12 and 13.

Table 9 Testing the relevance of instrument for happiness

		Correlation (r) between social support, happiness, and growth residual			
		$N=94$	$N=94$	$N=83$	$N=83$
		Social support	Social support	Social support	Social support
1	Happiness	.792***	.792***	.800***	.800***
2	Growth residual	.088 (Control variables include IQ and economic freedom)	.119 (Control variables include IQ and rule of law)	.099 (Control variables include IQSA and economic freedom)	.115 (Control variables include IQSA and rule of law)

Significance level: ***$p<.01$; **$p<.05$, *$p<.10$, $^{+}p<.20$. Growth residuals were obtained from the initial regressions that include GDP/c_{1960}, investment rate (I/GDP), population growth, institutional quality (economic freedom or rule of law), OPEC membership, cognitive ability, CA (IQ or IQSA) and happiness predicting the economic growth

Table 10 First-stage regressions predicting happiness

Social support	Dependent variable: happiness 2006–2017			
	3.120*** (4.251)	3.289*** (4.665)	3.567*** (5.137)	3.760*** (5.482)
Included control variable	IQ, economic freedom, and all other exogenous control variables	IQ, rule of law, and all other exogenous control variables	IQSA, economic freedom, and all other exogenous control variables	IQSA, rule of law, and all other exogenous control variables
N	94	94	83	83
Adj. R^2	.810	.809	.824	.820
F-statistic	57.590***	57.380***	55.693***	54.260***

Main entries are unstandardized coefficients. Values in parentheses are *t*-statistics. Exogenous control variables are GDP/c_{1960}, investment rate (I/GDP), population growth, institutional quality (economic freedom or rule of law), OPEC membership, and cognitive ability, CA (IQ or IQSA). Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

Table 11 List of countries included in the analysis

List of countries ($N = 101$)					
Algeria	Congo (Dem. Rep.)	Guatemala	Madagascar**	Norway	Switzerland
Argentina	Congo (Rep.)**	Guinea**	Malawi**	Pakistan**	Syria
Australia	Costa Rica	Honduras**	Malaysia	Panama	Taiwan**
Austria	Cyprus	Hong Kong	Mali	Paraguay	Tanzania
Bangladesh**	Denmark	Iceland	Malta	Peru	Thailand
Belgium	Dominican Republic	India	Mauritania*	Philippines	Togo*
Benin*	Ecuador	Indonesia	Mauritius	Portugal	Trinidad & Tobago
Bolivia**	Egypt	Iran	Mexico	Romania	Tunisia
Botswana	El Salvador	Ireland	Morocco	Rwanda**	Turkey
Brazil	Ethiopia**	Israel	Mozambique	Senegal	Uganda
Burundi*	Finland	Italy	Namibia	Sierra Leone**	United Kingdom
Cameroon	France	Jamaica**	Nepal**	Singapore	Uruguay
Canada	Gabon*	Japan	Netherlands	South Africa	USA
Cent. African Rep.**	Gambia**	Jordan	New Zealand	South Korea	Venezuela
Chile	Germany	Kenya	Nicaragua*	Spain	Zambia
China	Ghana	Lesotho	Niger*	Sri Lanka**	Zimbabwe
Colombia	Greece	Luxembourg	Nigeria**	Sweden^{+}	

Lynn and Vanhanen's (2012) IQ and Altinok et al.'s (2014) IQSA datasets overlapped for 76 countries. Countries labeled as ** ($n = 18$) and * ($n = 7$) are present only in the IQ and IQSA datasets, respectively

Table 12 Standardized estimates for Table 6. Discrete threshold regression analysis predicting the economic growth

	Dependent variable: economic growth rate (%) 1960–2017							
	(1)		(2)		(3)		(4)	
Happiness (IV) threshold estimate, γ	IQ (psychometric)		IQ (psychometric)		IQSA (student achievement)		IQSA (student achievement)	
	$\gamma = 6.366$		$\gamma = 4.958$		$\gamma = 4.745$		$\gamma = 4.785$	
Happiness (IV) regime	Happiness (IV) < 6.366	Happiness (IV) ≥ 6.366	Happiness (IV) < 4.958	Happiness (IV) ≥ 4.958	Happiness (IV) < 4.745	Happiness (IV) ≥ 4.745	Happiness (IV) < 4.785	Happiness (IV) ≥ 4.785
Cognitive ability (CA)	1.640*** (3.930)	1.584*** (3.452)	.816** (2.328)	1.499*** (3.413)	.234 (1.146)	.947*** (3.239)	.094 (.437)	.512*** (2.746)
GDP/c_{1960}	−1.149*** (−6.937)		−1.211*** (−6.939)		−1.201*** (−8.395)		−1.230*** (−9.260)	
Investment rate (I/GDP)	.240*** (3.086)		.162** (2.229)		.240*** (3.397)		.170** (2.508)	
Population growth	−.202*** (−2.861)		−.061 (−.849)		−.213*** (−2.805)		−.139* (−1.753)	
Economic freedom	.270*** (2.685)				.159 (1.536)			
Rule of law			.417*** (3.621)				.354*** (3.134)	
OPEC membership	.091 (1.544)		.138** (2.195)		.089 (1.297)		.135** (2.091)	
Happiness (IV)	.490* (1.815)		.187 (.598)		.184 (.681)		.164 (.698)	
No. of countries, N	68	26	29	65	17	66	18	65
Adj. R^2	.781		.805		.745		.767	

