Relevance of education and intelligence at the national level for the economic welfare of people

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Received 7 March 2006; received in revised form 12 February 2007; accepted 12 February 2007
Available online 27 April 2007

Abstract

Cognitive abilities are important for the economic and non-economic success of individuals and societies. For international analyses, the collection of IQ-measures from Lynn and Vanhanen was supplemented and meliorated by data from international student assessment studies (IEA-Reading, TIMSS, PISA, PIRLS). The cognitive level of a nation is highly correlated with its educational level ($r = .78$, $N = 173$). In international comparisons, it also shows a high correlation with gross domestic product (GDP, $r = .63$, $N = 185$). However, in cross-sectional studies, the causal relationship between intelligence and national wealth is difficult to determine. In longitudinal analyses with various samples of nations, education and cognitive abilities appear to be more important as developmental factors for GDP than economic freedom. Education and intelligence are also more relevant to economic welfare than vice versa, but at the national level the influence of economic wealth on cognitive development is still substantial.

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Keywords: Education; Intelligence; Economic growth; International cognitive ability comparisons; Modernity

1. The relevance of cognitive abilities at the individual and national level

Thinking ability, knowledge and the intelligent use of knowledge are considered to be important determinants of life success. The correlates of intelligence at the individual level include aspects of civil life such as employment status, income, life expectancy, moral development, behavior complying with legal standards, married life and beneficial education of children (Armor, 2003; Gottfredson & Deary, 2004; Herrnstein & Murray, 1994; Murray, 1998; Piaget, 1932; Schmidt & Hunter, 1998; Whalley & Deary, 2001). Education shows similar positive effects (Barnett, 1998), even lowering the risk of HIV infection (Sanderson, 2004; UNESCO, 2004).

Throughout the past century education has been viewed as an important determinant of the cultural, political and social success of nations and of cultural and religious groups (macro-social level; e.g. Weber, 1988/1920). At least since OECD studies about student cognitive competences like PISA and the international collection of intelligence test results by Lynn and Vanhanen (2002, 2006) cognitive abilities are considered to be positive determinants of national wealth. The basic assumption of international ability comparisons is that at the macro-social level cognitive abilities are...
important causal factors for economic welfare (measured as gross domestic product, GDP) and perhaps also for non-economic welfare (democracy, rule of law, human rights, health).

Cognitive abilities help individuals to succeed in school and find better opportunities in jobs and private life (door opener function), and they help in everyday life situations, especially when the understanding and effective use of causal relationships are required (problem solving function). Cognitive abilities are especially important in complex occupations with high demands on learning, novel problem solving and independent decision-making. However, the causal relationship is bidirectional since education and complex tasks are known to raise intelligence and knowledge (Ceci, 1991; Schooler, Mulatu, & Oates, 1999).

Intelligence and knowledge enhance individual and cultural rationality. They support rational decisions not only by private individuals, but also in institutions and the political system. They help to assess opportunities and risks (insight, precaution), to use effective means, to achieve institutional goals, to avoid accidents, to assess the importance of resources and anticipated outcomes (future outlook), and to maintain a climate of reason in which disputes are settled by verbal arguments rather than by the use of violence or coercion (e.g. Gottfredson, 2003; Habermas, 1976; Piaget, 1932; UNESCO, 2004). At the level of institutions and of nations, aggregated individual intelligence effects and genuine macro-social intelligence effects like efficient economic and administrative structures (“intelligent culture”) come together.

2. Research at macro-social data level

Research about intelligence at the national level is confronted with problems of data quality: At a more fundamental level, the comparability of cognitive test results across national and cultural boundaries has been called into question (Greenfield, 1997), with national IQ-measures being especially controversial. Lynn and Vanhanen (2002) collected intelligence test results from 81 countries and transformed the results into one common norm (“Greenwich IQ”). For 104 additional countries intelligence was estimated by using data from neighboring countries with similar social, cultural and racial characteristics. Their collection is a landmark, but subjected to some problems (see Barnett & Williams, 2004; Ervik, 2003; Hunt & Wittmann, in press; Richards, 2002; Volken, 2003): (1) there are countries with very small test samples; (2) in some cases, samples seem to be unrepresentative; (3) different tests were used across different countries; (4) different authors conducted the test surveys; (5) measurements of intelligence stem from different years (Lynn and Vanhanen corrected this); (6) missing data were estimated by using unweighted arithmetic means of neighboring countries with similar people. It is therefore not surprising that some researchers are skeptical. Hunt and Sternberg (2006), for example, criticized the “inadequate estimates of national IQ” (p. 131), and maintained that the “concept of national IQ is meaningless without carefully designed probability samples of the population” (p. 133). In response to these criticisms, Templer and Arikawa (2006, p. 139) admit problems but refer to the dearth of better information: “There is, however, no other international aggregation of IQs.”

But “intelligence tests” are not the only cognitive ability tests. International student assessments (PISA, TIMSS, PIRLS, IEA-Reading) use carefully standardized methods of data collection, but evidence other problems: (1) data exist mainly for developed countries; (2) they are chiefly representative for school-aged children and adolescents; (3) participation rates differ across countries; (4) and school dropouts are not represented (only the part of youth that attends school). (5) There are inconsistencies in the age levels; the TIMSS and PIRLS assessments in particular used class-level samples with different ages across countries. However, despite the many shortcomings of IQ tests and school assessments, the Lynn and Vanhanen IQs correlate so highly with the results of international school assessments that the two types of tests appear to measure the same or at least a similar construct (Rindermann, in press).

