Psychological Science
http://pss.sagepub.com/

Cognitive Capitalism : The Effect of Cognitive Ability on Wealth, as Mediated Through Scientific Achievement and Economic Freedom

Heiner Rindermann and James Thompson

Psychological Science published online 2 May 2011
DOI: 10.1177/0956797611407207

Psychological Science OnlineFirst, published on May 2, 2011 as doi:10.1177/0956797611407207

Research Article

Psychological Science
XX(X) 1–10

DOI: 10.1177/0956797611407207
http://pss.sagepub.com

Cognitive Capitalism: The Effect of Cognitive Ability on Wealth, as Mediated Through Scientific Achievement and Economic Freedom

Heiner Rindermann[1] and James Thompson[2]
[1]Chemnitz University of Technology and [2]University College London

Abstract

Traditional economic theories stress the relevance of political, institutional, geographic, and historical factors for economic growth. In contrast, human-capital theories suggest that peoples' competences, mediated by technological progress, are the deciding factor in a nation's wealth. Using three large-scale assessments, we calculated cognitive-competence sums for the mean and for upper- and lower-level groups for 90 countries and compared the influence of each group's intellectual ability on gross domestic product. In our cross-national analyses, we applied different statistical methods (path analyses, bootstrapping) and measures developed by different research groups to various country samples and historical periods. Our results underscore the decisive relevance of cognitive ability—particularly of an intellectual class with high cognitive ability and accomplishments in science, technology, engineering, and math—for national wealth. Furthermore, this group's cognitive ability predicts the quality of economic and political institutions, which further determines the economic affluence of the nation. Cognitive resources enable the evolution of capitalism and the rise of wealth.

Keywords

cognitive ability, cross-cultural differences, educational measurement, intelligence, TIMSS, PISA, PIRLS, STEM

Received 3/3/10; Revision accepted 12/30/10

Traditionally, differences in wealth between nations are explained by differences in institutional, economic, geographic, and historical-political factors (Landes, 1998). Newer models also include *human capital*, the stock of individuals' abilities that allows societies, nations, and cultures to work in an economically effective way. In the present study, we used different cognitive-ability data sets from 90 countries to show that cognitive ability is the decisive factor of human capital: Mean national cognitive ability predicts productivity, but the cognitive ability of the 95th percentile of the population (the intellectual class), via its direct influence on national excellence in scientific achievement and technological progress, is a more important predictor of a nation's wealth. Both of these ability levels are relevant for economic growth.

Additionally, the ability level of the intellectual class increases a society's *economic freedom*, which exists when private individuals and the leaders of companies can choose freely how to work, invest capital, and produce and consume goods and services. The increase in economic freedom also has a positive effect on societies' wealth. Analyses show that this pattern is stable across time, and it is independent of different variable measurements and data sets. On the one hand, the ability level of an intellectual class (relative to the general cognitive ability of the society) predicts wealth through excellence in scientific and technological achievements and by changing economic and political institutions in a more liberal, democratic, constitutional, and efficient way, all of which further wealth. On the other hand, wealth, economic freedom, and high intellectual achievement themselves have a positive effect on society's cognitive ability at all levels. In the long run, the positive interactions between cognitive ability and the intellectually stimulating quality of the physical,

Corresponding Authors:
Heiner Rindermann, Department of Psychology, Chemnitz University of Technology, Wilhelm-Raabe-Str. 43, D-09107 Chemnitz, Germany
E-mail: heiner.rindermann@psychologie.tu-chemnitz.de

James Thompson, Department of Psychology, University College London, Charles Bell House, 67–73 Riding House St., London W1W 7EJ, United Kingdom
E-mail: james.thompson@ucl.ac.uk

social, institutional, and cultural environment are mutually reinforcing, producing what economists refer to as a virtuous spiral.

Traditional Wealth and Modern Human-Capital Theories

In the important *libertarian approach*, which dates back to Smith (1776/1994) and the Austrian school of economic thought (Hayek, 1944/1994; Mises, 1927/2005), economic freedom is the essential prerequisite for growth and wealth. Economically free countries have free markets; low taxes, customs duties, and public expenditures; the rule of law; property rights; a free price mechanism; freedom of investment; and rare governmental interventions. Economic freedom allows a better allocation of labor and capital (including knowledge) than a state-controlled economy does. According to the economic-freedom paradigm, richer countries are rich because, as a result of political decisions, they have freer economies.

Dependency theories try to explain wealth differences, especially between First and Third World countries, as a result of asymmetric political and power structures. Such theories posit that colonialism and the postcolonial rule of European countries have resulted in terms of trade between rich and poor countries that are unfavorable for the poor countries.

In contrast, *human-capital theory* claims that attributes of persons are relevant for economic success. But "human capital" is a fuzzy term. Imagine using the term "kangaroo capital" to refer to the ability to make large leaps. What is needed is a psychological theory describing in more detail the essential attributes of persons who can work productively. On closer inspection of human-capital theories and research (Barro, 1991; Becker, 1964/1993; Heckman, 2000), two main psychological traits emerge. The first trait is *cognitive ability* (or cognitive competence), which comprises the ability to think (intelligence), the individual's store of true and relevant knowledge, and the intelligent use of this knowledge (cf. Nelson & Phelps, 1966, in which cognitive ability is defined as the "ability to receive, decode, and understand information," p. 69). The second trait is *industrious discipline*, which involves personality traits such as diligence, commitment, conscientiousness, discipline, and self-discipline (e.g., Heckman, 2000; Rindermann & Ceci, 2009).