Threshold estimates are significant at 5% level. Main entries are standardized coefficients estimated using White–Hinkley heteroskedasticity correction. Robust *t*-statistics are in parentheses and calculated with 10% trimming percentage. Constant terms are not shown. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

Table 13 Standardized estimates for Table 7. Discrete threshold regression weighted by the country's population size

	Dependent variable: economic growth rate (%) 1960–2017								
	(1)		(2)		(3)		(4)		
Happiness (IV) threshold estimate, γ	IQ (psychometric)		IQ (psychometric)		IQSA (student achievement)		IQSA (student achievement)		
	$\gamma = 6.366$		$\gamma = 6.161$		$\gamma = 6.362$		$\gamma_1 = 4.785$, $\gamma_2 = 6.379$		
Happiness (IV) regime	Happiness (IV) < 6.366	Happiness (IV) ≥ 6.366	Happiness (IV) < 6.161	Happiness (IV) ≥ 6.161	Happiness (IV) < 6.362	Happiness (IV) ≥ 6.362	Happiness (IV) < 4.785	4.785 ≤ Happiness (IV) < 6.379	Happiness (IV) ≥ 6.379
Cognitive ability (CA)	1.813*** (4.933)	1.791*** (4.134)	1.723*** (4.932)	1.566*** (3.709)	1.443*** (3.761)	1.319** (2.613)	.547** (2.226)	1.288*** (3.595)	.980** (2.229)
GDP/c_{1960}	−.926*** (−6.325)		−.948*** (−7.489)		−.972*** (−5.551)		−.953*** (−6.519)		
Investment rate (I/GDP)	.158* (1.673)		.064 (.611)		.139 (1.223)		.134 (1.439)		
Population growth	−.286*** (−3.063)		−.194* (−1.862)		−.377*** (−3.112)		−.292** (−2.646)		
Economic freedom	.324*** (3.238)				.304*** (2.788)				
Rule of law			.537*** (4.066)				.523*** (4.586)		
OPEC membership	.096** (2.174)		.161*** (3.876)		.094** (2.238)		.098* (1.960)		
Happiness (IV)	.180 (.833)		.316* (1.874)		.218 (.852)		−.048 (−.180)		
No. of countries, N	68	26	64	30	58	25	18	41	24
Adj. R^2	.835		.852		.826		.873		

Threshold estimates are significant at 5% level. Main entries are standardized coefficients estimated using White–Hinkley heteroskedasticity correction. Regressions were weighted by the square-root of total population of relevant countries. Robust t-statistics are in parentheses and calculated with 10% trimming percentage. Constant terms are not shown. Significance level: ***$p < .01$; **$p < .05$; *$p < .10$

Author's contribution NB developed the idea, performed the statistical analyses, and drafted the manuscript. MS helped to interpret the data and added substantial revisions to the first draft prepared by NB. HR revised the entire manuscript and added to introduction, results, and discussion. All authors discussed the results and contributed to the final manuscript.

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References

Altinok N, Diebolt C, Demeulemeester JL (2014) A new international database on education quality: 1965–2010. Appl Econ 46(11):1212–1247

Angrist N, Djankov S, Goldberg PK, Patrinos HA (2021) Measuring human capital using global learning data. Nature 592:403–408

Bai J, Perron P (2003) Critical values for multiple structural change tests. Econom J 6(1):72–78

Barro RJ (1991) Economic growth in a cross section of countries. Q J Econ 106:407–443

Barsade SG, Gibson DE (2007) Why does affect matter in organizations. Acad Manag Perspect 21(1):36–59

Bartels M (2015) Genetics of wellbeing and its components satisfaction with life, happiness, and quality of life: a review and meta-analysis of heritability studies. Behav Genet 45(2):137–156