3. Results of intelligence tests and student assessment tests as indicators of one common cognitive ability

There is no theoretically important difference between intelligence tests and student assessment tests. Both assess thinking and knowledge. Theoretically and empirically they are similar (Coleman & Cureton, 1954; Cronbach, 1984; Ceci, 1991; Jensen, 1998). At the national level the correlations between the two types of test are very high ($r = .80–.90$; Rindermann, in press). At the individual level, the correlation of the SAT (Scholastic Aptitude Test or Scholastic Assessment Test) with the ASVAB (Armed Services Vocational Aptitude Battery) is $r = .82$, and with APM (Advanced Progressive Matrices) it is $r = .48$ ($r = .72$ corrected for restricted range; Frey & Detterman, 2004). The GCSE (General Certificate of Secondary Education, national examination in England for students at age 16) correlates about
Abilities Test) and about \( r = .66 \) with the figural, school-distant scale of the CAT (Deary, Strand, Smith, & Fernandes, 2007).

But there is a theoretical difference between thinking and knowledge, although these two intertwined ability components are difficult to separate. Knowledge is always required to solve the kinds of task that individuals are confronted with in everyday life or that are used in cognitive ability tests. And thinking ability helps to increase and use knowledge.

Since intelligence tests and school assessment tests are alternative measures of an homogeneous construct, we can form a summary score from the two types of test (see Methods section). This will reduce the described flaws of the two types of test studies and will provide a concise measure of knowledge-reduced intelligence, of (as valuable and true estimated) knowledge and of thinking skills that are needed to make use of this knowledge. Being based in part on assessments of school-aged children and adolescents, it will represent mainly the intellectual level of young people, although it is likely to parallel quite closely the intelligence of adults in the country.

Compared to purely figural tests such as the Raven Matrices, this summed score represents to larger extent knowledge. But conventional intelligence tests use not only figural, but verbal and numerical tasks too, and intelligence theory always subsumed under intelligence the ability to process knowledge through the use of reasoning skills and the understanding of complex cognitive problems (Piaget, 1947; Cattell, 1987/1971; Carroll, 1993).

4. Cognitive abilities and wealth: the problem of causality

Lynn and Vanhanen (2002) have demonstrated a strong correlation of \( r = .62 \) between intelligence test results and GDP in 1998 (\( N = 185 \)). Hanushek and Kimko (2000), Jones and Schneider (2006), Ram (2007), Weede and Kämpf (2002), Weede (2006) and Whetzel and McDaniel (2006) showed that correlations of cognitive ability with national wealth and economic growth persist in regression models controlling for other plausible macro-social factors and when using different variables and measurement points. Positive correlations also exist for state comparisons within the USA \( (r = .81, \text{ Davenport \\& Remmers, 1950}; \ r = .50 \) without Washington DC, Kanazawa, 2006; \( r = .18–.28 \), McDaniel, 2006a,b). The interpretation – cognitive ability increases economic wealth by improving the quality of work in complex situations – is based on the economic human capital theory. A similar position is held by the economic organization OECD and by many economic researchers (e.g. Keating & Hertzman, 1999).

However, cross-sectional studies cannot present very strong evidence for causal interpretations of the cognitive-ability–GDP-relationship. Intelligence and knowledge can influence GDP or vice versa or maybe there is a reciprocal causality. As Ervik (2003) maintained: “Many alternative explanations to the causal interpretation of the results come to mind: for example, richer countries spend much more on schooling and childcare, and schooling and IQ scores are positively correlated. Hence, rich countries have higher IQ scores.” (p. 407) We need “proof regarding the direction of causality” (Barnett & Williams, 2004, p. 395). Because of these ambiguities, Whetzel and McDaniel (2006) demand for the IQ–GDP-relationship more “theory development and efforts at causal modeling” (p. 457). Hunt and Wittmann (in press) recommend longitudinal studies.

Longitudinal analyses that can distinguish the influence of cognitive abilities or education on national wealth from the influence of wealth on education or cognitive abilities have not been done so far. International data collections (Barro & Lee, 1993, 2000; Lee & Barro, 1997) allow such analyses. Cross-lagged panel designs, which compare the influence of competing factors in a defined historical period, are the best feasible method for analyzing such relationships. In these analyses the standardized path coefficients between different variables are to be interpreted, not the correlations (Rogosa, 1980). But non-experimental studies and studies at the macro-social level can never demonstrate in a compelling and unequivocal way causal effects of variables free from any historical context or free from the influence of other variables:

1. Outcomes could be caused by unmeasured determinants, which are correlated with intelligence, such as economic freedom or political freedom. This could lead both to over- and underestimation of the IQ effect.
2. Other determinants could be important too, for example natural resources. However, the aim of this study is not to provide a comprehensive explanation for national wealth and economic growth (backward), but merely to study the relevance of education and intelligence for these outcomes (forward). Further the existence of other important factors for wealth does not destroy the relevance of
cognitive abilities to wealth. (For example: The power of the sun to warm still exists on earth when additional heat is produced by volcanoes.)

3. Researched determinants could be influenced by other determinants and the effects of intelligence and education can be indirect. For example, education increases intelligence, intelligence increases the quality of work and the efficiency of organizations and institutions, which in turn increase wealth. But factors behind or between (mediators) do not detract from the importance of intelligence. They help to understand more deeply the causal relationships.

4. Intelligence could have different effects in various nations or historical periods. For example, intelligence could be less important for national wealth in countries at earlier stages of cultural, social and economic development. Thus the results would adequately describe the relationships for countries in modernity.

The aim could only be to show the effect of cognitive abilities controlling for important variables in a defined historical period.