A vast amount of research shows that cognitive ability contributes strongly to an individual's and a nation's wealth (Hanushek & Woessmann, 2009; Hunt & Wittmann, 2008; Jones & Schneider, 2006; Lynn & Vanhanen, 2002). Cognitive ability enhances the individual's understanding of concepts and causal relationships, and it increases insight, foresight, and rationality. It leads to proximal consequences, such as higher quality of work, better health, and more reasonable decisions in everyday life. Higher cognitive ability also improves individuals' access to better environments and enables individuals, institutions, societies, and cultures to improve the quality of the available environments. Cognitive ability also brings about distal consequences, such as greater wealth and longevity; a more democratic society; political and economic liberty; a more complex culture; and longitudinally, by backward effects of these environmental factors, enhanced intelligence (e.g., Deary, Batty, & Gale, 2008; Gottfredson, 2004; Rindermann & Meisenberg, 2009). However, there are additional factors underlying cognitive ability and mediating between cognitive ability and positive outcomes.

The Solow-Swan growth model of wealth supposes that technological innovations cause economic growth (Romer, 1990; Solow, 1956). Cognitive-ability theory argues that intellectual competence is essential for this process. In addition to the cognitive ability of scientists and engineers, other relevant factors necessary for technological innovation include the cognitive alertness of entrepreneurs (Schumpeter, 1939), their ability to acquire new technologies, and their ability to foresee consumer demand. Finally, workers and consumers must be competent to navigate through complex processes in work and everyday life and use technological innovations in an efficient way.

The Intellectual-Class Hypothesis

The intellectual-class hypothesis posits that individuals who are cognitively highly competent should have a positive effect on affluence, politics, and culture in their society. Several authors have referred to this phenomenon implicitly or explicitly; for example, Florida (2002) refers to the "creative class," Hanushek and Woessmann (2009) speak of "rocket scientists," Pritchett and Viarengo (2009) refer to "global performers," and La Griffe du Lion (2002) calls the intellectual class the "smart fraction" of the population (see also Gelade, 2008; Weiss, 2009). Unlike with other forms of capital, there are no diminishing returns for cognitive ability: The higher the cognitive ability and the more persons at higher cognitive levels, the better. Performing research at the level of individual differences, Park, Lubinski, and Benbow (2008) found that even among the top 1% of cognitively competent persons, the upper quartile (rank 99.75) unambiguously outperformed the lower quartile (rank 99.25) in scientific and technological fields, as measured by science, technology, engineering, and math (STEM) publications and patents.

The intellectual-class hypothesis can be operationalized in two different ways. One way is to measure the smart fraction of the population exceeding a given threshold: for example, an IQ greater than 106, 115, 130, or 145 (M = 100, SD = 15) or a student assessment score (SAS) greater than 540, 600, 700, or 800 (M = 500, SD = 100, as measured by the Trends in International Mathematics and Science Study, TIMSS; Programme for International Student Assessment, PISA; and Progress in International Reading Literacy Study, PIRLS, on one international norm derived from participating or Organisation for Economic Co-Operation and Development, OECD, countries). Different thresholds have been suggested by other researchers: an IQ of 108 or higher (La Griffe du Lion, 2002), an IQ of 140 or higher (Gelade, 2008, p. 717), an SAS of 600 or greater (equivalent to an IQ ≥ 115; Hanushek & Woessmann, 2009), an SAS of 625 or greater (IQ ≥ 119; Pritchett & Viarengo, 2009), and an IQ of 106 or higher (Weiss, 2009, p. 71). Second, the intellectual-class hypothesis can be operationalized by measuring the ability of an upper-level group, such as at the 90th, 95th, or 99th percentile of the population.

We adopted the second approach because it provides three advantages, two of which are practical and one of which is theoretical. First, the data from the student assessment studies (TIMSS, PISA, and PIRLS) are provided in this manner. Second, studies at the individual data level are carried out using the ability levels (not population shares) of gifted groups. Third, it is not the percentage of people in an upper stratum that is important; rather, its absolute cognitive level is what enables intellectual, cultural, institutional, political, and technological progress. The empirical IQ at the 95th percentile marks the lower boundary of that upper stratum's ability.

Previous Results

Using cross-national analyses on a small sample of 12 to 13 countries, Gelade (2008) showed that the smart fraction of the population (IQ ≥ 140) has a greater correlation with patent rates and gross domestic product (GDP) than does the mean IQ of the population. The effects of cognitive ability on wealth are mainly indirect (through patent rates). However, Gelade estimated (but did not measure) the percentage of the smart fraction from mean and subgroup data.

Hanushek and Woessmann (2009) used older and newer student assessment studies to calculate the percentage of students in math and science with SASs above 400 or 600 (equivalent to IQ ≥ 85 or IQ ≥ 115, respectively; N = 50 countries) using an OECD standardization sample. They related these percentages to average annual growth rate in GDP per capita from 1960 to 2000. The share of top-performing students was more than four times more important for growth than the share of students reaching basic ability was. However, Hanushek and Woessmann did not include a mean ability group, and they excluded several countries (former communist countries, oil production countries, outliers). Both procedures tend to exaggerate smart-fraction effects. Finally, Hanushek and Woessmann did not test the possible effects of economic advancement by technological innovation.