Bellet C, De Neve JE, Ward G (2020) Does employee happiness have an impact on productivity? CEP Discussion Paper No 1655. Centre for Economic Performance, London School of Economics and Political Science (pp 1–48)

Bénabou R, Tirole J (2003) Intrinsic and extrinsic motivation. Rev Econ Stud 70(3):489–520

Böckerman P, Ilmakunnas P (2012) The job satisfaction-productivity nexus: a study using matched survey and register data. ILR Rev 65(2):244–262

Bruni L, De Rosa D, Ferri G (2019) Cooperatives and happiness. Cross-country evidence on the role of relational capital. Appl Econ 51(30):3325–3343

Burhan NAS, Razak RC, Salleh F, Tovar MEL (2017) The higher intelligence of the 'creative minority' provides the infrastructure for entrepreneurial innovation. Intelligence 65:93–106

Burhan NAS, Razak RC, Ibrahim S, Selamat MR, Rosli MR (2018) Social classes of intelligence, economic growth and technological achievement: robust regression and outlier detection. J Interdiscip Econ 30(2):148–163

Buss DM (2000) The evolution of happiness. Am Psychol 55(1):15–23

Bryson A, Forth J, Stokes L (2017) Does employees' subjective well-being affect workplace performance? Human Relat 70(8):1017–1037

Coyle ThR, Rindermann H, Hancock D (2016) Cognitive capitalism: economic freedom moderates the effects of intellectual and average classes on economic productivity. Psychol Rep 119(2):411–427

Coyle ThR, Rindermann H, Hancock DG, Freeman J (2018) Nonlinear effects of cognitive ability on economic productivity. J Individ Differ 39(1):39–47

Delaney JT, Huselid MA (1996) The impact of human resource management practices on perceptions of organizational performance. Acad Manag J 39(4):949–969
DellaVigna S, Pope D (2017) What motivates effort? Evidence and expert forecasts. Rev Econ Stud 85(2):1029–1069
DiMaria CH, Peroni C, Sarracino F (2020) Happiness matters: productivity gains from subjective well-being. J Happiness Stud 21(1):139–160
Easterlin RA (1974) Does economic growth improve the human lot? Some empirical evidence. In: David PA, Reder MW (eds) Nations and households in economic growth. Academic Press, New York, pp 89–125
Easterlin RA, McVey LA, Switek M, Sawangfa O, Zweig JS (2010) The happiness–income paradox revisited. Proc Natl Acad Sci 107(52):22463–22468
Feenstra RC, Inklaar R, Timmer MP (2015) The next generation of the Penn world table. Am Econ Rev 105:3150–3182
Frey BS (2018) Happiness and management. In: Frey BS (ed) Economics of happiness. Springer, Cham, pp 55–58
Gneezy U, Rustichini A (2000) Pay enough or don't pay at all. Q J Econ 115(3):791–810
Goldstein K (1947) Human nature in the light of psychopathology. Harvard University Press, Cambridge, MA
Gottfredson LS (2007) Innovation, fatal accidents, and the evolution of general intelligence. In: Roberts MJ (ed) Integrating the mind: domain general versus domain specific processes in higher cognition. Psychology Press, Hove, UK, pp 387–425
Gottfredson LS (2018) *g* theory: how recurring variation in human intelligence and the complexity of everyday tasks create social structure and the democratic dilemma. In: Sternberg RJ (ed) The nature of human intelligence. Cambridge University Press, New York, pp 130–151
Grinblatt M, Ikäheimo S, Keloharju M, Knüpfer S (2015) IQ and mutual fund choice. Manag Sci 62:924–944
Grinde B (2002) Happiness in the perspective of evolutionary psychology. J Happiness Stud 3(4):331–354
Gwartney JD, Lawson RA, Hall JC, Murphy RH (2020) Economic freedom of the world: 2020 annual report. Vancouver, BC: The Fraser Institute
Haggard S, Tiede L (2011) The rule of law and economic growth: where are we? World Dev 39(5):673–685
Hanushek EA, Woessmann L (2011) The economics of international differences in educational achievement. In: Hanushek EA, Machin S, Woessmann L (eds) Handbook of the economics of education, vol III. Elsevier, Amsterdam, pp 89–200
Hanushek EA, Woessmann L (2015) The knowledge capital of nations. Education and the economics of growth. MIT Press, Cambridge, MA
Hart M (2007) Understanding human history. An analysis including the effects of geography and differential evolution. Washington Summit, Athens
Harter JK, Schmidt FL, Asplund JW, Killham EA, Agrawal S (2010) Causal impact of employee work perceptions on the bottom line of organizations. Perspect Psychol Sci 5(4):378–389
Hayek FA (2011/1960) The constitution of liberty. Chicago: University of Chicago Press
Helliwell J, Layard R, Sachs J, De Neve JE (2020) World happiness report 2020. Sustainable Development Solutions Network, New York
Hori M, Kamo Y (2018) Gender differences in happiness: the effects of marriage, social roles, and social support in East Asia. Appl Res Qual Life 13(4):839–857
Hosie P, Willemyns M, Sevastos P (2012) The impact of happiness on managers' contextual and task performance. Asia Pac J Human Resour 50:268–287
Inglehart R (1977) The silent revolution: changing values and political styles among western publics. Princeton University Press, Princeton, New Jersey
Inglehart R (2018) Culture shift in advanced industrial society. Princeton University Press, Princeton
Jebb AT, Tay L, Diener E, Oishi S (2018) Happiness, income satiation and turning points around the world. Nat Hum Behav 2:33–38
Johnson S, Robertson I, Cooper CL (2018) Well-being and employee engagement. In: Johnson S, Robertson I, Cooper CL (eds) WELL-BEING. Palgrave Macmillan, Cham, pp 31–42
Jones G (2012) Cognitive skill and technology diffusion: an empirical test. Econ Syst 36(3):444–460
Jones G (2016) Hive mind: how your nation's IQ matters so much more than your own. Stanford University Press, Stanford
Jones GR, George JM, Hill CW (2000) Contemporary management. Irwin/McGraw-Hill, Boston, MA
Jones G, Schneider WJ (2006) Intelligence, human capital, and economic growth: A Bayesian averaging of classical estimates (BACE) approach. J Econ Growth 11(1):71–93