5. Aims of this study

The first aim of the study is to describe the distribution of the new summary score of intellectual ability (formed from IQ and school achievement scores) across nations and its empirical validity (correlations with measures of education, economic success and other characteristics of societies).

The second aim is to investigate the influence of education and cognitive abilities on GDP and vice versa at the end of the 20th century with a cross-lagged design, controlling for the usually most important variable for economic growth: economic freedom.

6. Method

To reduce problems of poor data quality and to ensure that countries at all levels of cultural, social and economic development are represented in the sample, an average score was formed from different measures of one construct available for each country.

6.1. Cognitive abilities and corrections

The IQ-database of 113 countries stems from Lynn and Vanhanen (2006). These IQs are standardized on a common norm scale with the mean of Great Britain set at 100 and the British standard deviation set at 15. Their estimates for 79 states, based on measured data from neighboring countries, were corrected down (if student assessment studies are missing too) by 5 points. This was done because it is assumed that countries with missing data tend to be less developed with respect to education and research, which in turn tends to be associated with poorer cognitive development. For Liechtenstein, which is missed completely in Lynn and Vanhanen (but participated in PISA), the mean of Switzerland, Austria and Germany (IQ 100) was used. The correlations of uncorrected IQ with further cognitive ability measures are: with PISA 2000 sum uncorrected \( r = .88 \) (\( N = 46 \)), with PISA 2000 sum corrected \( r = .84 \) (\( N = 46 \)), with TIMSS sum \( r = .89 \) (\( N = 63 \)), with TIMSS sum corrected \( r = .88 \) (\( N = 63 \)), with PIRLS \( r = .78 \) (\( N = 33 \)), with PIRLS corrected \( r = .81 \) (\( N = 33 \)), with GDP 1998 \( r = .62 \) (\( N = 185 \)). Correlations of corrected IQ including Liechtenstein: with PISA 2000 sum uncorrected \( r = .88 \) (\( N = 47 \)), with PISA sum corrected \( r = .84 \) (\( N = 47 \)), with TIMSS sum corrected \( r = .89 \) (\( N = 63 \)), with TIMSS sum corrected \( r = .88 \) (\( N = 63 \)), with PIRLS \( r = .78 \) (\( N = 33 \)), with PIRLS corrected \( r = .81 \) (\( N = 33 \)), with GDP \( r = .63 \) (\( N = 185 \)).

PISA-2000 (Programme for International Student Assessment, OECD, 2003): The sum was formed from the scores for reading, mathematics and science literacy (41 states; \( \alpha = .98 \)). For PISA and other school achievement studies (TIMSS, PIRLS) the mean was set at 500 and the standard deviation at 100. Only 15-year old students took part in PISA. Invariably, the intellectual proficiency of all young people is overestimated for those countries in which the school enrolment ratio of 15-year olds is low, for example Albania (43%), Mexico (52%), Brazil (53%) and Peru (66%). This is because schooling is one of the most important determinants of cognitive development (Lurija, 1976/1974; Ceci, 1991), and those no longer in schools at age 15 are expected to have lower intellectual proficiency than those still in schools. Therefore the sum score was reduced according to the following formula: PISA2000c = PISA2000 − (100 − participation rate from 0 to 100) × 2. The correction means: Countries with 90% attendance rate get 20 points subtracted, with 80% attendance rate 40 points subtracted. Other corrections are conceivable. The used correction formula assumes a normal distribution from which an end piece of the lower part has been deleted: For example, when the lowest 16% of a normally distributed sample with a mean IQ of 100 are missing, the mean resulting IQ will be 104–105 (PISA: 530). The used formula subtracts for IQ 4.8 IQ-points or for PISA 32 points from the measured average and leads to
marginal stronger corrections. The corrections are stronger for extremely low school enrolment ratios, e.g., for 50% missing the formula would subtract 15 IQ-points or 100 PISA-points, although in a normally distributed sample the resulting mean would be only about 13 IQ-points or 87 PISA-points higher. The assumption is that with low and extremely low school enrolment ratios negative influences of other IQ-lowering factors, such as poor nutrition and health care, low appreciation of education, of reading books, of argumentation and thinking in everyday life, and intellectual simplicity of home environments and society, will increase. For a complete list of correlations between variables see Rindermann (in press).

**PISA-2003** (OECD, 2004a, 2004b): The summary score was formed for reading, mathematics, science and problem solving (40 states; \( \alpha = .99 \)). This score was corrected with the same formula as for PISA-2000 (PISA03K=PISA03−((100−PartRP03)*2)).

**TIMSS 1994−1995** (Third International Mathematics and Science Study, Beaton et al., 1996a; Beaton et al., 1996b; Martin et al., 1997; Mullis et al., 1997), 8th grade (N=39) and 4th grade (N=25). An averaged score of mathematics and science literacy was formed (\( \alpha = .94 \) and \( \alpha = .93 \)), and this was corrected for mean student age (formula for 8th grade: TI895k=TI895−((AgeTi958−14.308)*42); 4th grade TI495k=TI495−((AgeTi954−10.232)*42)). The correction means: Countries with students 1 year older than the mean (14.308 or 10.232 years) get 42 points subtracted, and for countries with students 1 year younger than the mean get 42 points added. One year of school is expected to represent a gain of ca. 42 points (mean of reports by Mullis et al., 1997, p. 29 and p. 41, Beaton et al., 1996a, p. 29, Beaton et al., 1996b, p. 29). For the 8th grade, information also exists about participation rates (“coverage of 13-year old students”; Beaton et al., 1996a, p. A12) and the correction formula was: TI958cc=TI958c−(100−ParRT958)*2. For Kuwait and Israel, no information about attendance rates was provided, so the value of the next Muslim neighbor Iran (72%) was used for Kuwait, and the worldwide mean (87.57%) was used for Israel.