In a previous analysis (Rindermann, Sailer, & Thompson, 2009), we used student assessment studies to calculate the cognitive-ability levels of the 95th and 5th percentiles as well as the mean for 90 countries from 1995 to 2007. Results showed that the 95th percentile had a larger effect on positively valued outcomes (scientific and technical achievement, GDP, government effectiveness, democracy, rule of law, political liberty) than the mean or the 5th percentile did.

However, there were five limitations of our previous analyses. First, we used GDP as an indicator of wealth. This meant that the difference between, for example, \$20,000 and \$25,000 would have the same import as the difference between \$5,000 and \$10,000. Instead, if we had used log GDP, increased wealth at lower levels would have been more important than at higher levels. Second, we included only 48 countries in our path analysis; 42 of the 90 countries were lost because of listwise deletion as a result of missing values. The results are thus less representative than they would have been had we been able to retain the complete sample. Third, the three cognitive-ability levels were highly correlated (multicollinearity), a situation leading to unstable path coefficients and suppressor effects. Fourth, the influence of other possible determinants on wealth, such as economic freedom and education, was not checked. Fifth, data from only the end of the 20th and the beginning of the 21st century were used. But—depending on educational policies, demographic factors, and migration—human capital and abilities can change. No study has checked the hypothesis that the development and functionality of economic institutions themselves could depend on cognitive ability, especially on the cognitive ability of an intellectual class.

Aim of the Present Study

The aim of this study was to check the effect of cognitive-ability levels on national wealth by using different variables, larger data samples, and different statistical methods than have been used in previous studies. In addition, we also used data from other researchers for different historical periods and controlled for the influence of other important determinants of wealth. Three ability levels—the mean, 95th, and 5th percentiles—were compared. These values (transformed to an international norm) differed across countries (see Figs. 1–3 and Results). We assumed that the cognitive level of an intellectual class predicts a society's wealth. Cognitive ability influences wealth through its effects on high achievement in technological and scientific research (indicated, e.g., by numbers of patents and scientists) and through improvement of economic institutions (economic freedom). The effect of cognitive ability on wealth should remain stable despite using different data sets, different indicators of intellectual and scientific achievement—including the number of eminent scientists in a country's past—and more sophisticated statistical analyses, or despite allowing for the general education level of society.

Method

A detailed description of the data and the statistical analyses we employed can be found in the Supplemental Material available online.

Data

Using TIMSS results from 1995 to 2007, PISA results from 2000 to 2006, and PIRLS results from 2001 to 2006, we calculated mean ability values for 90 countries for the 95th ability percentile (IQ of ~125), the 5th ability percentile (IQ of ~75)

Fig. 1. Level of cognitive ability at the 95th percentile in 90 nations (shaded in gray). Darker shading indicates higher cognitive ability; hatched areas indicate that no data were available.

Fig. 2. Level of cognitive ability at the mean (~50th percentile) in 90 nations (shaded in gray). Darker shading indicates higher cognitive ability; hatched areas indicate that no data were available.

Fig. 3. Level of cognitive ability at the 5th percentile in 90 nations (shaded in gray). Darker shading indicates higher cognitive ability; hatched areas indicate that no data were available.

and the mean (~50th ability percentile; IQ of ~100). The results of the different studies were aggregated in a stepwise manner and standardized on a common scale (United Kingdom: M = 100, SD = 15, known as the "Greenwich IQ"; see the Supplemental Material). Cognitive-ability values can be expressed in different scales (IQ or SAS); however, we used the IQ scale because it is better known but does not imply any theory of ability differences (culture, education, genes, wealth, politics, etc.). Nevertheless, the student assessment tasks are good indicators of crystallized intelligence (and to some extent also of fluid intelligence, especially PISA tasks), and there is a very strong *G* factor (country-level *g* factor), which could explain between 82% (GDP partialed out) and 95% of cross-country variance in competence studies independent of the scale (e.g., verbal, science literacy), student assessment study (e.g., PISA, TIMSS), grade level (e.g., fourth grade, eighth grade), and paradigm (psychometric intelligence, student assessment; Rindermann, 2007).

The cognitive levels of the 95th percentile and the mean were related to scientific and technological excellence (or high STEM achievement), as measured by patent rates (World Intellectual Property Organization, 2011), Nobel Prizes in science (Nobel Prize Committee, 2005), numbers of scientists (Kurian, 2001), and high-technology exports (Kurian, 2001) in a given country; all data were adjusted for population size (n = 88, Cronbach's α = .68). Final criteria were GDP in 1998 and 2003 (log of per capita purchasing-power parity). (The results of the 5th percentile showed a less important relation with wealth.)

Three further variables were analyzed. The first was economic freedom, which includes property rights, rule of law, low customs, taxes, government-spending ratio, and trade restrictions. Within our 90-nation sample, 73 countries met the criteria of the Fraser Institute for 2000 (Gwartney & Lawson, 2003) and 83 countries met the criteria of the Heritage Foundation for 1995 through 2000 (O'Driscoll, Holmes, & O'Grady, 2002). The second variable was the education level of society, which was indexed by summing the rate of literate adults in 1991, the rate of persons between 12 and 19 years old from 1960 to 1985 who graduated from a secondary school, and the years of school attendance of persons 25 years or older from 1990 to 2000 (n = 84 countries; Rindermann, 2007). The third variable was excellence from 800 BC to 1950 in science, mathematics, and technology, as measured by the eminence and number of important scientists in a country (n = 42 countries; Murray, 2003).