Jones G, Schneider WJ (2010) IQ in the production function: evidence from immigrant earnings. Econ Inq 48:743–755
Kahneman D, Deaton A (2010) High income improves evaluation of life but not emotional well-being. Proc Natl Acad Sci 107:16489–16493
Kanazawa S (2004) The Savanna principle. Manag Decis Econ 25(1):41–54
Kanazawa S, Li NP (2018) The Savanna theory of happiness. In: Hopcroft RL (ed) Oxford handbook of evolution, biology, and society. Oxford University Press, Oxford, pp 171–194
Kaufman SB, Reynolds MR, Liu X, Kaufman AS, McGrew KS (2012) Are cognitive *g* and academic achievement *g* one and the same *g*? An exploration on the Woodcock-Johnson and Kaufman tests. Intelligence 40(2):123–138
Koys DJ (2001) The effects of employee satisfaction, organizational citizenship behavior, turnover, and organizational effectiveness: a unit-level, longitudinal study. Pers Psychol 54(1):101–114
Krekel C, Ward G, De Neve JE (2019) Employee well-being, productivity, and firm performance: evidence and case studies. In: The Global Council for Happiness and Wellbeing (Ed.), Global happiness and wellbeing policy report 2019. Global Council for Happiness and Wellbeing. (pp 73–94)
Lee RB, Daly R (eds) (1999) The Cambridge encyclopedia of hunters and gatherers. Cambridge University Press, Cambridge
Li NP, Kanazawa S (2016) Country roads, take me home… to my friends: how intelligence, population density, and friendship affect modern happiness. Br J Psychol 107(4):675–697
Lim SS, Updike RL, Kaldjian AS, Barber RM, Cowling K, York H, Friedman J, Xu R, Whisnant JL, Taylor HJ, Leever AT (2018) Measuring human capital: a systematic analysis of 195 countries and territories, 1990–2016. Lancet 392:1217–1234
Lucas RE (1988) On the mechanics of economic development. J Monet Econ 22:3–42
Lynn R, Becker D (2019) The intelligence of nations. Ulster Institute for Social Research, London
Lynn R, Vanhanen T (2012) Intelligence: a unifying construct for the social sciences. Ulster Institute for Social Research, London
Mankiw NG, Romer D, Weil DN (1992) A contribution to the empirics of economic growth. Q J Econ 107(2):407–437
Maslow AH (1970) Motivation and personality, 2nd edn. Harper & Row, New York
McMahon F (2014) Economic freedom (Fraser Institute and Heritage Foundation). In: Michalos AC (ed) Encyclopedia of quality of life and well-being research. Springer, Netherlands, Dordrecht, pp 1795–1799
Meisenberg G, Lawless E, Lambert E, Newton A (2006) The social ecology of intelligence on a Caribbean island. Mank Q 46:395–433
Milks A, Parker D, Pope M (2019) External ballistics of Pleistocene hand-thrown spears: experimental performance data and implications for human evolution. Sci Rep 9(1):1–11
Mincer J (1958) Investment in human capital and personal income distribution. J Polit Econ 66:281–302
Minkov M, Bond MH (2017) A genetic component to national differences in happiness. J Happiness Stud 18(2):321–340
Murphy RH (2016) A comment on "measuring economic freedom: a comparison of two major sources." J Priv Enterp 31(3):69–91
Murray Ch (2003) Human accomplishment: the pursuit of excellence in the arts and sciences, 800 B.C. to 1950. Harper-Collins, New York
Myers DG, Diener E (2018) The scientific pursuit of happiness. Perspect Psychol Sci 13(2):218–225
Nesse RM (2004) Natural selection and the elusiveness of happiness. Philos Trans Royal Soc Lond Series B Biol Sci 359(1449):1333–1347
Nettle D (2005) Happiness: the science behind your smile. Oxford University Press, New York
Nyborg H, Jensen AR (2001) Occupation and income related to psychometric g. Intelligence 29(1):45–55
Oishi S, Diener E, Lucas RE (2007) The optimum level of well-being: can people be too happy? Perspect Psychol Sci 2(4):346–360
Oswald AJ (1997) Happiness and economic performance. Econ J 107(445):1815–1831
Oswald A, Proto E, Sgroi D (2015) Happiness and productivity. J Law Econ 33(4):789–822
Piekałkiewicz M (2017) Why do economists study happiness? Econ Labour Relat Rev 28(3):361–377
Proto E, Oswald AJ (2017) National happiness and genetic distance: a cautious exploration. Econ J 127(604):2127–2152
Rindermann H (2018) Cognitive capitalism: human capital and the wellbeing of nations. Cambridge University Press, Cambridge