**TIMSS 1999** (8th grade N=37; Martin et al., 2000; Mullis et al., 2000): The correction for older or younger than mean aged students was: T1899k=T1899−(AgeTi998−14.366)*42. The correction means: For countries with students 1 year older than the mean (14.366 years) 42 points were deducted, and for countries with students 1 year younger than the mean 42 points were added. No information is presented in the reports about participation rates.

**TIMSS 2003** (8th grade N=44, 4th grade N=24; Martin, Mullis, Gonzalez, & Chrostowski, 2004; Mullis, Martin, Gonzalez, & Chrostowski, 2004). The correction formulas for older or younger than mean student age are for the 8th grade: TI803k=TI803−((AgeTi038−14.459)*42); for the 4th grade: TI403−((AgeTi034−10.368)*42). No information is presented in the reports about participation rates.

**IEA-Reading-Study** 1991 (N=24 countries for 9-year olds and N=31 countries for 14-year olds; Elley, 1992). The mean age was 9.77 for 9-year olds and 14.73 years for 14-year olds. The correction formula for older or younger than mean student age and for low participation rates of students are for the 9-year old student study are: Read09k=Read09−((Age9−9.7692)*42)−((100−PR9E)*2); for the 14-year old student study: Read14k=Read14−((Age14−14.7333)*42)−((100−PR14E)*2).

**PIRLS 2001** (Progress in International Reading Literacy Study, N=33 countries; Mullis, Martin, Gonzalez, & Kennedy, 2003): Reading competences of fourth graders. Correction for older or younger than mean student age (formula: PIRLSK=PIRLS−((Age−10.312)*42)). The correction formula means: For countries with students 1 year older than the mean (10.312 years) 42 points were deducted and for countries with students 1 year younger than the mean were added 42 points. No information is presented in the reports about participation rates.

**Average score of all corrected measures of cognitive abilities**: Aggregation of different ability scales within studies was done by taking the arithmetic mean. The original scale was conserved. Between different studies, different grades/ages of the same study in the same year (e.g., in IEA-Reading 1991, and TIMSS 1995), different years of the same study (PISA 2000 and 2003; TIMSS 1995, 1999 and 2003), and different studies (IEA-Reading, TIMSS, PISA, PIRLS and IQ-collection), aggregation was only possible after development of a standardization formula with those countries that participated in at least two studies. This was required because different scales had different means and standard deviations (e.g., 500 and 100 vs. 100 and 15), and different assessments had different standardization samples (but the same scales, e.g., IEA-Reading, TIMSS and PISA, or TIMSS 1995 grade 4 vs. 8; PISA 2000 vs. 2003). Before aggregation, the means and standard deviations for those countries that took part in two (or more) studies were calculated. The aggregation was done stepwise: First, the different scales of one study were averaged (e.g., for TIMSS 1999: mathematics and science); then different age or grade levels of
one study in 1 year (e.g. IEA-Reading 1991 9- and 14 years old, TIMSS 1995 4th and 8th grade); then different survey years of one study type (PISA 2000 and 2003, or TIMSS 1995, 1999 and 2003); and finally different studies of one student assessment approach (age, PISA-studies, vs. class, TIMSS-studies and PIRLS, vs. mixed and old study, IEA-Reading). At the end, one total score was calculated for all cognitive ability studies. Student assessment studies were given twice the weight of the Lynn and Vanhanen (2006) IQ collection because they are more recent, have larger samples, and consist of more studies. A similar total score was calculated for student assessment studies only (PISA, TIMSS, PIRLS, IEA-Reading).

Correlations of both sum scores, first total sum value, second student assessment sum value, with single study measures are: total sum value with IQ-L&V corrected $r = .99$ ($N = 193$) and student assessment value with IQ-L&V corrected $r = .86$ ($N = 77$), with PISA sum corrected $r = .97$ ($N = 48$) and $r = .99$ ($N = 48$), TIMSS sum corrected $r = .97$ ($N = 63$) and $r = .98$ ($N = 63$), IEA-Reading corrected $r = .95$ ($N = 31$) and $r = .96$ ($N = 31$), PIRLS corrected $r = .95$ ($N = 33$) and $r = .97$ ($N = 33$). Both sum scores (all cognitive ability studies and student assessment studies only) correlate with $r = .98$ ($N = 78$).

The results of the different cognitive ability studies are highly correlated. Outcomes of factor analyses support an unidimensional factor structure (93–95% of the variance was explained by the first unrotated factor; Rindermann, 2006, in press).

6.2. Attributes of societies


**Quality and quantity of school education of students:** Standardized scores were averaged for the percentage of children attending pre-school or kindergarten, hours taught per year in regular schools, young age of streaming (as an indicator of emphasis on school performance, streaming in younger age leads to a higher value), use of performance tests by schools for counseling parents or streaming decisions, central exams, discipline (low skipping rate, punctuality, low rate of interruptions or behavioral problems during teaching), supplementary lessons during afternoon, evening, weekend or holidays, small classes and low student–teacher-ratios, and reaching of high grades at a young age (e.g., in the age of 10 pupils at grade 5 and not in the age of 11 at grade 4). Data are collected from the OECD- and IEA-studies and from Barro and Lee (1993), $\alpha = .59$, $N = 158$.

**Gross domestic product** (purchasing power parity) per capita 1998 from Lynn and Vanhanen (2002), $N = 185$. Their sources are UN data sets.