Statistical analyses

Path analyses were calculated at the latent level using Mplus (Version 5.21; Muthén & Muthén, 2008) and full-information maximum likelihood (FIML, with no listwise deletion in the case of missing data). Because of the high correlation (r = .97) between the two predictors—cognitive ability at the mean and at the 95th percentile—path coefficients were not stable. Because of empirical redundancy, the conventional solution would have been to use only one predictor of these two. However, in this study, the differences between these theoretically nonredundant determinants were exactly what we were interested in. We therefore chose four alternative solutions. First, we checked the stability of effects in different country compositions (n = 48 countries and n = 90 countries). Second, we checked the stability of effects with different variables (GDP or log GDP). Third, we used bootstrapping: Out of the total sample of 90 countries, random subsamples were drawn with replacement. Individual countries might be included in any particular subsample several times; other countries might never be drawn. This subsampling procedure was repeated 999 times, resulting in a distribution of betas for the two predictors. This was done using Mplus in the R programming environment (R Development Core Team, 2008). Fourth, we compared our data with the data of other researchers for different country samples and historical periods (cross-validation).

Results

Figures 1, 2, and 3 show the distributions of the 95th percentile, mean, and 5th percentile cognitive-ability levels, respectively, across 90 countries. Because of their high correlations (mean with 95th percentile: r = .969; mean with 5th percentile: r = .973; 95th percentile with 5th percentile: r = .899), the results for the three levels are similar but not identical. For example, consider the differences between the United States and Canada. At the 95th percentile, there was no difference in IQ (United States: M = 120.30; Canada: M = 120.32). However, there was a 3-point difference in IQ at the mean (United States: M = 98.41; Canada: M = 101.75) and a 5-point difference at the 5th percentile (United States: M = 74.90; Canada: M = 79.59). These differences probably reflect different educational systems (such as a large amount of private-sector education) and migration histories. The largest ability difference between the 95th and the 5th percentiles occurred in South Africa (64 IQ points), but the difference was also large in the United States (45 IQ points); this difference was small in countries such as Macao (33 IQ points) and Finland (36 IQ points). The results for Kazakhstan are based on only one study (TIMSS 2007, fourth graders) and seem to be an anomaly.

The bootstrapping procedure showed that the 95th percentile had a larger effect on high STEM achievement (β = −0.09–0.75) than the mean did (β = −0.22–0.68). The effect of high STEM achievement on wealth was still very large (β = 0.71–2.06).

For the analysis, FIML was used (N = 90 countries) to estimate the influence of the 95th percentile and the mean on wealth (indexed by log GDP), as mediated by high STEM achievement and economic freedom (Fig. 4). The effects on wealth of high STEM achievement (adjusted for population size) and economic freedom, both of which depend on cognitive ability, were contrasted with the effects of education level on wealth. The model fit the data well (comparative fit index, or CFI = .97, standardized root-mean-square residual, or SRMR = .07). There was an impressive effect difference between the 95th percentile and the mean on high STEM achievement (95th percentile: β = 0.75; mean: β = 0.02). High STEM achievement had a larger effect on wealth (β = 0.62) than economic freedom did (β = 0.37). High STEM achievement also had a much larger effect on wealth (β = 0.62) than the education level of society did (β = 0.00). We therefore excluded the education level of society as a variable. Finally, there was a remarkable effect difference between the 95th percentile and the mean on economic freedom (95th percentile: β = 0.88; mean: β = −0.39). As was high STEM achievement, the economic freedom of a society and its economic system was predicted by the cognitive ability of the 95th percentile.

Comparison With Data Collected by Other Researchers

Murray's (2003) data from historiometric analyses of eminent scientists from 800 BC to 1950 (relative to population size) in 38 countries correlated at the country level, 95th percentile: r = .44; mean: r = .41; 5th percentile: r = .37. The model fit the data well (CFI = 1, SRMR = .01). The 95th percentile had a greater effect on high STEM achievement (β = 0.70) than did the mean (β = −0.19; n = 42; see Fig. 5). Additionally, there was a strong effect of eminent scientists on high STEM achievement (β = 0.37). Both cognitive ability and the frequency and number of eminent scientists indicate the level of intellectual classes in societies. Present high STEM achievement increased wealth (β = 0.39), as did the ability level of the 95th percentile (β = 0.54).

Intellectual eminence is relevant for wealth and seems to be stable across centuries. Because the rate of eminent scientists was measured centuries before current wealth was, and because cross-country differences in intellectual eminence are stable (rs = .44–.62), the direct and indirect effects of intellectual eminence on wealth seem to be mainly causal. Additionally, past longitudinal cross-lagged analyses across a generation (defined as a 30-year interval from the 1960s to the end of the century, controlled for economic freedom) have shown a stronger influence of cognitive ability on wealth than of wealth on nations' mean cognitive ability. This substantiates the influence of cognitive ability on economic development (Rindermann, 2008). Economic systems and wealth have changed radically in the past, depending on modernization and sometimes on political revolutions (as in Europe's former communist countries), whereas cognitive-ability differences and intellectual eminence have been less affected by these factors.