Rindermann H, Baumeister AEE (2015) Validating the interpretations of PISA and TIMSS tasks: a rating study. Int J Test 15(1):1–22
Rindermann H, Becker D (2018) FLynn-effect and economic growth: do national increases in intelligence lead to increases in GDP? Intelligence 69:87–93
Rindermann H, Carl N (2018) Human rights: why countries differ. Comp Sociol 17:29–69
Rindermann H, Carl N (2020) The good country index, cognitive ability and culture. Comp Sociol 19:39–68
Rodrik D, Subramanian A, Trebbi F (2004) Institutions rule: the primacy of institutions over geography and integration in economic development. J Econ Growth 9(2):131–165
Romer PM (1990) Endogenous technological change. J Polit Econ 98(5):S71–S102
Ryan RM, Deci EL (2000) Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol 55(1):68–78
Sabri MF, Dass TM, Burhan NAS, Abdul Wahab HAR, Wijekoon R, Simanjuntak M (2021) Determinants of life satisfaction among female-headed households in Malaysia. Int J Bus Soc 22(1):276–295
Salgado JF, Anderson N, Moscoso S, Bertua C, De Fruyt F, Rolland JP (2003) A meta-analytic study of general mental ability validity for different occupations in the European Community. J Appl Psychol 88:1068–1081
Shad M, Ibrahim S, Azman-Saini WNW, Baharumshah AZ, Burhan NAS (2018) The impact of social capital on international financial integration. Int J Econ Manag 12(S2):583–597
Schmidt FL (2012) Cognitive tests used in selection can have content validity as well as criterion validity. Int J Sel Assess 20:1–13
Schultz D (1977) Growth psychology: models of the healthy personality. Van Nostrand, New York
Shuck B, Reio TG (2014) Employee engagement and well-being a moderation model and implications for practice. J Leadersh Organ Stud 21(1):43–58
Stock JH, Watson MW (2020) Introduction to econometrics, 4th edn. Pearson Education Limited, Harlow
Veenhoven R (2014) Happiness levels stability. In: Michalos AC (ed) Encyclopedia of quality of life and well-being research. Springer, Netherlands, Dordrecht, pp 2667–2669
Weede E (2004) Does human capital strongly affect economic growth rates? Yes, but only if assessed properly. Comp Sociol 3(2):115–134
Weede E, Kämpf S (2002) The impact of intelligence and institutional improvements on economic growth. Kyklos 55:361–380
Whiteley PF (2000) Economic growth and social capital. Political Studies 48:443–466
World Bank (2020) World Development Indicators 2020. Accessed from: World Bank. http://data.worldbank.org/products/wdi
World Bank (2021) Worldwide Governance Indicators. Accessed from: World Bank. https://databank.worldbank.org/source/worldwide-governance-indicators
Wright TA, Cropanzano R (2004) The role of psychological well-being in job performance: a fresh look at an age-old quest. Organ Dyn 33(4):338–351