**Speed of life** 1992–1995 from Levine (1997), containing service speed at post office (how much time is needed to sell a stamp), walking speed and accuracy of clocks ($\alpha = .72, N = 31$).

**Number of books** (parents and children) from PIRLS 2001 and TIMSS 1995, 1999 and 2003 ($\alpha = .94, N = 63$).


**Interpersonal trust** in 1990s from Inglehart (1997), $N = 41$.


**Homicide rate** (per 100000 inhabitants) 1995 and 2002 ($\alpha = .41, N = 138$) and rate of solved cases for homicide 1995 and 2002 ($\alpha = .77, N = 122$) from Interpol (2004).

**War 1960–1990, $N = 118$,** from Sala-i-Martin (1997) completed and corrected by the author for the years between 1960 and 2000, $N = 186$. The variable represents not only participation in war, but intensity of war and the destructive effect of war in their own country including civil war (e.g. USA small value in spite of participation in many wars; Afghanistan, Haiti, Liberia and Somalia maximum value). Correlation between war from Sala-i-Martin and the new war variable: $r = .66$.

**HIV-infection rate** 2001 and 2003 for adults from UNAIDS/WHO (2003), $\alpha = .99, N = 165$.

**Government spending ratio** 1980–89 from Barro and Lee (1993), $N = 138$. Percentage of government spending (e.g. for redistribution, for administration, for police, for military, for infrastructure) of gross domestic product.

Number of children per woman (total fertility rate, TFR), 1960–84 average from Barro and Lee (1993), N = 130.


Geographic distance from equator from Sala-i-Martin (1997), N = 133.

6.3. Data for cross-lagged study (repeated measurements)

Years at school was the “average schooling years in the total population over age 25” according to Barro and Lee (2000). (For 1970 N = 101 countries, for 2000 N = 104 countries.)

GDP was from Barro and Lee (1993) for 1970 (122 countries), and from Lynn and Vanhanen (2002) for 1998 (185 countries).

Economic freedom ratings for 1970 and 2000 (122 countries each) were from the Fraser Institute (Gwartney & Lawson, 2003).

Measures from former studies on cognitive abilities come from student assessment studies collected by Lee and Barro (1997). From 1964: IEA-Mathematics 13-year old students, eighth grade; IEA-Mathematics at the end of secondary school. From 1972: Science 10-year old students; science 14-year old students; science at the end of secondary school; reading 13-year old students. Mean correlation with weighted N and after Fisher’s-Z-transformation is r = .62. The complete sample for old student assessment studies includes 19 nations: Australia, Belgium, Chile, Finland, France, Germany, Great Britain, Hungary, India, Iran, Israel, Italy, Japan, Malawi, Netherlands, New Zealand, Sweden, Thailand, USA.

The overall cognitive ability score including intelligence tests from Lynn and Vanhanen is not usable as a second measurement point of cognitive abilities because in many countries part of the IQ values is of older origin. Therefore only data from student assessment studies between 1991 and 2003 were used for the cross-lagged analysis.

The time period match is not perfect, but it approximates a 30-year interval. The use of GDP from 1998 and 2000 leads to nearly identical results. The 1998 data show one advantage: 1998 is nearly half-way between 1991 and 2003, the time range of the more recent set of student assessment studies.

6.4. Cognitive ability data only from the youth of nations — a problem?

The use of large-scale assessments from students between 9 and 15 years of age to explain macro-social development (e.g. growth) seems to be questionable. Students do not work, vote or make political decisions. However, intelligence is fairly stable during adult life, and therefore adolescents represent a plausible proxy for the intelligence level of the working population during the following decades. In addition, the school achievement of children and adolescents closely parallels the intellectual ability level of adults in the country. This is shown in a correlation of r = .70 between the average scores of student performance studies and the results of the adult literacy study of the OECD (2000; N = 20, r = .73 with the total score of all cognitive ability studies; Rindermann, in press). Therefore differences between nations in the adolescent population correlate with differences between nations in the adult population. Differences in reproduction rates of the adults could cause problems in cross-sectional, but not in longitudinal studies.

6.5. Statistical methods

Pearson product moment correlations were used for bivariate correlations, additionally GDP was partialed out. Longitudinal effects were calculated by the use of cross-lagged path coefficients in a cross-lagged panel design (see Shadish, Cook, & Campbell, 2002; for causal interpretation: Pearl, 2000). This method provides a test of reciprocal causal relations between two or more variables. The standardized path coefficients (β) between time-lagged variables are reported, along with correlations in parentheses. Additional correlations help to estimate the influence of other variables in the model (by inspection of the difference between the correlation coefficient and the path coefficient), they allow a check of the model (1 – error = R² = Σrβ) and to calculate the proportion of explained variance through each factor (R² = Σrβ). According to Rogosa (1980), unlike the path coefficients the cross-lagged correlations are not useful for estimating causal effects because of their stronger dependence on the stability and variance of the
variables. An even more important reason is that cross-lagged path coefficients represent the incremental part of the other variables in the model, the part that is not explained by self-prediction. Even highly stable variables, such as GDP, can be explained by other variables in a model. The cross-lagged path analyses were done with LISREL. Good values for fit indices are SRMR ≤ .08 (Hu & Bentler, 1999) or SRMR ≤ .05 (Schermelleh-Engel, Moosbrugger, & Müller, 2003) and CFI ≥ .95 (Hu & Bentler, 1999) or CFI ≥ .97 (Schermelleh-Engel et al., 2003).