We also utilized the data from Hanushek and Woessmann (2009, pp. A15–A17) for students with SAS scores of 400 or higher (equivalent to IQ of ~85) and scores of 600 or higher (equivalent to IQ of ~115) in 50 countries from 1964 through 2003 (see Fig. 6). The percentage of students with SAS scores above 400 correlated with our 5th percentile cognitive-ability level, r = .90, and the percentage of students with SAS scores above 600 correlated with our 95th percentile cognitive-ability

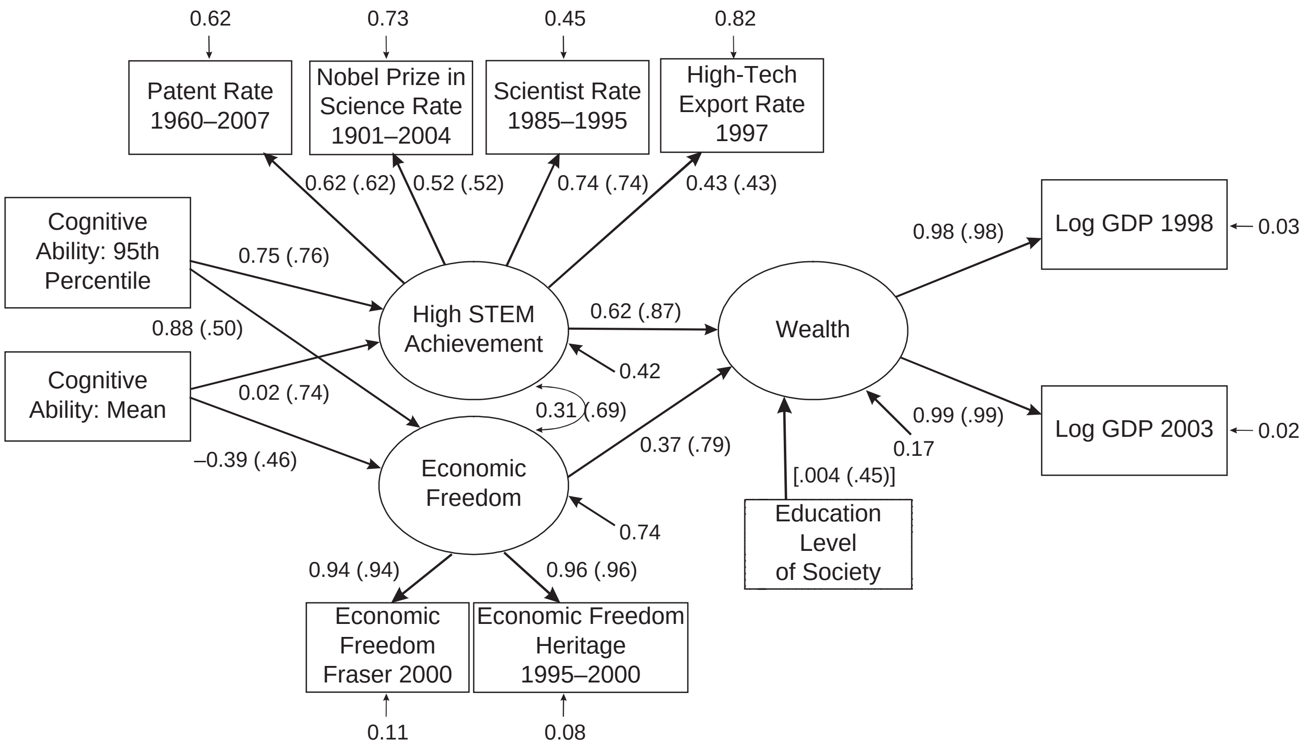

Fig. 4. Model estimated using full-information maximum likelihood to show the effects of cognitive ability (mean and 95th percentile) on wealth for 90 nations. Mediators included in the model were economic freedom and high achievement in science, technology, engineering, and math (STEM). High STEM achievement was adjusted for population size and was indexed by four variables (see the text for details). Economic freedom was indexed by data from the Fraser Institute for 2000 (Gwartney & Lawson, 2003) and the Heritage Foundation for 1995 through 2000 (O'Driscoll, Holmes, & O'Grady, 2002). Wealth was indexed by log gross domestic product (GDP) in 1998 and 2003. Standardized path coefficients are shown, with correlations in parentheses. The effect of the education level of society on wealth is indicated in brackets because this variable had a nonsignificant effect and therefore could be deleted from the model.

level, r = .85, in 47 countries. The percentage of students with scores above 400 and 600 correlated in 50 countries, r = .73. The model fit the data well (CFI = .95, SRMR = .07). The percentage with scores above 600 had a slightly greater effect on high STEM achievement (β = 0.43) than the percentage with scores above 400 did (β = 0.41); for economic freedom, the effect of the percentage with scores above 600 was much larger than the effect of scores above 400 (above 600: β = 0.65;

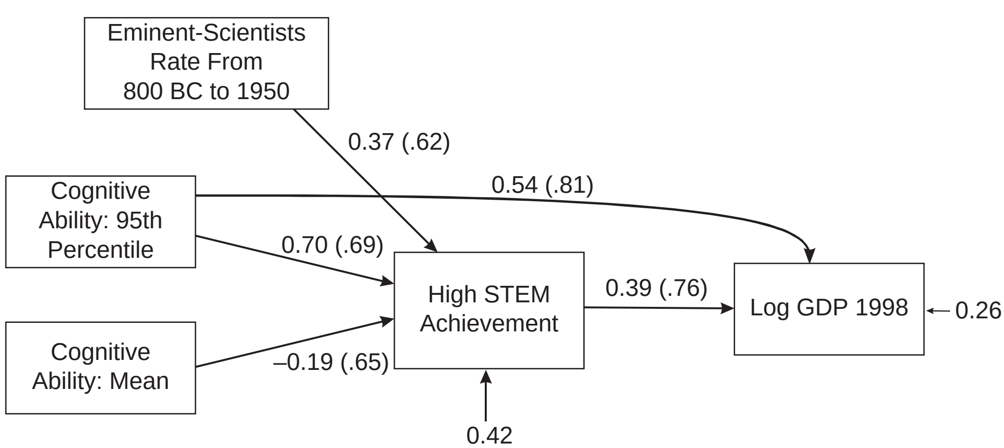

Fig. 5. Model estimated using full-information maximum likelihood to show the effects of cognitive ability and the rate of eminent scientists from 800 BC to 1950 on wealth for 42 nations. Wealth was indexed by log gross domestic product (GDP) in 1998. The mediator included in the model was high achievement in science, technology, engineering, and math (STEM), which was adjusted for population size. Standardized path coefficients are shown, with correlations in parentheses.

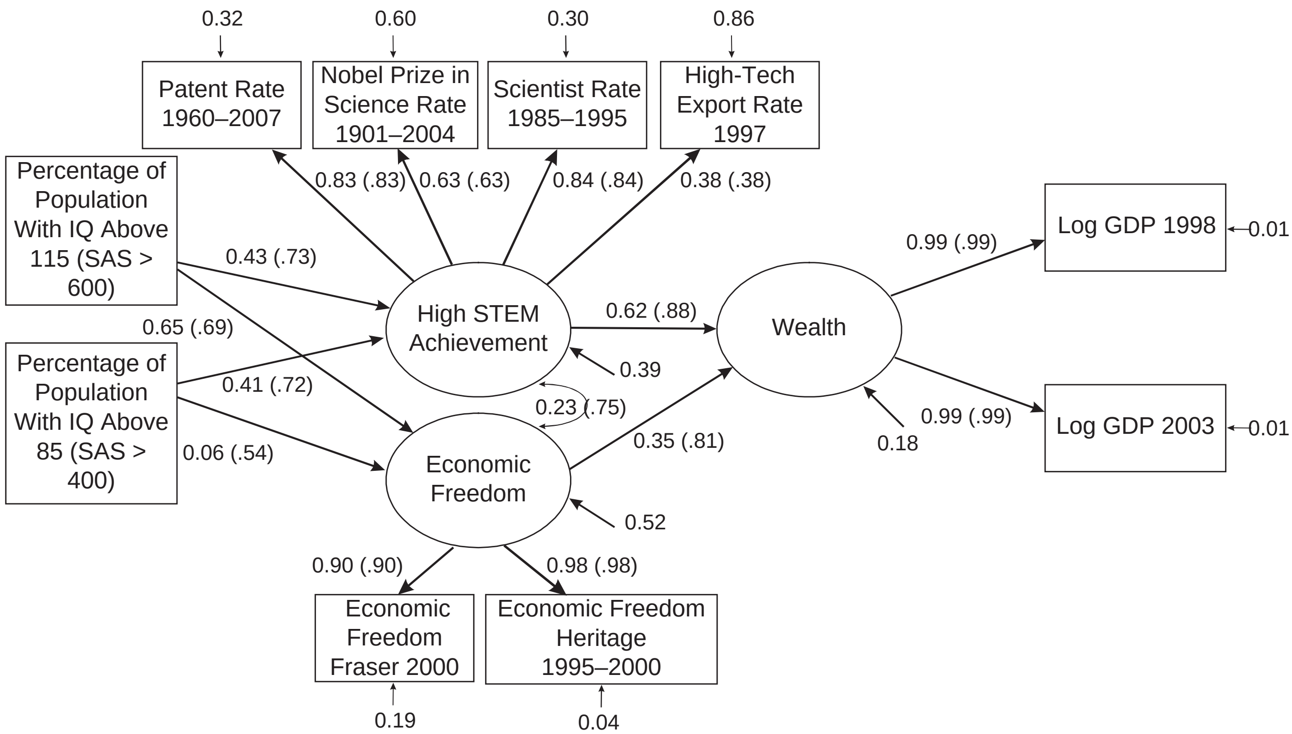

Fig. 6. Model estimated using full-information maximum likelihood to show the effects of the percentage of individuals with a student assessment score (SAS) above 400 and above 600 (corresponding with IQs of 85 and 115, respectively) on wealth for 50 nations. Mediators included in the model were economic freedom and high achievement in science, technology, engineering, and math (STEM). High STEM achievement was adjusted for population size and was indexed by four variables (see the text for details). Economic freedom was indexed by data from the Fraser Institute for 2000 (Gwartney & Lawson, 2003) and the Heritage Foundation for 1995 through 2000 (O'Driscoll, Holmes, & O'Grady, 2002). Wealth was indexed by log gross domestic product (GDP) in 1998 and 2003. Standardized path coefficients are shown, with correlations in parentheses.

above 400: $\beta = 0.06$). Wealth depends more on high STEM achievement than on economic freedom, but both show a positive effect and both depend on cognitive ability, especially on the share of the population above a medium-high cognitive threshold of around 600 (IQ ≥ 115).