Cross-lagged panel designs can explain the changes in a variable from a former to a subsequent measurement point. They cannot explain the origin of differences at the first measurement point. Generalization to other time periods is possible only with additional assumptions, justification and empirical evidence (e.g. “because of the relevance of invention, organization and planning, intelligence and knowledge in developed societies have been important for growth from 1950 to 1970 as well”). For longitudinal cross-lagged panel designs GDP is a more appropriate variable than economic growth (the difference between two measurement points itself represents growth, the change in wealth).

Like all non-experimental designs, cross-lagged panel designs are useful for causal interpretations only if the “right” variables are included. The non-inclusion of causal variables that are correlated with the variables in the analysis can bias the results. A less relevant problem is the absence of background variables like culture, because they probably stand behind the researched variables and mainly work through them (e.g. culture influences education, cognitive abilities and economic freedom and through these factors culture has influence on national wealth). To reduce problems of causal interpretation, the conventionally most important variable for economic growth, economic freedom, was included, different samples were used (for educational variables there exists a larger sample) and in further studies political aspects were considered (Rindermann, submitted for publication). Additional variables, such as mineral resources, are important for national wealth (Lynn & Vanhanen, 2002, 2006; Whetzel & McDaniel, 2006), but they do not change the influence of education, cognitive abilities and economic freedom.

Significance tests were not used for interpretation (for an in-depth justification e.g. Cohen, 1994; Falk & Greenbaum, 1995; Gigerenzer, 2004; Hunter, 1997). Especially at the macro-social level they are not appropriate for scientific reasoning. More instructive for inductive generalization – which is not possible with significance tests – is the demonstration of the stability of relationships across different country samples, different variables, different measurement points and various studies of different authors.

For drawing the map the SAS program was used.

7. Results

7.1. International distribution of intelligence and knowledge

Mean cognitive abilities differ greatly between countries (Fig. 1). The East Asia region has the highest cognitive ability scores, including Taiwan (first), Singapore (second), China (third), South Korea (fourth), Hong Kong (fifth) and Japan (sixth). Second are North-, West- and Central-Europe and the countries which have been settled by these Europeans: Finland (seventh), Netherlands (ninth), Canada (tenth), Great Britain (eleventh), Iceland (twelfth), Switzerland (thirteenth), Austria (fifteenth), New Zealand (sixteenth), Sweden (seventeenth), Australia (eighteenth), Belgium (twentieth), Norway (twenty-first), USA (twenty-third), France (twenty-fourth), Germany (twenty-fifth) and Denmark (twenty-seventh).

Medium results are achieved for South and East Europe (here the highest results are for: Italy with 14th and Czech Republic with 19th rank) and low results for Latin America (here the highest rank is for Uruguay with 55th).

Scores are low in the Muslim Middle East and even lower in sub-Saharan Africa. With one exception, all of the 34 lowest-scoring countries are in sub-Saharan Africa. The exception is Haiti (185th, data were estimated by Lynn and Vanhanen by using test results from Jamaica, estimated intelligence test data were corrected down by 5 points), a country with a population and culture similar to sub-Saharan Africa. Even some countries with good economic development and relatively stable democracy and rule of law, for example Botswana (138th) and South Africa (155th), score low on measures of cognitive ability. Intervention studies using formal education or training have demonstrated an unused potential for cognitive improvement in these countries (Skuy et al., 2002). Extremely rich Arab countries such as Kuwait (100th) score no better than poor Arab countries (Lebanon, 93rd; Iran, 81st).

Regions with low cognitive abilities, including sub-Saharan Africa and the Muslim Middle East, seem to be prone to cultural and social crisis (see UNDP, 2003; UNESCO, 2004). Low political power and political instability are associated with low cognitive ability.

These observations suggest important causal relationships of cognitive abilities with political, cultural and economic conditions. But are the cognitive ability
And if they are valid, what are the causes of national differences in cognitive abilities?

7.2. Correlations with important macro-social variables

Correlations (Pearson’s $r$) with country-level variables, mainly from the 1990s, show close relations between cognitive abilities and educational attributes (Fig. 2). In countries with young adults of a high educational level, there are good quality and quantity of school education and plenty of books at home, with the result that intelligence test and school performance test scores are higher.

But there are also high correlations with social, political and economic variables including quality and speed of bureaucracy, rule of law, gross domestic product (GDP), low corruption, democracy, economic freedom and economic growth. The correlation between cognitive ability level and GDP ($r=.63$, $N=185$) even increases when the logarithm of GDP is used ($r=.70$, $N=185$), but remains below the correlations with education (educational level of adults $r=.78$, $N=173$, quality and quantity of school education $r=.74$, $N=158$). An increase of 10 IQ points corresponds to a doubling of the GDP (Dickerson, 2006). Even interpersonal trust and the rate of solved homicide cases are associated positively with intelligence and knowledge. Negatively correlated are homicide rates, war (destruction by war; see also DeGroot, 1951), HIV-infection rates, high government spending ratio, income inequality and the child rate per woman (total fertility rate). The negative correlation with homicide corresponds to similar results at the individual and US-state level (Lynn & Vanhanen, 2002; McDaniel, 2006b), the negative correlation with HIV is mirrored by a positive correlation with health at US-state level (McDaniel, 2006b).