Discussion

In modern society, the cognitive level of the intellectual class and its relative size are more important for economic development than are the mean cognitive level or the cognitive level and relative size of lower-ability groups. STEM achievements depend on the level of cognitive ability of the intellectual class; additionally, the intellectual class's ability level positively influences wealth by increasing economic freedom. We confirmed this result using different measures of the ability and percentage of intellectual classes, different country samples, different time intervals and historical periods, and different statistical methods. The results underscore the relevance of human capital for the wealth of nations, more particularly, the relevance of the intellectual classes, as mediated by high accomplishment in STEM and by economic freedom.

In concrete numbers, an increase of 1 IQ point in the intellectual class raises the average GDP by $468 U.S., whereas an increase of 1 IQ point in the cognitive ability of the mean raises average GDP by $229 U.S. These effects are backed by similar effects at the level of individuals: Murray (2002) found that in sibling comparisons within families, 1 extra IQ point produced an extra $810 (expressed in 2000 dollars) per year by age 35.

Wealth and economic freedom longitudinally also have positive "backward" effects on cognitive ability: In a cross-lagged panel analysis with an interval from around 1970 to 2000, GDP and economic freedom both furthered cognitive ability (β = 0.17–0.21; Rindermann, 2008). Theories assuming the influence of one single factor, and only in one direction, are too simple to adequately describe the complexity of socioeconomic processes. Development occurs within a virtuous spiral between ability, economic freedom, and wealth. A social environment in which IQs are higher allows intelligence to flourish (Rindermann & Heller, 2005), creating a collective cognitive ability that further stimulates the physical, social, and cultural environment. Further research has to look in-depth at these processes. Of course, wealth can be acquired from natural resources (e.g., Argentina and Venezuela demonstrated *staples growth*, enlarged wealth by increased export of primary products; Landes, 1990). But these considerations do not rule out a causal interpretation, backed by empirical data and theoretical explanations, of the effect of cognitive ability, mediated through technological progress, on wealth. Cross-lagged studies have demonstrated a positive effect of ability. Studies using indicators from past centuries (Fig. 5) show a positive effect of former scientific excellence on wealth, with high STEM achievement as a mediator. Longitudinal studies at the level of individuals also show a positive effect of cognitive ability on later wealth.

The average cognitive-ability level is not trivial: In the majority of analyses, it has a positive effect on social development. Many persons with high cognitive ability have parents in the average intelligence group. This is because the average ability group is large and because the group members with higher cognitive ability have relatively fewer children. Finally, nations need persons with the ability to use modern technology, to adopt and implement new technology from abroad (Benhabib & Spiegel, 1994), and to make rational choices as workers, consumers, and citizens.

Of course, cognitive ability is not the only determinant of wealth: Further studies should take a more detailed look at how cognitive ability works. It is reasonable to assume that high intelligence, extensive knowledge, and the intelligent application of this knowledge are a prerequisite for high achievement in cognitively demanding STEM tasks. But how is this related to economic freedom? On the one hand, intelligent persons gain from economic freedom because free societies more strongly reward economic competence than premodern countries did or unfree countries do. In the latter countries, connections, political orientations, class, family and ethnic affiliations, and sometimes pure physical strength determine success. On the other hand, cognitive ability in the leaders of a society is necessary for the development of an economically free system with functioning institutions, such as courts, police, and effective governments. The intellectual class, apart from theoretical and practical scientists, also comprises engineers, teachers, politicians, physicians, architects, technicians, people working in the judicial system, administrative managers, and entrepreneurs.

Our central thesis is that national wealth depends mainly on a nation's internal attributes, predominant among which is national cognitive ability and, specifically, the intellectual level of the cognitive elite, which facilitates cultural and social progress generally. This thesis may seem provocative. Yet nations can exercise greater control over precisely such variables than over factors such as the nation's history, terms of trade with other countries, available mineral resources, or geographical conditions. We believe we have shown extensive empirical evidence to substantiate our thesis.

At the individual level, intelligence and knowledge are necessary for achievement in cognitively demanding tasks, such as employment. But the implications of our thesis are even broader: Wealth in modern times is the result of *cognitive capitalism*. Cognitive capitalism refers to the idea that the cognitive ability of society as a whole, and of its cognitive elite in particular, is the prerequisite for the development of technological progress, for the historic development of modern society with its increasing cognitive demands and complexity, and for the wealth-furthering norms and institutions that form the core of the capitalist system (economic freedom, free markets, rule of law, property rights). In effect, cognitive ability is crucial in creating and sustaining a high-achievement milieu leading not only to economic growth and wealth, but also to a democratic and free society.

Acknowledgments

We want to express our gratitude to Eric Hanushek, Garett Jones, Charles Murray, Ivailo Partchev, Michael Sailer, Tatu Vanhanen, and Erich Weede, all of whom helped improve our research, collected or provided us with data, or conducted statistical analyses.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

References

Barro, R. J. (1991). Economic growth in a cross-section of countries. *The Quarterly Journal of Economics*, *106*, 407–443.

Becker, G. S. (1993). *Human capital*. Chicago, IL: University of Chicago Press. (Original work published 1964)

Benhabib, J., & Spiegel, M. (1994). The role of human capital in economic development: Evidence from aggregate cross-country data. *Journal of Monetary Economics*, *34*, 143–173.