Even after partialing out GDP, educational variables (education of young adults, education of the youth and number of books) remain highly correlated with cognitive abilities. Political, economic and social attributes of societies show less stable correlations. The positive correlation between adult education and cognitive ability remains stable in different international sub-groups: in developed $r=.56$, $N=82$ or less developed countries $r=.55$, $N=91$; in sub-Saharan Africa $r=.48$, $N=46$ or in Europe $r=.45$, $N=37$; in traditionally Catholic countries $r=.62$, $N=36$, Protestant countries $r=.21$, $N=13$, Orthodox countries $r=.95$, $N=13$, countries of eastern religions (Confucian, Buddhist, Shinto) $r=.73$, $N=15$ and Muslim countries $r=.71$, $N=32$. After controlling for distance from the equator, the partial correlation between adult education and cognitive ability is $r_p=.63$, $N=133$.

The ability to think and to use knowledge seems to be attributable to education (see Barber, 2005). Differences in cognitive abilities at international level reflect differences in education. This has been shown in many studies at the individual level (Lurija, 1976/1974; Ceci, 1991; Stelzl, Merz, Remer, & Ehlers, 1995; Winship & Korenman, 1997). The same is demonstrated here at the country level, with high and stable correlations between cognitive measures and school education.
The correlational pattern shows that intelligence and knowledge are indicators, causes and/or consequences of a successful civil society (see Rindermann, submitted for publication). One causal hypothesis will be tested here: the economic wealth thesis.

7.3. Cross-lagged relationships between education and GDP and between cognitive ability and GDP

Lynn and Vanhanen (2002) have demonstrated a correlation of $r = .62$ between IQ and GDP98 at the country level ($N = 185$). After downward correction of their estimates for countries with missing data this correlation is $r = .63$. The correlation of PISA 2000 with GDP98 is even higher despite substantial range restriction ($r = .69$, $N = 40$; $r = .72$ with correction for participation rate). Other authors have confirmed the results. In direct comparisons, GDP is more strongly associated with cognitive ability measures ($r = .65$, $N = 185$) than with educational variables ($r = .60$, $N = 173$). The difference is even more marked for the regression coefficients in a 2-predictor model ($\beta_{CA \rightarrow GDP} = .48$, $r = .65$, $\beta_{Edu \rightarrow GDP} = .22$, $r = .60$, $N = 173$). Educational information is less reliable and valid than are ability measures. And years in school and academic degrees (e.g., “secondary school complete”) are less important than the quality of the product that leaves the schools. But cross-sectional studies do not reveal the direction of the causal arrow between cognitive ability and GDP. Intelligence and knowledge can influence GDP (human capital theory) or vice versa (e.g., by better nutrition and health care) or maybe there is a reciprocal causation. This question can best be approached through the use of longitudinal cross-lagged analysis.

For the path analysis in Fig. 4 (years of schooling) the fit indices are good: SRMR = .02 and CFI = .97. Education has a stronger impact than economic freedom (including aspects of rule of law) on GDP ($\beta_{SY1 \rightarrow GDP2} = .40$, $r = .84$, vs. $\beta_{EF1 \rightarrow GDP2} = .23$, $r = .68$; see also Table 1). The longer and the more the children of 1970 attended school, the better was the economic development between 1970 and the end of the century.

This analysis included two ex-communist countries, Hungary and Poland. When these two countries are excluded, the results for the remaining 86 countries remain the same: The impact of years in school (SY) on GDP ($\beta_{SY1 \rightarrow GDP2} = .43$, $r = .86$) is stronger than the effect of economic freedom on GDP ($\beta_{EF1 \rightarrow GDP2} = .22$, $r = .69$), and even stronger than the effect of old GDP on

Fig. 2. Correlations between cognitive ability and society attributes.
new GDP ($\beta_{\text{GDP1} \rightarrow \text{GDP2}} = .37$, $r = .88$). Reverse effects on education (years at school) are small: $\beta_{\text{EF1} \rightarrow \text{SY2}} = .09$ ($r = .55$), $\beta_{\text{GDP1} \rightarrow \text{SY2}} = -.08$ ($r = .79$) and $\beta_{\text{SY1} \rightarrow \text{SY2}} = .95$ ($r = .93$).

By using the logarithm of GDP the results remain similar for the entire 88-nations sample, with a stronger impact of education ($\beta_{\text{SY1} \rightarrow \text{GDP2}} = .27$, $r = .84$) than economic freedom ($\beta_{\text{EF1} \rightarrow \text{GDP2}} = .10$, $r = .60$) on GDP. Effects on education are small: $\beta_{\text{EF1} \rightarrow \text{SY2}} = .03$ ($r = .51$) and $\beta_{\text{GDP1} \rightarrow \text{SY2}} = .18$ ($r = .85$).

Formal education can create economic wealth only by increasing human capital. It does so not by conferring educational degrees, but by changing the attitudes and raising the cognitive ability of students. In the presented analyses, education is treated as a proxy for cognitive ability, the capacity to understand and solve problems by thinking and using of knowledge. But the effects of education can go beyond knowledge and reasoning skills (including attitude change such as conscientiousness and cooperativeness). In order to confirm that the effects of schooling are mediated through increased cognitive skills, we have to repeat the analysis with cognitive ability measures substituting for the measure of schooling.

Here we are limited to a sample of only 17 nations that includes Australia, Belgium, Chile, Finland, France, Germany, Great Britain, Hungary, Iran, Israel, Italy, Japan, Netherlands, New Zealand, Sweden, Thailand, and the USA. But the results are virtually the same (Fig. 5). For the path analysis in Fig. 5 the fit indices are very good: SRMR = .02 and CFI = 1.00. Again, economic growth is more strongly related to school-related cognitive abilities ($\beta_{\text{CA1} \rightarrow \text{GDP2}} = .29$) than to economic freedom ($\beta_{\text{EF1} \rightarrow \text{GDP2}} = .10$).

When ex-communist Hungary is excluded from the sample, the results remain similar. The impact of cognitive abilities on GDP ($\beta_{\text{CA1} \rightarrow \text{GDP2}} = .34$, $r = .73$) is still stronger than the impact of economic freedom ($\beta_{\text{EF1} \rightarrow \text{GDP2}} = .08$, $r = .51$).

The results remain similar when the logarithm of GDP is used for the 17-nations sample, with a stronger impact of cognitive abilities ($\beta_{\text{CA1} \rightarrow \text{GDP2}} = .38$, $r = .72$) than economic freedom ($\beta_{\text{EF1} \rightarrow \text{GDP2}} = .45$, $r = .45$), and a stronger impact of cognitive abilities on gross domestic product than gross domestic product on cognitive abilities ($\beta_{\text{GDP1} \rightarrow \text{CA2}} = .20$, $r = .67$). Thus education and cognitive abilities are more important than economic freedom as determinants of economic growth.

Differences between nations in education and cognitive abilities explain better later differences in wealth than differences in economic freedom do.

But national wealth influences the development of cognitive abilities too ($\beta_{\text{GDP1} \rightarrow \text{CA2}} = .21$; see Fig. 5). Good nutrition and health care are considered important for the development of cognitive abilities, especially among the poor sections of society (Lynn, 1990; Glewwe & King, 2001; Whaley et al., 2003), probably also the access to mass media like newspaper, TV and Internet (Barber, 2006). These factors are likely to be important for cognitive differences among countries as well.

The correlations between macro-social variables increase from 1970 to 2000. They may reflect the growing interdependence of the success of nations in modern age.

8. Discussion

The high correlations with a host of macro-social variables (Figs. 2 and 3) demonstrate the validity of intelligence as a link in the causal nexus of cultural, political and economic “modernization”. Measures of formal schooling, in particular, are closely related to measures of cognitive ability. International differences in cognitive abilities correlate with differences in educational levels. These correlations especially support
the validity of international intelligence comparisons. Education itself probably depends mainly on cultural factors, less on economic. The education–intelligence relationship is presumably reciprocal: schooling raises intelligence, and intelligent people realize the advantages to be gained through a better education. This does not negate the importance of other factors for cognitive development. Prosperity (Fig. 5) and genes (Rushton & Jensen, 2005) are all likely to contribute also to intelligence differences between nations and groups.

The economic, social and cultural complexity of modern societies would be impossible without a high level of cognitive abilities. Conversely, high intelligence would not develop without this complexity. The 20th century has seen near-exponential advances in science and technology, massive increases in the complexity of commercial enterprises and government bureaucracies and, perhaps most important, a vast expansion of the school system (Meyer, Ramirez, & Soysal, 1992; Schofer & Meyer, 2005). This has been accompanied by large IQ gains, which have been in excess of 3 points per decade in many countries during much of the 20th century (Flynn, 1987). Thus cognitive development and cultural modernization are intimately associated (Oesterdiekhoff, 2000). It has been proposed that the unusual developments of the past one or two centuries are based on positive feedback loops in which increased and better school education, technological advances and rising prosperity raised intelligence, and rising intelligence entailed further advances in technology, prosperity and the school system (Meisenberg, Lawless, Lambert, & Newton, 2005; Meisenberg, in press).

The results reported here show that during the last third of the 20th century, education and cognitive abilities were more important for economic wealth than economic wealth was for education and cognitive abilities. This result is stable across the different national samples of education and ability and remains after adding additional factors like economic freedom. Intelligence is even more important for wealth than economic freedom (see also Weede, 2006)! Whereas the importance of intelligence for many personal life outcomes has been recognized for some time (Gottfredson, 2003; Herrnstein & Murray, 1994), we should realize that intelligence is also an important determinant for the economic and social development of nations (for example the functioning of institutions in the systems of law, economics and politics). The present study shows that a high level of cognitive

![Fig. 3. Partial correlations between cognitive ability and society attributes (GDP partialed out).](image-url)
development can be an antecedent and likely cause for economic growth, but other macro-social outcomes (e.g., democracy, rule of law, national power or health) are likely to be influenced by education and intelligence as well (Rindermann, submitted for publication; Rindermann & Meisenberg, submitted for publication). Certainly the positive influence of young people’s schooling and intelligence on the level of economic freedom 30 years later (Figs. 4 and 5) deserves further investigation. Future theoretical and empirical research has to analyze the causal mechanism underlying the effects of ability on development of societies in a more detailed manner. For example, there is a positive relationship with low government spending ratio ($r = .47$ and $r_p = .24$). Abilities seem to enable a more liberal economic constitution and thriftiness of state interventions. Conversely, a population with low education and intelligence seems to necessitate more state intervention, which tends to widen the influence of powerful special-interest groups.

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**Fig. 4.** Standardized path coefficients (and correlations in parentheses) between average schooling years in the total population over age 25, economic freedom and gross domestic product (error terms as unexplained variance on the right), $N=88$ nations, only measured data.

**Fig. 5.** Standardized path coefficients (and correlations in parentheses) between cognitive abilities (students’ assessment studies from 1964 to 1972 and 1991 to 2003), economic freedom and gross domestic product (error terms as unexplained variance on the right), $N=17$, only measured data.
Acknowledgements

I have benefited from a lot of suggestions, help and critics received after talks, lectures and distribution of preliminary drafts of this paper by colleagues (especially by Gerhard Meisenberg, Georg W. Oesterdieckhoff, and Erich Weede) and students from Germany, Austria and the USA and by the three anonymous reviewers.

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