Deary, I. J., Batty, G. D., & Gale, C. R. (2008). Childhood intelligence predicts voter turnout, voting preferences, and political involvement in adulthood. *Intelligence*, *36*, 548–555.

Florida, R. (2002). *The rise of the creative class*. New York, NY: Basic Books.

Gelade, G. A. (2008). IQ, cultural values, and the technological achievement of nations. *Intelligence*, *36*, 711–718.

Gottfredson, L. S. (2004). Life, death, and intelligence. *Journal of Cognitive Education and Psychology*, *4*, 23–46.

Gwartney, J., & Lawson, R. (2003). *Economic freedom of the world: 2003 annual report*. Vancouver, British Columbia, Canada: Fraser Institute.

Hanushek, E. A., & Woessmann, L. (2009). *Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation* (Discussion Paper No. 4575). Retrieved from Institute for the Study of Labor Web site: http://ftp.iza.org/dp4575.pdf

Hayek, F. A. V. (1994). *The road to serfdom*. Chicago, IL: University of Chicago Press. (Original work published 1944)

Heckman, J. J. (2000). Policies to foster human capital. *Research in Economics*, *54*, 3–56.

Hunt, E., & Wittmann, W. (2008). National intelligence and national prosperity. *Intelligence*, *36*, 1–9.

Jones, G., & Schneider, W. J. (2006). Intelligence, human capital, and economic growth. *Journal of Economic Growth*, *11*, 71–93.

Kurian, G. T. (2001). *The illustrated book of world rankings*. Armonk, NY: Sharpe.

La Griffe du Lion. (2002). *The smart fraction theory of IQ and the wealth of nations*. Retrieved from www.lagriffedulion.f2s.com/sft.htm

Landes, D. S. (1990). Why are we so rich and they so poor? *American Economic Review*, *80*, 1–13.

Landes, D. S. (1998). *The wealth and poverty of nations*. New York, NY: Norton.

Lynn, R., & Vanhanen, T. (2002). *IQ and the wealth of nations*. Westport, CT: Praeger.

Mises, L. V. (2005). *Liberalism*. Indianapolis, IN: Liberty Fund. (Original work published 1927)

Murray, C. (2002). IQ and income inequality in a sample of sibling pairs from advantaged family backgrounds. *American Economic Review*, *92*, 339–343.

Murray, C. (2003). *Human accomplishment*. New York, NY: HarperCollins.

Muthén, L. K., & Muthén, B. O. (2008). Mplus (Version 5.21) [Computer software]. Los Angeles, CA: Muthén & Muthén.

Nelson, R. R., & Phelps, E. S. (1966). Investment in humans, technological diffusion, and economic growth. *American Economic Review*, *56*, 69–75.

Nobel Prize Committee. (2005). *All Nobel prizes*. Retrieved from http://nobelprize.org/nobel_prizes/lists/all

O'Driscoll, G. P., Jr., Holmes, K. R., & O'Grady, M. A. (Eds.). (2002). *2002 index of economic freedom*. Washington, DC: Heritage Foundation; New York, NY: The Wall Street Journal.

Park, G., Lubinski, D., & Benbow, C. P. (2008). Ability differences among people who have commensurate degrees matter for scientific creativity. *Psychological Science*, *19*, 957–961.

Pritchett, L., & Viarengo, M. (2009). Producing superstars for the economic Mundial: The Mexican predicament with quality of education. In R. Hausmann, E. L. Austin, & I. Mia (Eds.), *The Mexico competitiveness report 2009* (pp. 71–89). Geneva, Switzerland: World Economic Forum; Boston, MA: Harvard University.

R Development Core Team. (2008). *R: A language and environment for statistical computin*g. Retrieved from http://www.R-project.org

Rindermann, H. (2007). The big *G*-factor of national cognitive ability. *European Journal of Personality*, *21*, 767–787.

Rindermann, H. (2008). Relevance of education and intelligence at the national level for the economic welfare of people. *Intelligence*, *36*, 127–142.

Rindermann, H., & Ceci, S. J. (2009). Educational policy and country outcomes in international cognitive competence studies. *Perspectives on Psychological Science*, *4*, 551–568.

Rindermann, H., & Heller, K. A. (2005). The benefit of gifted classes and talent schools for developing students' competences and enhancing academic self-concept. *Zeitschrift für Pädagogische Psychologie*, *19*, 133–136.

Rindermann, H., & Meisenberg, G. (2009). Relevance of education and intelligence at the national level for health: The case of HIV and AIDS. *Intelligence*, *37*, 383–395.

Rindermann, H., Sailer, M., & Thompson, J. (2009). The impact of smart fractions, cognitive ability of politicians and average competence of peoples on social development. *Talent Development and Excellence*, *1*, 3–25.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*, S71–S102.

Schumpeter, J. A. (1939). *Business cycles: A theoretical, historical, and statistical analysis of the capitalist process*. New York, NY: McGraw-Hill.

Smith, A. (1994). *An inquiry into the nature and causes of the wealth of nations*. New York, NY: Modern Library. (Original work published 1776)

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, *70*, 65–94.

Weiss, V. (2009). National IQ means transformed from PISA scores. *Journal of Social, Political and Economic Studies*, *34*, 71–94.

World Intellectual Property Organization. (2011). Patent applications by patent office (1883-2009) by resident and non-resident. In *Statistics on patents*. Retrieved from www.wipo.int/ipstats/en/statistics/patents